WILL EARLY DESIGN EXPERIENCES IMPROVE RETENTION OF FEMALE ENGINEERING STUDENTS? YES, BUT.

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Many studies have criticized the typical undergraduate engineering curriculum today for putting too much emphasis on specialized departmental courses that develop analysis skills at the expense of inter- and multidisciplinary courses that develop synthesis and problem solving skills. And students agree. Especially females are calling for a curriculum that explores complex problems with societal relevancy rather than decontextualized textbook examples.

The introduction of group design experiences at the lower division level has been promoted as a means to add multidisciplinary problem solving and team experiences into the curriculum. There is much to be said for these reforms. Such activities give freshman and sophomore students a taste of engineering that too often eludes them while they are off on the other side of campus taking basic math, science, humanities and social science courses. Case studies of exemplary industrial design practice sensitize students to life cycle design issues, such as design for manufacturability, quality management and market issues in the design process. Group design competitions expose the students to the importance of teamwork and multifunctional synthesis. It is proposed that such activities will improve retention rates by igniting students enthusiasm in engineering and motivating them to persevere in their the undergraduate program.

It has also been suggested that these design activities should be modeled after industrial design teams so that students have a sense of what "real world" design is all about. Unfortunately, some of the innovative programs with this goal in mind

have backfired. Women students who are often the intended beneficiaries of these programs frequently turn out to be unintended casualties. Why is this?

The problem arises when instructors, eager to provide problem solving and design experiences, encourage students to work in cooperative groups without paying attention to structuring the group dynamics. There is no question that industry provides models in exemplary team building that has led to the success of commercial products in the marketplace. But industry has yet to solve some of stereotypical traps that design teams can fall into, particularly with respect to gender. These patterns of gender-bias in the workplace show up very early in group learning in educational settings as well. In both college and precollege settings, we find that, frequently, cooperative groups reinforce societal stereotypes, thereby disadvantaging the very female students they are intended to serve. For example, in a program called "Computer as Lab Partner" designed for middle school classes, we find that female students were frequently the subject of ridicule and insult in cooperative groups. Often the statements directed towards these females, sound like they come right out of situation comedies on television. For example, in one group, students report "the reason we didn't get the right answer is because we listened to Jessica".

By following common stereotypes, students in design groups may reinforce the view that females cannot succeed in technical fields. Females may be reluctant to take leadership roles, be discouraged when their ideas are rejected by males, and angered when they are interrupted. Male students may discredit the contributions of the female students, and worse yet, ignore them and not even take their ideas and contributions seriously. Thus classroom experiences in team problem solving may result in female students becoming convinced that they are unwelcome in science and engineering.

This phenomenon of female marginalization and isolation in cooperative groups is not limited to middle school students. The danger is that it can also occur in problem-solving groups at the university level. As faculty involved with improving undergraduate engineering education, we are advocates for adding more

design and and problem solving activities in the curriculum. However, such reforms can lead to unintended results. One innovative program at UC Berkeley that introduced design at the freshman level was well received overall with the male students but devastating for at least one female student and disheartening for other female students. Excerpts from diaries at the end of the semester revealed that the women's opinions and ideas were sometimes ignored or ridiculed in four student design teams with only a single female student. Consider a few condensed excerpts from one of the male student's diary:

> *Week 1*: I attended my first design group meeting. I was lucky to be in a group with guys I know -- all but one girl that is, Eva. *Week 2*: We had our first idea session for the design. I think I had the best ideas and convinced everyone else. *Week 3*: We finally made some progress today. We all worked hard except Eva. She doesn't even say anything. *Week 4*: We decided to divide up the work because we don't have much time left and much to do. The hard part was to figure our what Eva could do. *Week 5*: Everyone is really pulling through on this project. All but Eva -- she won't even show up for the meetings. It isn't fair that she should get any credit for this project. (John's diary)

One is tempted to infer that Eva was not carrying her own weight in the team and was somewhat of a slouch. However, her diary paints a much different picture of in-group versus out-group dynamics and gender biases.

> *Week 1*: I attended my first design group meeting. The other students in the group seem to already know each other. I feel a little left out. *Week 2*: We had our first idea session for the design. No one seems to like my ideas. They are critical of everything I say. *Week 3*: Things don't seem to be getting very far. I decided to be quiet today so as not to be criticized. This is very frustrating. *Week 4*: We have a lot of work to do and only two weeks left before the project is due. None of these guys think I can do anything and only assign me grunt work to do. *Week 5*: I give up. I can't go to the meetings anymore - it is too depressing. Maybe I shouldn't be an engineer. (Eva's diary).

These anecdotes indicate potential problems with unstructured group learning. In many cases, female students are blamed inappropriately when there are perceived failures. Sometimes they are blamed because the results do not come out correctly. Other times, they were blamed because they do not take their fair share of the responsibility. As a result, female students frequently conclude that they haven't got any good ideas when, in fact, their ideas are fine. However, their ability to get their ideas heard is seriously impaired.

Thus, efforts to add problem-solving and design activities to precollege and college courses must be accompanied by a judicious and careful structuring of group situations as well as training for all group members, instructors and teaching assistants. Groups are but one element of the repertoire of teaching strategies. Unless they are used such that all can participate and be respected for their ideas, they may backfire and undo the benefits of authentic learning experiences.

Yet, the difficulties of implementing problem-solving and design in the curriculum do not offset their benefits. Unless we actively encourage students to engage in authentic learning experiences and support them as they carry out these activities, we are unlikely to prepare students for the complex and demanding jobs and educational experiences that they must succeed at in the future.

The *Synthesis* Undergraduate Engineering Coalition is addressing just these complex, challenging problems in order to improve engineering education for coalition schools and nationally. We are developing instructional materials for multidisciplinary design teams and instructional techniques that serve to motivate and enhance the experiences for a diverse range of students, taking ethnicity and gender into account. Many of these programs involve collaboration with our industrial partners. For further information write: Synthesis Coalition Headquarters, 443 Engineering &Theory Center, Cornell University, Ithaca, NY 14853.