INCREASING FEMALE ENROLLMENT IN THE INDUSTRIAL ENGINEERING PROGRAM AT THE UNIVERSITY OF MINNESOTA DULUTH

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I. Introduction

The national average for female students enrolled in Industrial Engineering programs in the U.S. is approximately 33% \(^1\). This figure is nearly three times the percentage of female students enrolled in the Industrial Engineering (IE) program at the University of Minnesota Duluth (UMD), which is currently 12%, ranging from a low of 9% percent to a high of 15% over the last 5 years. Although the department has speculated about reasons for this discrepancy, including the emphasis on manufacturing and laboratory courses, no formal study has been conducted to investigate this hypothesis. The department therefore decided to gather information to help understand why the female enrollment is low.

Initial efforts focused on gathering available data regarding the enrollment and retention of female students in the IE program. Surprisingly, the data was not readily available and certain types of retention information are kept for no more than two years. Although manual sorting and inspection provided some information, the college does not track data at the departmental level by gender. Except for participation in a national pilot survey conducted by the Women in Engineering Programs and Advocates Network (WEPAN) in Spring 1998, college wide data is not routinely collected to assess student views or perceptions. \(^2\) It was therefore necessary to first develop methods for collecting, analyzing, and interpreting data and information, and to establish a methodology for ongoing studies and program development.

This paper describes the initial efforts of a study that was conducted to help the Industrial Engineering Department understand factors that contribute to the relatively low enrollment of females in the program, and to identify steps that the department can take to reduce this discrepancy. The study, which began during Fall Semester 2000, embraces the concept of continuous improvement and is expected to continue over the next several years. The following section describes the methodology.

II. The Methodology

The methodology used in this study is depicted in Figure 1 on the next page. The study began by gathering information to compare the IE program at UMD to similar engineering programs in the region in order to determine if the low female enrollment at UMD is a regional or a departmental attribute. The second step was to identify factors affecting female enrollment and assess student needs using various methods, such as focus groups, self-administered questionnaires, and interviews. Two of these methods were used for the first cycle: a focus group was created during Fall Semester 2000, and self-administered surveys were distributed during Spring 2001.
Next, the institutional resources available to assist women in engineering were identified. The college sponsors a mentoring program that is administered through the office of the college dean, and a student organization, Women in Engineering and Science (WES), sponsors social activities. Although these existing programs may meet the needs of some students, it is possible that new programs may need to be developed to extend the support.

Finally, follow-up studies will be conducted to determine the level of student participation in various programs and to assess the extent to which a program is meeting student needs in order to identify opportunities for improvement. The cycle will be repeated on a continual basis, although the cycle time may vary. At the end of spring semester 2001, the study completed step 3. The first step, regional comparisons, is discussed in the next section.

III. Regional Comparisons

The University of Minnesota Duluth is the only university in Minnesota that offers a B.S. degree in Industrial Engineering, although two other universities in the northern Midwest region, North Dakota State University and the University of Wisconsin Madison, also offer undergraduate IE degrees. Similar engineering programs exist at the University of Minnesota Twin Cities and the University of Wisconsin, Stout, which offer BS degrees in Mechanical Engineering and Manufacturing Engineering, respectively. These programs are similar in terms of their emphasis on manufacturing and mechanical systems. The enrollments at each of these of universities and the percentage of females enrolled in each program are presented in Table 1.
Table 1. Female Enrollment in Comparable Engineering Programs at Regional Universities

<table>
<thead>
<tr>
<th>University/Program (Location)</th>
<th>Total program enrollment</th>
<th>Percentage of females</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Minnesota Duluth/IE</td>
<td>133</td>
<td>12%</td>
</tr>
<tr>
<td>North Dakota State/IE (Fargo, ND)</td>
<td>80</td>
<td>16.25%</td>
</tr>
<tr>
<td>North Dakota State/Manufacturing Engineering. (Fargo, ND)</td>
<td>27</td>
<td>7.4%</td>
</tr>
<tr>
<td>University of Wisconsin Madison/IE (Madison, WI)</td>
<td>225</td>
<td>45%</td>
</tr>
<tr>
<td>University of Minnesota Twin Cities/Mechanical Engr. (Minneapolis, MN)</td>
<td>573</td>
<td>15.5%*</td>
</tr>
<tr>
<td>University of Wisconsin Stout/Manufacturing Engr. (Menominie, WI)</td>
<td>186</td>
<td>10.2%</td>
</tr>
</tbody>
</table>

*The national average for Mechanical Engineering is 13%.

Except for the University of Wisconsin, Madison, the female enrollment at UMD does not appear to be significantly different from the other universities; however, some programs have relatively low total enrollment, so a slight change in the number of women could have a large impact on the percentage of women in the programs. Although purely anecdotal at this point, the three highest percentages of women are enrolled in departments that offer Ph.D.s and are located in more populated areas. It is possible, therefore, that Duluth’s smaller size (88,000) compared to Minneapolis, Madison, and Fargo, may have an effect. Another possible explanation for the relatively low enrollment of women in the IE program at UMD is the number of students who transfer to UMD from the regional community colleges, which tend to have fairly low percentages of females enrolled in the preengineering programs.

The College of Science and Engineering at UMD estimates that 20% of the students in the entire college transfer from regional community colleges. The female enrollment at the community colleges, the pipeline, could impact the number of females enrolled in engineering at UMD. Further investigation, however, showed that female IE students are not recruited from the regional community colleges. Additionally, the survey results from Spring 2001 revealed that approximately 25% of all the students enrolled in IE transferred from other colleges, but only about 20% of these transfer students (or 5% of the total students enrolled in IE) attended the regional community colleges, much lower than the college estimate. Furthermore, approximately half of the females in the IE Department transferred from other institutions, but none from the regional community colleges. The community colleges represent an untapped resource for potential IE students, and Table 2 shows the percentage females enrolled in preengineering programs at these regional community colleges.
Table 2. Percentages of Females Enrolled in Preengineering Programs at Regional Community Colleges

<table>
<thead>
<tr>
<th>Community College</th>
<th>Total enrollment in pre-engineering</th>
<th>Percentage of females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hibbing Community College</td>
<td>27</td>
<td>5</td>
</tr>
<tr>
<td>Itasca Community College</td>
<td>80</td>
<td>18</td>
</tr>
<tr>
<td>Mesabi Range Community College*</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

* Mesabi is in the process of rebuilding their engineering program.

Although the percentage of females at Itasca Community College (ICC) is relatively high, discussions with the faculty member who directs the preengineering program at ICC revealed that many of the students attend North Dakota State University (NDSU) because NDSU heavily recruits from ICC. The other community colleges do not have high percentages of female enrollment, but should not be ignored as a source of potential IE students.

Although regional comparisons may provide some explanation for the low numbers of women enrolled in the IE program, it is only a partial explanation and institutional and departmental factors should still be investigated. One factor may be the strength of the programs that support women in engineering, discussed in the next section.

IV. Programs Supporting Women in Engineering

There is no formal department program that supports women in industrial engineering. Based on the survey results the IE faculty seem to be very encouraging and receptive toward the females, already providing a climate of encouragement and belonging that will serve as a sound basis for developing new programs. The WES student group is not highly publicized and not all of the women in the industrial engineering program are aware of its existence. The college sponsors a mentoring program and two of the female students in industrial engineering have been assigned mentors who are majoring in another engineering field. Both are pleased with the program, saying that it has been very helpful in supporting them with the preengineering courses, particularly Physics and Statics. One other student tried to participate but her mentor wasn’t available most of the time, and when she became a mentor, her “mentee” decided not to pursue engineering. Her experience was not positive and she no longer participates in the program.

The IE Department does not want to duplicate programs that exist at the college level, but we do want to provide opportunities for women in the IE program to get together to discuss issues. Therefore, informal brown bag lunch gatherings began during Spring Semester 2001. The female students were interested in participating in this activity, and it is expected to provide an opportunity to exchange ideas, identify possible activities, and provide an atmosphere where everyone can get together just to talk. Because the brown bag lunches just started this semester, it’s difficult to gage their success. Turnout has been fairly low due primarily to very busy student schedules, but it is hoped that a regularly announced meeting will increase attendance.
In summary, except for the mentoring program, there is no other program that sponsors activities solely for women in engineering. This could be one factor that affects the enrollment, and others are discussed in the following section.

V. Factors Affecting Female Enrollment at UMD

In trying to determine departmental and institutional factors that influence female enrollment in the IE department, previous research results were studied and the students were queried. This section first discusses the previous research results and implications for the IE department. Next, the student input, gathered using both a focus group and surveys, is presented.

Previous Research Results

Previous research has identified various factors that affect the number of women in the engineering profession. One study identified those factors as isolation, the perceived irrelevance of theoretical preparatory courses, negative experiences in laboratory courses, classroom climate, and lack of role models.4 Similar factors were identified by a pilot survey conducted in 1998 by WEPAN which identified, among other reasons, a lack of self confidence and a lack of intrinsic desire to do engineering.5 These findings may also be attributed to external factors such as isolation and campus climate.6 According to a national study conducted by Larry, McClure, and Oaxaca, participation of women in the engineering professions was influenced by self-concept, peer influence, and goal commitment.7 Other studies have suggested that the different learning styles of women may influence their desire to enter engineering.8,9 Finally, another author contends that the problem is the image that engineering is not about helping society, a frequently cited desire of female students.10

Although most of these factors were addressed on the survey administered during Spring 2001, one factor, the lack of role models may be significant. There are 27 tenured and tenure-track faculty in the three engineering departments at UMD: Industrial Engineering, Chemical Engineering, and Electrical Computer Engineering. Each department has one non-tenured woman in a tenure track position, and all three have been in their current positions for less than one year, with two beginning in Fall 2000 and one in Spring 2001. The Chemical Engineering department also has two female instructors with adjunct appointments. Based on a snapshot of the college this academic year, there is a direct correlation between the number of women faculty and instructors, and the number of female students, shown in Table 3.

<table>
<thead>
<tr>
<th>Department</th>
<th>Number/percentage of female faculty</th>
<th>Number/percentage of female students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Engineering</td>
<td>3/43%*</td>
<td>37/29%</td>
</tr>
<tr>
<td>Industrial Engineering</td>
<td>1/14%</td>
<td>16/12%</td>
</tr>
<tr>
<td>Electrical Computer Engineering</td>
<td>1/8%</td>
<td>5/3%</td>
</tr>
</tbody>
</table>

*Two of the faculty members hold adjunct appointments.
The figures in Table 3 clearly indicate a lack of role models, and support the research findings that correlate role models and female enrollment in engineering.

Previous research has identified other factors that may also help explain the low enrollment of females. To solicit student response regarding these other factors, a focus group meeting was held and surveys administered. The next section describes the focus group meeting.

Focus Group Meeting

Near the end of the Fall Semester 2000, an informal meeting was held to discuss the relatively low numbers of women enrolled in the program. Before the meeting, all students were contacted via e-mail to explain the faculty’s concern and to begin plans for an initial meeting. All students had an opportunity to choose the best meeting time, and to provide comments and input prior to the meeting. Although free pizza was provided as an incentive, twenty-two students out of the total 133 enrolled in the program attended the first meeting, and seven of the sixteen women enrolled in the program were in attendance. This group formed the basis of the initial focus group.

The first meeting began with an overview of enrollment statistics, comparing UMD to the national average. The students wanted to understand precisely what was meant by “enrollment”, so an explanation of entry, graduation, and total enrollment measurements were presented. Satisfied that everyone understood the enrollment issue, students wanted to know how UMD compared to regional universities and community colleges. This concern was somewhat surprising, but refreshing in the sense that the students wanted to understand the context in which this issue was raised and the extent to which UMD was different than surrounding institutions.

The three factors raised immediately by the students were the role of the high school guidance counselors, the culture/attitude of northern Minnesota society, and the rural nature of northern Minnesota. First, the majority of the students indicated that their high school guidance counselors did not steer them toward engineering, an experience strongly confirmed by the women. This conclusion was also reinforced by the results of the survey administered during Spring 2001. Second, students felt that people living in northern Minnesota were less accepting of women in engineering, and that this attitude may be due, in part, to the rural nature of the region. (This view has been echoed by two senior women engineers who are employed in the engineering field in the Duluth area, although this observation was not shared with students at the meeting.)

The students unanimously agreed that the IE program was not well advertised, and that the department could do a much better job of publicizing the program. Although these factors are not confined to deterring women from engineering, increased visibility could influence any student’s decision to pursue an IE degree and serve to attract more female students to the program. The students also noted that this lack of public awareness is promulgated by three other factors: the physical location of the department, the lack of awareness of the campus tour guides, and the lack of public outreach between UMD and the community. The physical location is somewhat isolated, as IE department is located in the last building at the far east end of campus, just beyond the point where the campus tour returns to the administration building. The
campus tours always stop at the entrance to the building, as a convenient round trip path is located at this spot. The tour guides never venture further.

The tour route is a simple problem to solve, but the lack of public outreach is an issue that requires a longer-term solution involving institutional support. It seems reasonable, however, that a campus-wide engineering event which showcased student talents and skills would help student perceptions of what industrial engineers do, and help recruit women who see other women involved in this event.

Prior to the first focus group meeting, a faculty member suggested that the lab-intensive courses deterred female students from the program. When this possibility was raised at the meeting, it was met with a resounding "No!" The women all indicated that the laboratory courses served to increase their level of confidence, although they were intimidated at first. About 25% of the male students also said they were intimidated at the beginning of a laboratory course. This response is supported by previous research\textsuperscript{11}; however, research also indicates that a negative laboratory experience deters women from engineering.\textsuperscript{12}

The majority of the students would like to have known more about what an industrial engineer does, as this would have made the field more attractive to them when they were deciding on an engineering field. There was unanimous agreement that proper advising before freshman enrollment is very critical because poor advice can not only cause slower matriculation, but may result in choosing another area of engineering.

Finally, the facilitator raised the issue of campus climate. Two female participants felt that some teachers are less tolerant of the females and conveyed a belief that women are "slower" at math than their male counterparts, perhaps feeling intimidated by women who understand math. Another female participant, however, countered this perception, by suggesting that some teachers favor female students. Survey results seem to indicate a positive campus climate, however.

In summary, the first meeting was successful in terms of "breaking the ice," involving students in this process, and developing a rapport for future discussions. It also helped to identify departmental and institutional issues related to advising and public outreach/advertising. However, the effect of these factors on female enrollment is not clear and students did not raise other factors that have been shown to affect female enrollment.

The first focus group meeting also did not touch on the issue of retention, although several female students had raised this concern privately. Apparently, one student knew of one woman who had left the IE Department because of the "climate," although she did not provide any details. Another concern, therefore, is to consider the retention of females in the Industrial Engineering Department.

Retention of Females in Engineering at UMD

It is very difficult to determine how many women leave engineering in the first two years because it is only after the second year that students declare a major in engineering, creating an institutional record of a change in major. Although a freshman level course is required of all
students who want to major in industrial engineering, statistics regarding matriculation and the progress of males and females in engineering is not collected.

The college does, however, gather data that indicates when students change majors or colleges. This information is not kept past two years, and it is not recorded at the departmental level or inspected for gender differences. Therefore, sifting through this information to obtain retention data by department and gender is fairly time consuming and may prove to be a cumbersome task if repeated on an annual basis. Nevertheless, based on the last two years of data, 10 males (4.1%) and 1 female (0.4%) have left the IE program, and 29 males (11.8%) and 6 females (2.4%) have transferred into the IE program from other majors. These statistics indicate that retention of females is not a serious problem, at least during this two-year time frame; however the IE Department may want to address the loss of the male students, which seems high. Nevertheless, the next step was to administer a survey to the IE students to try to identify factors affecting female enrollment, including the department climate. These results are discussed in the next section.

Survey results

An annotated version of the survey is presented in the appendix. The survey questions were selected on the basis of previous research, including questions related to factors that affect female enrollment in engineering. Several questions mirrored those asked on the WEPAN survey in 1998 in order to make national and college-wide comparisons, as UMD participated in the pilot survey in 1998. Other questions reflect the interests of the IE Department, and all faculty provided feedback and input for the survey. All questions were rated on a 5-point Likert scale, and higher scores indicate a greater degree of an affirmative response than a lower score. The responses to most questions ranged from “Not at All” to “Very Much”, although some used different descriptors, shown in the appendix.

The survey was administered to five IE classes in order to capture the responses of students who are freshmen, sophomores, juniors, and seniors. Of the 133 students enrolled in the program, 91 were surveyed. Of these 91, 80 were males and 11 were females. The total population of males is 117, and the total population of females is 16. Due to the small population sizes, finite population correction factors were applied where appropriate.

The most surprising result of this survey is that there was a statistically significant difference between the average female and male response on nearly every question. This significance was due to the relatively large portion of the two populations – male and female – included in the survey. Although this may arise questions of validity, useful information is still provided from the survey.

Table 4, which begins on the next page, lists the top 20 questions that resulted in the greatest divergence between female and male responses, providing the average responses of each group. The difference between the responses has a level of significance of at least .0005, and is based on the t-statistic adjusted for a finite population, assuming unequal variances and ten degrees of freedom. The last column of Table 4 also presents the responses from the engineering students at UMD who took the national WEPAN survey during spring 1998 in order to provide a basis for
The institutional results showed no significant differences between male and female responses except for financial support. Furthermore, comparison between these institutional results and the survey conducted within the department is somewhat difficult because only 52 students responded to the WEPAN survey, of which 15 of were Industrial Engineering majors.

Table 4. Responses with Significant Differences between Male and Female Students Enrolled in Industrial Engineering Courses at the University of Minnesota Duluth, Spring Semester 2001.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Question</th>
<th>Avg. response (female)</th>
<th>Avg. response (male)</th>
<th>Avg. female/male response from 1998 WEPAN survey of engineering students at UMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How confident are you in your college abilities in your college math and statistics courses?</td>
<td>4.45</td>
<td>3.79</td>
<td>Asked only about math courses: 3.94/3.95</td>
</tr>
<tr>
<td>2</td>
<td>To what extent do you feel your professors in IE care whether or not you learn the course material?</td>
<td>4.09</td>
<td>3.35</td>
<td>Asked about professors in general: 3.61/3.43</td>
</tr>
<tr>
<td>3</td>
<td>How comfortable are you meeting with your professors outside of class for academic assistance? (within the Industrial Engineering Department)</td>
<td>4.45</td>
<td>3.77</td>
<td>Not asked (NA)</td>
</tr>
<tr>
<td>4</td>
<td>What is the overall quality of teaching you have received in your college physics courses?</td>
<td>3.00</td>
<td>2.43</td>
<td>1.82/2.21</td>
</tr>
<tr>
<td>5</td>
<td>I am interested in participating in activities that help recruit new students in the IE program</td>
<td>3.09</td>
<td>2.35</td>
<td>NA</td>
</tr>
<tr>
<td>6</td>
<td>How comfortable are you meeting professors outside of class for academic assistance? (outside of the Industrial Engineering Department)</td>
<td>4.09</td>
<td>3.47</td>
<td>4.32/3.86</td>
</tr>
<tr>
<td>7</td>
<td>Since entering college, has your self-confidence in math: (decreased – increased)</td>
<td>3.91</td>
<td>3.37</td>
<td>3.94/3.95</td>
</tr>
<tr>
<td>8</td>
<td>How active are you in student professional societies and engineering related activities?</td>
<td>2.64</td>
<td>1.91</td>
<td>2.48/2.60</td>
</tr>
<tr>
<td>9</td>
<td>The following people encouraged me to pursue an Industrial Engineering degree: IE faculty member or IE advisor</td>
<td>3.40</td>
<td>2.74</td>
<td>NA</td>
</tr>
</tbody>
</table>
Table 4. Continued

<table>
<thead>
<tr>
<th></th>
<th>Since you entered college, has your overall academic self-confidence: (decreased – increased)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td></td>
<td>3.91</td>
<td>3.35</td>
</tr>
<tr>
<td>11</td>
<td>What is the overall quality of teaching you have received in your college math and statistics courses?</td>
<td>3.80</td>
<td>3.26</td>
</tr>
<tr>
<td>12</td>
<td>How involved are you with study groups in your IE courses?</td>
<td>2.82</td>
<td>2.24</td>
</tr>
<tr>
<td>13</td>
<td>How productive do you feel when working in a group lab setting?</td>
<td>4.10</td>
<td>3.72</td>
</tr>
<tr>
<td>14</td>
<td>How confident are you in your abilities in your college physics courses?</td>
<td>2.90</td>
<td>3.32</td>
</tr>
<tr>
<td>15</td>
<td>The following people encouraged me to pursue an Industrial Engineering degree: My friends</td>
<td>2.40</td>
<td>1.88</td>
</tr>
<tr>
<td>16</td>
<td>Do you feel that you know more than your grades reflect in IE courses?</td>
<td>3.09</td>
<td>3.54</td>
</tr>
<tr>
<td>17</td>
<td>I am interested in participating in activities that will help me get to know other IE students better</td>
<td>3.73</td>
<td>3.29</td>
</tr>
<tr>
<td>18</td>
<td>Do you feel that you know less than your grades reflect in IE courses?</td>
<td>1.45</td>
<td>1.77</td>
</tr>
<tr>
<td>19</td>
<td>Are you confident that industrial engineering is the right major for you?</td>
<td>4.09</td>
<td>3.74</td>
</tr>
<tr>
<td>20</td>
<td>How satisfied are you with the assistance you receive outside of class from professors? (within the Industrial Engineering Department)</td>
<td>3.82</td>
<td>3.44</td>
</tr>
</tbody>
</table>

There are some differences in the results of the departmental survey and both the national results of the WEPAN Pilot Climate Survey and the institutional results from the same survey. For example, the overall academic self-confidence of females was, on average higher than the males. This finding is inconsistent with the national and institutional survey results. Second, when asked if Industrial Engineering was the right major, the average female response was also higher than the average male response, just the opposite of the national survey results. Finally, when asked how comfortable the student felt asking questions in class, the female average response was 3.36 compared to the male response of 3.14; when asked about comfort level in asking questions in their IE classes, there was no difference, with average responses of males of females being 3.64 and 3.63 respectively. The national results indicated just the opposite, with males tending to be more comfortable asking questions in class.

In other areas, the departmental survey was consistent with the results of the national WEPAN survey. For example, the WEPAN survey indicated a significant difference between males and females in terms of their comfort with lab equipment. The results of the departmental survey
also found this to be true, with an average female response of 3.55 and an average male response of 3.86, a statistically significant difference. Departmental survey results were also consistent with the national WEPAN results regarding confidence in Physics courses, with an average female response of 2.90 and male response, 3.32. The level of confidence in engineering courses (defined in the departmental survey as non-IE courses) was also consistent with national results, with an average female response of 3.45 and an average male response of 3.71.

One important result of this survey is the disparity in the responses of males and females with respect to the quality of teaching in both Physics and Math/Statistics courses. Due to the relatively higher percentage of female students who transferred into the IE Department, it is likely that they did not take their Physics or Math courses at UMD. It may be the case that the perceived difference in the quality of teaching is due not to gender, but to educational institution.

In summary, the female students tend to be more comfortable asking questions in class than the males, and they tend to believe that the professors care more than the males about whether or not they learn the material. They are also more comfortable meeting professors outside of class and are more satisfied with the assistance they receive from professors. The females tend to be more involved with study groups, are more interested in participating in activities that will help them to get to know other IE students better, and were more encouraged by IE faculty or IE advisors and their friends to pursue an IE degree than their male counterparts. Unlike males, the female students tend to believe that their grades are a better reflection of their knowledge. The female students are more involved in social activities and may possess more of the social skills that support their comfort level when meeting with professors, asking questions, and participating in classes, study groups, and professional activities.

These results can be used in several different ways to help identify areas of improvement. One method is to identify areas where there are significant differences in male and female responses, and another is to identify areas where the response is lower than a target. For example, an average response between 4 and 5 may be acceptable, but anything lower may indicate an area that needs improvement. When asked to what extent lab work was valuable, the average response of female students was 3.91 compared to the male response of 3.84. Perhaps the IE Department could engage in efforts of making lab work more relevant or valuable to the students. These decisions will be made and prioritized within the IE Department, being part of the cycle of continuous improvement.

In terms of increasing female enrollment, the survey results may provide some guidance. For example, when the students were asked about the level of encouragement (not at all to very much) given by high school guidance counselors to pursue engineering, the average female response was 1.82 compared to an average male response of 2.18, a statistically significant difference. Similarly, a high school teacher was more likely to encourage a male student to pursue an industrial engineering degree compared to a female student (average responses of 1.92 and 1.70 respectively). Not only is the encouragement between male and female students significantly different, it is relatively low for both groups. One strong recommendation is to work with high schools to promote both engineering and industrial engineering education. Other recommendations are presented in Section VI.
VI. Follow-up Studies and Activities

The survey results indicate that the Industrial Engineering Department is doing a fairly good job of retaining female students; however, improvements can be made in terms of recruiting new students, particularly from the regional community colleges.

Specifically, several activities should be pursued at both the college and departmental level:

- Recruit students from the regional community colleges.
- Visit high schools to encourage students to pursue an engineering degree and to educate guidance counselors, and science and math teachers about career opportunities in engineering.
- Increase the exposure of the IE department through advertising, community outreach, and sponsored activities, including IE students in these efforts if they are interested.
- Investigate the possibility of developing K-12 outreach programs such as summer camps and mentoring programs.
- Continue the brown bag lunches and try to include more female students.
- Collaborate with WES to sponsor activities for female engineering students.
- Work with the campus freshman advisors to assist them with advising potential engineering students.
- Work with the campus tour guides to help them understand the types of projects performed in the engineering departments, and how the facility supports those projects.
- Conduct surveys or interviews in other departments at UMD to try to determine why female students who are capable of pursuing an engineering degree decide to pursue other degrees instead.
- Continue to gather information and statistics to assess the changes in enrollment and retention of female IE students, as well as their needs.
- Gather data to determine the number of women enrolled in freshman courses who have not declared a major in industrial engineering in order to identify problems with retention prior to the sophomore year.

The IE Department may also wish to address issues associated with the climate, particularly with respect to the laboratory courses where there is a divergence between male and female responses. As in the national survey results, the female students are less comfortable with the lab equipment, but support additional lab work to help overcome their lower confidence level. Unlike males, they feel more productive in the group lab setting. The IE Department may also want to consider the assistance provided to students outside of class, as the average responses of males and females were both less than 4.0.

These activities require the support and participation of all the department members and the support of the college, so it will be essential to garner this support. There is a commitment to diversity issues within the college, but the extent of the support that may be available to support a new initiative is not clear, as no proposals have been developed at this time. The purpose of this study, investigating the ways to increase female enrollment in Industrial Engineering, has now progressed to the stage of developing new programs, which will be pursued in the next several months.
VII. Conclusion

Although the issue of relatively low female enrollment in the Industrial Engineering program is easily stated, it is not easily studied or resolved. Baseline information is somewhat difficult to obtain, as the college does not collect detailed data at the departmental level. It’s much too easy to “lose” students during their first two years before they declare a major in engineering. Also, the low numbers of women in engineering, in general, and industrial engineering in particular, provide too few colleagues and role models for new female engineering students to turn to for support.

In spite of these conditions, however, a continual effort that seeks to understand the student issues and address these needs is a necessary first step. The good news is that the IE Department is encouraging the female students, and the female students feel comfortable asking questions and meeting professors outside of class even more than the male students. On the other hand, few female students are recruited from the student body at UMD, the majority transferring in from other institutions, and even fewer are recruited from the regional community colleges.

The next step of this process is to use the results from the departmental survey to develop a recruitment and improvement plan. This will require prioritization of the activities suggested in the previous section and a commitment by the department and the college. The Industrial Engineering Department will continue to gather data and information in order to target areas that have been improved and those that still need to be addressed. These additional steps will also help to refine and develop the methodology that is outlined at the beginning of this paper, hopefully assisting other departments who also face low or declining female enrollment, as it is this author’s belief that a departmental understanding and willingness to address this issue is a vital step in improving the educational climate in engineering for all students.

Bibliography

2. The college surveys new students every year to determine how they are adjusting, factors affecting academic performance, and future plans.

MARTHA WILSON
Martha Wilson is an Assistant Professor in the Department of Industrial Engineering at the University of Minnesota Duluth. Dr. Wilson received her B.S. degree in Industrial Engineering from Ohio State University, an M.S. degree in Mineral Economics from the Colorado School of Mines, and a Ph.D. in Industrial Engineering from the University of Washington.
APPENDIX: Survey questions.

This is an annotated version of the survey. The scales have been omitted due to the space constraints. However, the beginning of each section indicates the extreme responses on the 5 point Likert scale that was used.

1. How many semesters have you attended UMD, including this semester? ________

2. Did you transfer to UMD from another school? YES NO

   If you answered YES, when did you transfer? _________________

   If you answered YES, from where did you transfer? _____________________________________

3. Are you male or female? M F

4. Circle the class that best describes your progress at UMD: Freshman Sophomore Junior Senior

This section refers to the quality of courses that you have taken OUTSIDE the Industrial Engineering Department.

<table>
<thead>
<tr>
<th>Scale for question 5: 1=poor, 5 = excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale for questions 6 through 13: 1 = not at all, 5 = very much</td>
</tr>
</tbody>
</table>

5. What is the overall quality of teaching you have received in your college:

   a. math and statistics courses?
   b. physics courses?
   c. engineering courses? (non-IE, e.g. Statics, Dynamics, Mechanics of Materials, E-power)
   d. chemistry courses?

6. Do you feel that you know more than your grades reflect in non-IE courses?

7. Do you feel that you know less than your grades reflect in non-IE courses?

8. How satisfied are you with the assistance you receive outside of class from professors?

9. How comfortable are you meeting professors outside of class for academic assistance?

10. How comfortable do you feel asking questions in class?

11. How confident are you in your abilities in your college:

   a. chemistry courses?
   b. physics courses?
   c. engineering courses (non-IE)?

12. To what extent do engineering students compete against each other in class?

13. How involved are you with study groups in courses outside the IE Department?

This section refers to the quality of courses that you have taken WITHIN the Industrial Engineering Department.

<table>
<thead>
<tr>
<th>Scale for question 14: 1 = poor, 5 = excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale for questions 15 through 27: 1 = not at all, 5 = very much</td>
</tr>
</tbody>
</table>

14. What is the overall quality of teaching you have received in your IE courses?

15. To what extent do you feel your professors care whether or not you learn the course material?

16. Do you feel that you know more than your grades reflect in IE courses?

17. Do you feel that you know less than your grades reflect in IE courses?

18. How satisfied are you with the assistance you receive outside of class from professors?

19. How comfortable are you meeting professors outside of class for academic assistance?

20. To what extent is your lab work valuable?

21. How much does lab work add to your understanding of course material?

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22. How well are lab experiments and/or exercises explained prior to labs?
23. How comfortable are you when using lab equipment?
24. How well are lab responsibilities shared equally among lab group members?
25. How productive do you feel when working in a group lab setting?
26. Would you like to see the number of IE labs increased?
27. Would you like to see the number of IE labs decreased?

General Questions.

Scale for question 28 through 38: 1 = not at all, 5 = very much
Scale for questions 39 through 41: 1 = decreased, 5 = increased, 3 = stayed the same

28. How comfortable do you feel asking questions in your IE classes?
29. How confident are you in your abilities in your IE courses?
30. How involved are you with study groups in your IE courses?
31. How much do/would you like to be involved with study groups in your IE courses?
32. Do you have a mentor (formal or informal) among the IE faculty?
33. To what extent do IE students compete against each other in class?
34. How confident are you in your abilities in your IE courses?
35. How confident are you in your overall academic ability?
36. Do you feel overwhelmed by your overall course workload?
37. Were you encouraged by others to pursue an industrial engineering degree?
38. Are you confident that industrial engineering is the right major for you?
39. Since you entered college, has your self-confidence in math:
40. Since you entered college, has your self-confidence in science:
41. Since you entered college, has your overall academic self-confidence:

Involvement in student activities

Scale for questions 42 through 44: 1 = not at all, 5 = very much

42. How well are you informed of student professional societies and engineering related activities? (for example, IIE, ASME, Tau Beta Pi)
43. How active are you in student professional societies and engineering related activities?
44. I am interested in participating in activities that:
   a. Help recruit new students in the IE program
   b. Showcase student projects and talents to the public
   c. Will help me get to know other IE students better
   d. Will help me get to know the IE faculty and staff better

The following people encouraged me to pursue an Engineering degree

<table>
<thead>
<tr>
<th></th>
<th>Not At All</th>
<th>Very Much</th>
</tr>
</thead>
<tbody>
<tr>
<td>My parents</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Other family members</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>My friends</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>High school teacher(s)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>High school guidance counselor</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>IE faculty member or IE advisor</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>A faculty member outside of IE Dept</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>An orientation advisor</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
The following people encouraged me to pursue an **Industrial Engineering** degree

<table>
<thead>
<tr>
<th></th>
<th>Not At All</th>
<th>Very Much</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1 2 3 4 5</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>An orientation advisor</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

How did you find out about industrial engineering?

Did you attend UMD specifically to pursue a degree in IE? YES NO

If you answered NO, how did you find out about IE?