QUALITY OF ENGINEERING EDUCATION ASSESSMENT AT THE UNIVERSITY OF WASHINGTON

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ABSTRACT

This paper presents the findings from a survey designed to assess the quality of engineering education at the University of Washington. The findings from our study indicate that there is still work to do to improve the quality of engineering education as perceived by students. Significant index differences were found between males and females on their ratings of teaching quality, department assistance or lab quality, although the lower average rating for females in lab quality nearly reached significance. However, both males and females rated most items in the middle of a 1-5 scale.

I. INTRODUCTION

In the US, as in most other countries, the field of engineering has been traditionally occupied by men. However, demographic trends indicate that by the year 2000 sixty-eight percent of the new entrants into the US labor force will be women and minorities.[1] Led by government and industry, this reality has manifested itself in a national movement to encourage educational institutions to increase the numbers of women and minorities pursuing careers in engineering.[2]

Statistics compiled over the last two decades reflect the status of women in engineering. The percentage of first year female undergraduates in engineering increased from 8.9% (6,730) in 1975 to 17% (18,689) in 1983.[3] However, the next seven years yielded mostly stagnant numbers and some decline. In 1990, female freshmen in engineering regained some momentum and the percentage increased from 17.7% (16,674) to nearly 19% in 1995, by slight but consistent annual increases.[4] However, women received only 17.4% of the baccalaureate degrees, 16.7% of the masters degrees and 12.1% of the doctoral degrees in engineering in 1995.[5] These figures impact our workforce substantially. Women are 9% of all working engineers this year.

Why are women still underrepresented in engineering? The research indicates that women's educational experiences differ considerably from men, even when they attend the same institutions and the same classes. Many factors, including family and social and academic expectations, contribute to the continuation of these differences.

II. FACTORS AFFECTING THE UNDERREPRESENTATION OF WOMEN

Women drop out of engineering at higher rates than men.[6] The persistence rates of men in science, math and engineering majors varies between 39 to 61 percent and for women 30 to 46 percent, depending upon the type of institution.[7] Seymour found that women in general may not be well served by engineering education as it presently stands. In the last few years, the post-secondary community has begun to consider the importance of faculty, peer and teaching assistants' behaviors in creating an institutional climate that fosters the full development of female as well as male students.

In a 1984 study on the academic climate in university classrooms, Hall and Sandler identified several factors contributing to a chilly climate. The chilly climate is characterized by seemingly insignificant behaviors that either single out, or ignore and discount individuals because of sex, race or age.[8] For example, female students are less likely to be asked to lead project teams than male students, and female students are more frequently interrupted in class. While any of these behaviors in and of themselves may seem like insignificant incidences, when experienced on a continuous basis, they create a climate that makes it more difficult for female students to succeed.

Subsequent studies have been conducted to test the validity of Hall and Sandler's findings. Foster surveyed men and women students at a Midwestern college regarding thirty-three of the behaviors Hall and Sandler cited. The results of the survey confirmed a number of chilling practices with women reporting higher frequencies than men.[9] Both men and women recognized the chilling practices, though women viewed the behaviors as more important in their ability to feel confident and able on campus.

Crawford and MacLeod report that low self-esteem inhibits the performance of women in all fields in higher education.[10] Female students tend to feel less confident of their intellectual abilities and tend to feel they must be very prepared and know a great deal before expressing their ideas in class. Women often do not interact in classrooms out of fear that they "might appear unintelligent in the eyes of other students."[11] Men more often report that they fail to participate because they "have not done the assigned readings." These findings reflect the research that has been done on young girls and boys in elementary school where boys are criticized for being sloppy, lazy or misbehaving, while girls are criticized when they make an academic error. In other words, girl's abilities and intellect are questioned, whereas boy's "efforts" are questioned. Crawford and MacLeod recommended that instructors be more aware of gender differences and use sensitive classroom strategies to create a "student-friendly" climate for both genders.

Seymour and Hewitt found that women feel as though their opinions are discounted in the classroom, which lowers their perceptions of their abilities.[12] Rayman and Brett also found that women have lower self-confidence, perceived ability, and self-reliance than men.[13] Examples of negative faculty interactions with female students include: giving women less time and attention than men in and out of class; frequently interrupting women; giving minimal responses to or ignoring entirely women's questions.[14] Because of differential treatment from faculty, Blaisdell noted that often women experience a “learned helplessness.”[15] For example, professors will allow men to complete a task or problem, while they will “just do it” for female students.

Further studies indicate that a range of covert and overt behaviors continue to contribute to the chilly climate, especially for women who pursue engineering degrees. Small but consistent messages and behaviors reinforce sexist expectations and decrease women’s overall sense of self-competence in undergraduate classrooms.[16] Fischer and Good, for example, found that when both male and female students have more male instructors and more male peers, their perception of the absence of women’s research and publications in mainstream academia can be significantly predicted.[17] The researchers suggest that male instructors may be “less likely than female instructors to be aware of the historical neglect of women’s contributions and less likely to rectify the situation.”[18] They also surmised that instructors of either sex, when faced with a class that is proportionately more male, feel less inclination to make an effort to include women’s scholarship resulting in an “inadvertent perpetuation of the status quo.”[19]

Other factors contributing to a negative environment include pedagogical methods and faculty interactions with students. Rosser argues that traditional teaching uses a certain perspective which does not relate to women students. Since most scientists, mathematicians and engineers in the U.S. are white, middle- to upper-class and male, curricular and teaching techniques reflect their perspective on the physical natural world and technology.”[20] Studies have found that this might be disadvantageous to female students who perform better under different conditions.[21] For example, Rosser suggests that instead of using bombs dropping to illustrate gravity, care packages dropping from airplanes would be examples understood by both women and men.

Particularly in science and engineering, male graduate students are frequently teaching assistants in the lower level courses. Although little data exists, it has been estimated that between 30% and 50% of an undergraduate’s contact hours in the freshman and sophomore years at research universities are with teaching assistants.[22] More than half of the graduate students receiving financial support from university engineering departments are foreign nationals.[23] The Task Force on Women, Minorities, and the Handicapped in Science and Technology reports that the presence and different cultural attitudes of foreign students, particularly as teaching assistants, “may even discourage some Americans, such as women, from taking science and engineering courses.”[24]

Research indicates that the largest drop out rate for women is at the end of the freshman year and beginning of sophomore year. A five year longitudinal study of female undergraduates in engineering has found that the primary reasons for switching are a combination of losing interest in science and engineering, being attracted by another field, and being discouraged by academic difficulties and low grades.[25] Not surprisingly, the reasons for leaving are also the most frequently reported concerns or barriers to progress reported by women students who persist: fear of losing interest, intimidation, lack of self-confidence, poor advising, and not being accepted in their department.

Gender stereotyped roles continue to appear in other arenas as well. Ginorio suggested that students of color may feel that the rigors of science and engineering conflict with their responsibilities to their community and family.[26] Because the workload and competition are so intense, they may no longer have as much time to spend with their community and family. Instead, they conform to a scientific identity that is mainly white in an effort to be a part of the science community. Ginorio describes an alternative scenario in which students' involvement in their communities of origin and their loyalty to their families would be perceived as strengths, not as weaknesses of character.

III. WHAT IS BEING DONE

In an effort to address the underrepresentation of women in engineering, institutions across the US have implemented university-level programs to increase enrollments and degrees granted for women. Often isolated, these programs, in most cases, represent marginal attempts by institutions to effect a transformation in the climate for women in engineering.[27] There are exceptions to this at institutions where there is commitment from the top administration and where a systemic approach involving faculty, students, and staff is implemented to effect change in the climate.

Even with a surge in growth of these programs over the last six years, there is only a 6% increase in enrollments and 2% increase in degrees awarded to women in engineering[28]. Although a relationship has been found between the number of degrees granted to women and institutions with women in engineering programs, this relationship does not imply that the latter necessarily directly leads to more degrees granted.[29] Institutions with programs have found that the total enrollments and degrees granted to women in engineering have plateaued between 20-25 percent and 16-18 percent, respectively.

The National Science Foundation, other federal agencies, and private organizations have taken a leadership role in proposing and examining systemic change in higher education. With their combined support over a series of years, WEPAN - Women in Engineering Program Advocates Network - was established. WEPAN, a non-profit educational organization, was founded in 1990 in order to effect a positive change in the engineering infrastructure, in which the academic and social climate becomes conducive to women in engineering. To do this, technical assistance and training are offered to colleges and universities to initiate or expand women in engineering and science programs focused on recruitment and retention at the pre-college, undergraduate and graduate levels.

According to a study conducted by the Engineering Workforce Commission of the American Association of Engineering Societies (AAES), the year of WEPAN's inception marked the start of an upward trend of women in engineering.[30] Since that time, there has been a one-half percent increase annually. By contrast, in the eight years prior to the creation of WEPAN, the number of women in engineering stagnated and some decline was evident.

In order to further increases in the enrollments and degrees awarded to women in engineering, positive change in the academic and social climate for male and female students in science and engineering, will need to occur. As a first step to encouraging incentives for change, a few educational institutions have conducted surveys to assess the climate for women in science and engineering, including: University of Michigan, Michigan Technological University, Southeastern University, New Jersey Institute of Technology, University of Arizona, Pennsylvania State University, Clarkson University, Texas A&M University, and Iowa State University. The primary objectives of the surveys are to determine if there are differences between male and female faculty and students in their perceptions of the academic climate, and if so, to identify factors that need to be addressed to improve the climate for both males and females.

At the University of Washington (UW), the Women in Engineering Initiative was established in 1988 to increase the participation of women in engineering. With intervention programs that range from peer tutoring and mentoring to graduate programs and international exchanges, women who study engineering at the UW have access to a comprehensive set of academic and retention programs. Each of the programs are evaluated to measure the effectiveness in increasing the retention of students. Although specific gains in retention have been realized, no measure of the overall climate for male and female students had been made.[31] Consequently in 1993, a climate survey was designed and administered in the College of Engineering to assess the quality of engineering education as perceived by male and female students.

The survey was designed by Brainard, director of Women in Engineering and affiliate faculty in Women Studies, and Gillmore, director of the Office of Educational Assessment and was administered in 1993, 1994, 1995 and 1996. With plans to continue administering the survey annually through the year 2000, the objectives are to:

- Evaluate the climate in engineering and the quality of engineering education to determine if there are differences between male and female students in their perceptions of barriers to successful completion of an engineering degree;
- Identify factors in engineering that need to be addressed to improve the climate for both male and female students;
- Propose strategies to the dean of engineering for increasing the recruitment and retention of women and minorities in engineering.

IV. METHODOLOGY

Building on the factors identified in the literature, a survey was designed to include questions that related to the barriers and challenges faced by women. After the survey was designed, it was then pilot-tested on two groups of undergraduate students. Modifications were made to the survey based on student suggestions. The survey includes the following major categories:

- Quality of Engineering Teaching Assistants
- Quality of Teaching in Engineering
- Quality of Engineering Labs
- Quality of Engineering Departmental Assistance
- General information about text books, computing labs, study groups etc.
- Demographic information

The survey is administered once each year. It is mailed to the students' local addresses and includes a cover letter from the dean of engineering stating the objectives of the survey and assuring the students of the confidentiality of their responses. Follow-up e-mails and postcards are sent about three weeks after the original mailing.

The survey is sent to all female and minority students and a random selection of an equal number of male students who are juniors and seniors in the College of Engineering. With an average of 220 responses each year, the survey is analyzed by gender, department, ethnicity and several other variables.

Table 1
Response Rates by Year

Year	Surveys Mailed	Surveys Received	Response Rate
1993	682	283	41.5%
1994	676	233	34.5%
1995	570	136	24.0%
1996	624	226	36.2%

The survey instrument contains 49 questions; 43 attitudinal and 6 demographic. To empirically determine the structure of the instrument, a principle components factor analysis, followed by a varimax rotation, was applied to the attitudinal item data. The five factor solution made most sense in terms of item content. However, the items loading most highly on one of the factors did not seem to be of homogeneous content and were broken into three smaller scales. The items of the resulting eight scales are found in Table 2, along with the reliability (Cronbach's Alpha) of each. One can see that the number of items in each scale ranged from ten to two, and the reliabilities ranged from .81 to .50. Four items were of idiosyncratic content and failed to load on any factor. These results are not reported here.

Table 2
The Scales
(Negatively worded items in italics)

Scale 1. Teaching Quality (Alpha = .79)
1. What was the overall quality of the teaching you have received (1 = poor, 5 = excellent)
2. How enthusiastic are the professors in their teaching?
3. How much do professors add to the course above the course text?
4. To what extent do you feel your professors care whether or not you learn the course material?
5. *To what extent do you feel your professors place more value on their research than teaching?*

6. How often are you treated with respect by your professor?
7. *To what extent do you feel professors presume you have a lower ability than you actually have?*
8. *To what extent do professors set office hours and not keep them?*
9. *To what extent do professors set office hours and then discourage you from attending them?*
10. How satisfied are you with assistance you receive outside of class from professors?

Scale 2: Lab Quality (Alpha = .79)

1. To what extent is your lab work valuable?
2. How much does lab work add to your understanding of the course material?
3. How well are lab experiments explained prior to labs?
4. How comfortable are you when using lab equipment?
5. How effective are lab manuals in helping you perform a lab assignment?
6. How well are lab responsibilities shared equally among lab group members?
7. How productive do you feel when working in a group lab setting?
8. To what extent would more labs be worthwhile?

Scale 3. Teaching Assistants (Alpha = .81)

1. How effective are your TA's in teaching?
2. For those TA's who are not native English Speakers, to what extent is it a problem?
3. How effective are our TA's in communicating with you?
4. How competent do you feel your TA's are in the subjects they are teaching?
5. How satisfied are you with the assistance you receive from TA's?
6. Do you feel TA's are available enough hours?

Scale 4. Department Assistance (Alpha = .72)

1. How effective is your department in scheduling courses?
2. How satisfied are you with the assistance you receive from departmental advisors?
3. How much assistance do you receive from your department when problems arise?
4. How well are you informed of professional societies and engineering related activities?

Scale 5. Competition (Alpha = .59)

1. To what degree do you feel your grades reflect your knowledge of course material?
2. To what extent do you feel overwhelmed by the fast pace and heavy work load?
3. To what extent does the competition in your departmental classes positively impact you?
4. To what extent does the competition in your departmental classes negatively impact you?

Scale 6: Intrinsic Interest (Alpha = .50)

1. To what extent do you feel a non-technical major offers a better education?
2. To what extent do you feel you were influenced by others to pursue an engineering degree?
3. To what extent do you feel you had an intrinsic interest in studying engineering?

Scale 7. Study Groups (Alpha = .72)

1. How involved are you with study groups?
2. How much would you like to be involved with study groups?

Scale 8. Student/Teacher Interaction (Alpha = .56)

1. How comfortable are you seeing professors after class during their office hours?
2. How comfortable do you feel asking questions in class?

There is one notable limitation to this study. The subjects included only juniors and seniors in engineering. At the University of Washington, students are in the College of Arts & Sciences during their freshmen and sophomore years taking the prerequisites courses in chemistry, physics and mathematics. At the end of their sophomore year, they apply to specific departments in the College of Engineering and enter in their junior year into the engineering curriculum. A great deal of anecdotal evidence exists that once students, male or female, are accepted into engineering in the junior year, the drop-out rate decreases dramatically. At UW, it is less than 5% with no difference between males and females. Given this low drop-out rate during the junior and senior years, one would expect to not find as many perceived barriers as in the first few years. Ideally, all four classes would be included in the survey. However, in the case of the UW as well as many other institutions, students in the freshman and sophomore years are taking courses in physics, math and chemistry, which are offered outside of the College of Engineering.

V. RESULTS

This study focused on three demographic variables: sex, ethnicity, and year of survey. Tables 3 and 4 present the cross tabulations of year and ethnicity with sex. The number of males and female respondents are of nearly equal size. Also, the numbers of African American, Hispanic, Native American, and "Other" respondents are low. In subsequent analyses using this variable, we have combined these ethnicities into a single category labeled "Other".

Table 3
Number of Respondents by Sex and Ethnicity*

Ethnicity	Male	Female	Total
Asian	115	118	233
Caucasian	271	255	526
Other	73	58	131
African American	5	8	13
Hispanic	16	11	27
Native American	5	10	15
Other	37	29	66
Total	**449**	**429**	**878**

**58 respondents failed to indicate their sex.*

Table 4
Number of Respondents by Year of Survey

Year	Male	Female	Total
1993	141	142	283
1994	119	114	233
1995	58	78	136
1996	131	95	226
Total	**449**	**429**	**878**

The scales exhibited small correlations among themselves, ranging from .39 to - .10. Thus, a multivariate analysis of variance was computed, using the eight scales as dependent variables and sex, ethnicity, and year as independent variables. Because only those respondents with complete data on all items were included in this analysis, the number of students for this analysis was reduced to 619. The results are found in Table 5. One can see that the main effects for all three variables were significant. However, none of the interactions were significant.[32] This result implies that differences in each variable can be viewed alone. To determine the nature of the differences, we next present univariate comparisons on sex, ethnicity, and year for each of the scales.

Table 5
Multivariate Analysis of Variance

Effect	F	DF	Sig.
Sex (S)	3.33	8, 575	.001
Ethnicity (E)	4.88	16, 1152	.0001
Year (Y)	1.97	24, 1731	.003
S x E	1.13	16, 1152	Ns
S x Y	0.79	24, 1731	Ns
E x Y	1.05	48, 3480	Ns
S x E x Y	0.97	48, 3480	Ns

The statistical significance of differences between the average ratings of the two genders was tested by use of an independent *t* test. The results are summarized in Table 6. Significant differences between males and females were found for five of the scales. Females gave significantly higher ratings to teaching assistants and study groups. Males gave significantly higher ratings to competition, intrinsic interest, and student/teacher interactions. No significant differences were found for the students' rating of teaching quality, department assistance, or lab quality, although the lower average rating for females on lab quality nearly reached significance.

Table 6
Gender

Scale	Male	Female	Diff.	t	Sig.
Teaching Quality	3.47	3.52	-0.05	1.18	Ns
Lab Quality	3.31	3.22	0.09	-1.88	Ns
Teaching Assistants	3.18	3.30	-0.12	-3.08	0.01
Department Assistance	3.47	3.47	0.00	0.02	Ns
Competition	2.99	2.76	0.23	4.62	0.001
Intrinsic Interest	3.84	3.72	0.12	2.13	0.05
Study Groups	2.95	3.28	-0.33	4.29	0.001
Student/Teacher Interaction	3.30	3.10	0.20	2.90	0.005

Differences among students of various ethnic groups were tested for significance in two ways. First, a one way analysis of variance was used to determine the significance of differences among the three groups: Asian, Caucasian, and Other. In addition, we computed an independent t test comparing Asian and Caucasian students. This was done because the Other group was a mixture and thus its results were hard to interpret.[33] The results are displayed in Table 7.

Table 7
Ethnicity*

Scale	Asian	Caucasian	Other	F	Sig.	t	Sig.
Teaching Quality	3.43	3.55	3.37	5.89	0.005	-2.53	.05
Lab Quality	3.19	3.25	3.49	7.68	0.001	-1.21	Ns
Teaching Assistants	3.33	3.19	3.30	3.40	0.034	2.44	.05
Department Assistance	3.26	3.55	3.51	9.86	0.001	-4.45	.001
Competition	3.00	2.83	2.87	3.97	0.05	2.81	.005
Intrinsic Interest	3.50	3.89	3.82	19.19	0.001	-6.18	.001
Study Groups	3.16	3.05	3.27	2.29	Ns	1.28	Ns
Student/Teacher Interaction	2.89	3.33	3.25	15.13	0.001	-5.57	001

**The F test compares the averages of all three groups; the t test compares Asian & Caucasian students.*

Comparisons between Asian and Caucasian students revealed significant differences on six of the eight scales. Asian students gave higher ratings to the teaching assistants and to competition. In contrast, Caucasian students gave higher ratings to teaching quality, departmental assistance, intrinsic interest, and student/teacher interaction. Differences for the latter two variables were particularly large. Students in the Other category gave considerably larger ratings to lab quality than the other two groups, although the difference is not enough to be significant. Their average ratings on all other variables with significant differences were between the Asian and Caucasian student averages except for teaching quality for which they had the lowest rating. In most cases the Other group's average was more similar to the Caucasian than the Asian average rating.

The survey has been administered over four years. To determine whether the climate, as perceived by students, has systematically changed over this period, we did a one-way analysis of variance with a test for linear trend on each of the scales. One can see from Table 8 that the linear trend was significant for all scales except Intrinsic Interest. Furthermore, the trend was in an upward direction for every scale, as one can quickly note from the fact that the means for 1996 are higher in all cases than those for 1993.

Table 8
Year of Survey*

Scale	1993	1994	1995	1996	F	Sig.
Teaching Quality	3.37	3.43	3.62	3.62	29.91	0.001
Lab Quality	3.19	3.24	3.27	3.39	11.52	0.001
Teaching Assistants	3.13	3.29	3.29	3.31	7.69	0.01
Department Assistance	3.33	3.53	3.46	3.58	8.92	0.005
Competition	2.83	2.85	2.95	2.94	4.20	0.05
Intrinsic Interest	3.75	3.73	3.81	3.86	2.91	Ns
Study Groups	3.05	3.05	3.06	3.29	5.22	0.05
Student/Teacher Interaction	3.14	3.17	3.03	3.40	6.44	0.01

**Significance tests to determine presence of a linear trend.*

VI. Discussion

A few of the results revealed surprises. Although the literature indicates that women tend to have many problems with teaching assistants, our results indicated that indeed women gave significantly higher ratings to teaching assistants (TA's) than men. It should be noted that men rated their interactions with faculty significantly higher than the women. These two findings could indicate that the female students have formed closer and more personal relationships with the teaching assistants, who are in most cases less intimidating than the faculty. It should also be noted that during the period between 1993 and 1996, several of the larger departments implemented mandatory TA training. Perhaps, we are seeing the results of TA training as being very effective for female students.

Another surprising result was that there were no significant differences between male and female ratings of teaching quality, department assistance or lab quality. Again, the research indicates that the experiences women have in lab settings are quite different than men, and in many cases, women have been discouraged from continuing engineering based on inequitable experiences. Often small in number, women are assigned to lab teams as the only woman with four or five men. It is not uncommon that the woman is delegated the task of keeping notes rather than "doing" the experiments.

On the other hand, males giving significantly higher ratings to competition and intrinsic interest was to be expected. In another ongoing study, women report that competition is one of the most significant barriers to their pursuit of a degree, and is often cited as one of the top two reasons for dropping out or switching majors.[34] Women more than men tend to prefer working in study groups as a team rather than compete, as was found in this study.

With regard to ethnicity, very few conclusions can be drawn. Because the numbers were too small to analyze, the groupings were Asian, Caucasian and Other. Other included Hispanic, Native American, African-American and those students who did not indicate their ethnicity on the survey. Many multi-racial students do not complete the ethnicity questions because they do not feel an appropriate box is listed. This has become a major issue which is under consideration by the US Census Bureau.

However, it is interesting to note that the Caucasian and Other groups rated intrinsic interest significantly higher than the Asian group, although Asians rated competition significantly higher. This finding could help dispel stereotypical myths about Asian students being more intrinsically interested in math and sciences than other groups. It is difficult to make any broad conclusions about the Other group because many of the students did not indicate ethnicity and because one cannot make assumptions across ethnicities.

During the 1993-96 span, new courses that stress the design component of engineering, referred to as ECSEL (Engineering Coalition of Schools for Excellence in Education and Leadership) classes, had been added to the freshmen and sophomore curriculum. Students were asked on the survey, "How aware are you of the ECSEL classes?" Although no significant gender differences occurred, male and female students responded an average of 1.5 on a 1-5 scale of not at all to very much. Even over the four year period, the average response was 1.5 to this question. Obviously, very few students were aware of the ECSEL courses, which leads one to believe that a new approach to marketing the course needs to be considered.

Finally, have we seen an improvement in the quality of engineering over the four years that the survey has been administered? The results indicate that there was a significant and systematic positive change. There are numerous explanations for this finding. Clearly, there has been more focus on curriculum change through the ECSEL Coalition and new design courses, undergraduate education, and diversity. The Women in Engineering Initiative has demonstrated increased retention rates through its Undergraduate Retention Program.[35] The Minority Science & Engineering Program and MESA have also made significant strides to increase the recruitment and retention of minorities. Although the results indicate an upward trend in students' perceptions of the quality of their engineering education, on a scale of 1 to 5, the ratings are still only in the middle range.

In conclusion, the findings from our study indicate that there is still work to do to improve the quality of engineering education as perceived by students. Significant index differences were found between males and females on their ratings of teaching quality, department assistance or lab quality, although the lower average rating for females in lab quality nearly reached significance. However, both males and females rated most items in the middle of a 1-5 scale.

It appears from this study that a more in-depth analysis needs to be made to determine what students believe would improve the quality of their engineering education. Small focus groups would help in determining why students rate their education as slightly better than average and what could be done to improve the situation. In addition, the survey needs to be administered to pre-engineering students, that is, those in their freshmen and sophomore years. The results of this next level of analysis could provide more insight into recommendations to improve the perceived quality of education. Finally, because the survey appears to be reliable and valid, we plan to explore with the other ECSEL institutions the possibility of using the survey on their campuses.

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[35] Brainard, 1996.

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