

## **HUMANIZATION OF THE ENGINEERING CURRICULUM**

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Today there exists a challenge to incorporate new and improved teaching practices which will be more appealing to a diverse engineering student body throughout the engineering curriculum. It is generally believed that application of modified teaching paradigms will lead to increased recruitment and retention among women and underrepresented ethnic groups in engineering, and this is desirable for increasing diversity in the engineering workforce. We present an overview discussion of specific women-related issues important to the transformation of engineering curricula, and we report initial results of student surveys on teaching preferences and effectiveness. The issues which we identify have been determined through a semester long workshop series exposing engineering faculty to contemporary issues and ideas related to women in science and engineering. Our recommended guidelines for curriculum transformation support a more humanistic approach in teaching and a continuation of efforts that will lead to greater diversity. These are suggested as a means to insure greater satisfaction and enthusiasm for all students. Initial survey results for a freshman level engineering population have confirmed that diversity in terms of gender and ethnicity are desirable for all students. However, the level of importance is greater for women students.

### **ENGINEERING CURRICULUM TRANSFORMATION PROJECT**

An engineering curriculum transformation project has been initiated at the University of Maryland through the support of the A. James Clark School of Engineering's Women in Engineering Program (WIE) and the University of Maryland Center for Teaching Excellence (CTE). The project included a semester long series of workshops and seminars featuring experts in the field of women in science and engineering. Additionally, a parallel series of guided, small group discussions was facilitated under the direction of Dr. Deborah Rosenfelt, Professor of Women's Studies and Director of the campus curriculum transformation project. The workshop participants included 9 school of engineering faculty and 6 Undergraduate Teaching Fellows who were women. Each faculty member (or faculty pair) was assigned an undergraduate teaching fellow, and based on information gained through the workshops, seminars, group discussions, and personal experiences of the faculty/fellow team, modifications to 6 school of



engineering courses were implemented, ranging from freshman to senior level.

The participating faculty group created a list of specific women-related issues that were deemed important in realization of the project goals. The issues generally revolved around a theme of inclusion: regard for the relevance of course material to topics of interest for all student populations represented, regard for the level of competence of all student populations represented, education of students and faculty in basic human interaction skills, and on-going evaluation of teaching effectiveness and student satisfaction<sup>1,2,3,6</sup>. The recommendations are as follows:

1. Provide context to the course material, including historical, social, and contemporary relevance and application.
2. Promote the contributions of women and ethnically underrepresented scientists and engineers.
3. Use diverse teaching methods including visual, verbal and other multimedia techniques.
4. Create and apply a variety of teaching analogies, including a mix of gender neutral analogies, analogies relating to a typically female experience, and analogies relating to a typically male experience.
5. Include group assignments and group activities in student responsibilities.
6. Selection criteria for members within a group should not be random and should be based on the needs of the students, as well as the needs of the problem.
7. Provide training in basic interpersonal skills, including diversity training, group dynamics and conflict resolution for faculty and students.
8. Include freshman and sophomore level courses that provide encouragement for students.
9. Develop workshops, seminars or short courses which provide remedial level instruction in laboratory and computer skills.
10. Maintain an on-going critique of teaching effectiveness through student-student and student-faculty interactions.

These recommendations should be regarded as a set of guidelines which may be applied in developing a curriculum which is more appealing for all students. However, many of the issues outlined are particularly important for women students and also for students from underrepresented ethnic groups in engineering. This has been confirmed through external studies of women and underrepresented groups in general science fields<sup>8</sup>. However, we are now conducting student surveys and focus group interviews to gauge the validity of these statements for engineering students. Initial results of written surveys for a freshman class selected for participation in the curriculum transformation project are presented below.

## ENES 100 FRESHMAN INTRODUCTION TO ENGINEERING DESIGN

The ENES 100 engineering design course was implemented through the Engineering Coalition of Schools for Excellence in Education and Leadership (ECSEL). The course is designed to provide a complete product development experience, including product design, construction and evaluation for first year engineering students. The course objectives include cultivation of skills in the use of CAD tools to produce engineering drawings, use of spreadsheet software to calculate simple expressions and in graphing and data display, simple free-body diagrams and equilibrium analysis, written and oral presentation skills, basic manufacturing and wood working skills, product testing and evaluation, and teamwork skills. The only prerequisite for the course is high school level physics.

The ENES 100 course is considered a contemporary model for introduction of design oriented classes early in the engineering curriculum. The students are separated into teams of 6 and are given a product specification. The students must then design a product that will meet the design specifications. The curriculum transformation modifications which have been applied to this course relate directly to items 1, 6 and 7 from the list given above. The modifications were as follows:

- additional criterion was placed on the product specification to add a useful context to the project goals.
- a modified set of criteria was used in the selection of team members
- a workshop on group dynamics was held

### MODIFICATION OF PRODUCT SPECIFICATIONS

The product specifications assigned to each of the ENES 100 sections included design and construction of a vehicle which could capture the energy created by a 15 mph wind source and carry a 40 lb. payload a minimum distance of 30 feet in a reasonable time frame. Several size constraints were also placed on the final product. In addition to the standard specifications, the students were given several incentives for constructing a product that would be useful for human entertainment. For example, bonus points were given for carrying a payload more in line with the weight of an adult. Additionally, incentive points were available to the team which constructed a vehicle judged visually most appealing by a group of 4<sup>th</sup> grade students.

### Observations

Incorporation of the design modifications greatly increased the level of enthusiasm of each of the teams. Product designs were generally dominated by the drive to improve payload capabilities, and to develop a product theme that would appeal to children. Special product features such as bicycle-style hand braking systems, additional safety equipment to protect young riders and decorative pictures and illustrations were included on various designs. At the conclusion of the semester, a few teams donated their designs to local high school and community centers. However, when questioned

about the usefulness of the project, most students did not recognize a practical use for the vehicles.

#### CRITERION FOR TEAM MEMBER ASSIGNMENTS

The criterion used in making team selections included three components as follows:

1. Each team must have at least one member with a reliable car.
2. No team will have only one female or African descent member.
3. No team will have subsets of members who describe themselves as being friends.

Using this criterion, women students were assigned to three of the five teams in the class. One team had three women members, two teams had two women members and two teams had no women members. One of the seven initially enrolled women students subsequently dropped the class. This student had been assigned to the team containing three women students. There were four students of African descent, and none of these students dropped the class. Of the six women students completing the class, one was of African descent and one of Hispanic descent.

#### Observations

One of the more interesting topics of debate during the curriculum transformation project group discussions involved faculty prerogative in selection of individuals to be grouped for a group assignment. In spite of empirical evidence which supports the stipulation that women students typically experience frustration and dissatisfaction when isolated in team situations<sup>2,3,6</sup>, many of the participating faculty felt strongly that creating a false environment by increasing the presence of underrepresented students should not be pursued. The educational experience gained from a more realistic environment is of more value and would be more appreciated following graduation. A few faculty members felt that this was not as critical for particularly lower level students.

In past offerings of the ENES 100 class, gender and ethnicity have not been considered in making team selections. For those past cases, it has been observed that women students (when isolated) often complain of not being taken serious for analytical activities. Also, it has been observed that women students become frustrated when team members are reluctant to complete assigned tasks in a timely manner. Moreover, male students often complain of women team mates who are overly concerned with completing tasks on time and maintaining adherence to a planned schedule of activities. Using the criteria of no isolated women students, and no isolated African descent students, this type of situation was not observed by the instructor or teaching fellow. Also, the overall morale and cohesiveness of each of the teams was much improved over past experiences for the same instructor.

### GROUP DYNAMICS WORKSHOP

The group dynamics workshop was hosted by Ms. Symone Colquitt, a volunteer elementary school parent who has gained experience in coaching team design projects by managing a group of six, 4th grade students in the construction of a battery powered vehicle. The activity was part of a national competition titled "Odyssey of the Minds". The workshop involved a short introduction outlining effective team characteristics followed by a series of brainstorming activities. Finally, a hands on activity that required brainstorming, group decision making and allocation of tasks was performed. The workshop was held early in the semester, but was not done prior to the first group homework assignment.

During the workshop, brainstorming activities were assessed by judges who determined the level of creativity in responses of individual team members to a general question. Bonus points were awarded to teams whenever particularly creative responses were given by one of the team members. However, pre-game comments given by the workshop facilitator placed a clear emphasis on achieving a large quantity of responses, and on withholding judgment of responses by team members.

### Observations

A few general observations noted from the workshop included the following:

- Almost all of the students spent an inordinate amount of time concentrating on the judge's assessment of responses given by team members.
- A few male students openly challenged the worth of emphasizing quantity of responses over the quality of responses within the context of a brainstorming activity.
- Evidence of team camaraderie developed as the activity progressed.

In addition to the observed improvement in team satisfaction for women students, the team dynamics for the overall class was also greatly improved over past experiences. All of the teams demonstrated an ability to resolve conflict without intervention on the part of the instructor or the teaching fellow. This has previously not occurred. Also, when students were questioned about the number of teammates they respected, the average response was 4.8 for women students and 4.1 for men students.

### **ASSESSMENT AND EVALUATION**

As a means of evaluating the effectiveness of the modified team selection criteria and the group dynamics workshop, and also to begin compilation of data on effective teaching practices and methods, two surveys were written and distributed to the students. The surveys were written with the assistance of faculty and graduate students in the department of psychology and the ENES 100 instructor and teaching fellow. The first survey was distributed after completion of approximately 40% of the semester and the second survey was distributed after completion of approximately 90% of the

semester. The first survey was completed by 19 male and 7 female students, and the second survey was completed by 18 male students and 5 female students. Additionally, a third survey was distributed by the WIE office after completion of approximately 60% of the semester. A few statistically significant trends for the population sampled have been identified.

## **SURVEY RESULTS**

The surveys were structured so that students were asked to quantify how well they agreed with a statement on a scale from 1 to 5. 1 is strongly disagree, 5 is strongly agree and 3 is neutral. The statistically significant results are listed and discussed below.

- All students prefer an ethnically diverse environment for academic work. However, this is more true for women students (avg.=4.6 in survey 1, avg.=5.0 in survey 2) than for men students (avg.=4.1 in survey 1, avg.=3.6 in survey 2).
- All students prefer a gender mixed environment for academic work. This is more true for women students (avg.=4.6 in survey 1, avg.=5.0 in survey 2) than for men students (avg.=4.2 in survey 1, avg.=4.2 in survey 2).
- Women students agreed that it is important to use examples and give assignments which are inclusive of different groups of people in terms of gender and ethnicity (avg.=4.5 in WIE survey). Men are more or less neutral (avg. =3.3 in WIE survey).
- Men students tend to agree that team meetings improved following the group dynamics workshop (avg.=3.8 in survey 1). Women students were neutral (avg.=3.1 in survey 1).
- Women students tended to strongly agree that team meetings improved over the course of the semester (avg.=4.6 in survey 2). Men students tended to agree with this statement also, but less strongly (avg.=3.7 in survey 2).
- In the initial survey, white students were neutral when asked if team meetings had improved following the group dynamics workshop (average=3.1). Other students tended to agree with the statement (average=3.9)
- Although the teaching fellow was not overly utilized, white students were slightly more likely to approach the teaching fellow for assistance (avg. #visits=1.6) than other students (avg. #visits=1.1).

Other statistically significant results indicate that men students consistently disagreed that gender or ethnicity will affect an instructor's teaching approach or the student's ability to learn. Women students strongly disagreed with statements to this effect. Also, all students disagreed that teaching methods and examples presented in class prepared them for completion of the class project or enhanced their conceptual understanding of the material. Lastly, all students felt their team exhibited positive characteristics. Men students tended to agree with these statements, and women students tended to strongly agree.

## CONCLUSIONS

A curriculum transformation project in engineering has been initiated which will seek to improve the attractiveness and appeal of the engineering curriculum for women and ethnically underrepresented students in engineering. A group of 9 engineering faculty have convened and identified specific woman-related issues that should impact realization of the project goals. The issues identified revolve around the theme of humanization of the engineering curriculum through a philosophy of inclusion, education of students and faculty in basic human interaction skills, regard for the relevance of course materials to topics and applications of interest to all student populations represented, regard for the initial level of competence of all student populations represented, and on-going evaluation of teaching effectiveness and student enthusiasm. Initial results from student surveys indicate women students place more emphasis on team oriented activities, and while all students tend to prefer diverse academic environments in terms of gender and ethnicity, these issues are more important for women students. We also have observed that control of academic environments based on the needs of the participating students is more likely to result in increased levels of satisfaction and enthusiasm for women students. Specifically, avoiding isolation of women students for group assignments and group interactions is recommended. Finally, conventional methods used in teaching engineering principles and concepts do not meet the needs of students in general, regardless of gender.

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