The Benefits of Multi-Disciplinary Collaboration

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Background

References exist to show that learning, retention and professional development can be enhanced through collaboration. In the book *Women's Ways of Knowing*, the authors assert that a passion for learning is experienced when students witness first-hand the process of problem-solving, rather than merely being "handed" theories. As the authors write,

> So long as teachers hide the imperfect processes of their thinking, allowing their students to glimpse only the polished products, students will remain convinced that only Einstein – or a professor – could think up a theory. The problem is especially acute with respect to science. Science is usually taught by males and is regarded as the quintessentially masculine intellectual activity. And science is taught – or, at least, it is heard by students in most introductory courses – as a series of sibylline statements. The professor is not indulging in conjecture; he is telling the truth. (1997, p. 217).

Many engineering programs through capstone design courses address such a method of teaching. And yet, often the professor excludes himself (or herself) from the problem-solving process, serving only as a "consultant" to design teams who can find the right questions to ask. Belenky and her colleagues suggest that female students find little more satisfaction with this experience than they do in the lecture hall. For these women, the process of learning, of creating, and of designing is much more valuable than the product of the design experience. As Belenky writes, these women "believe that people have an obligation to share with others how they know and what they learn when they 'jump outside of the given.' " Carol Edelsky writes of the same desire, noting in her study of women at various professional meetings, that when in collaborative environments, these women experienced "high levels of communicative involvement and satisfaction." (1981, p. 416)

Female faculty members who share an enthusiasm for collaboration would be described by Belenky as "constructivists." These academics enjoy learning most when reciprocity and cooperation are prominent. As Belenky writes, "although doubting may still be used to test ideas and may even be described as invigorating or fun, constructivist women are much more likely to replace doubting with believing as the best way of getting the feel of a new idea." (1997, p. 145)

The National Institute of Health has recognized that scientific advances are being made at the interfaces of traditional disciplines and approaches to science are becoming more integrative. (2003, p. 2) As such, an interdisciplinary engineering education is a realistic model for training future leaders in the engineering sciences for the purpose of advancing the research abilities of engineering graduates.

The National Science Foundation funded Project Kaleidoscope in 1990, a study to identify best practices in the teaching of undergraduate math and science. In "The Women's College Difference," Sebrechts (1999, p. 47) discusses the report generated at the conclusion of this project. This report recommended that "mathematics and science education be driven by collaboration among students and faculty, requiring that cooperation and inclusion be favored over competitiveness and exclusion." The necessity of a collaborative learning environment that favors cooperation over competition is most critical for female students. Matthew, et al, identified collaborative learning as, "one of the most effective learning methods for college students, particularly women." (1996, p. 7)

By collaborating with students during the process of learning, faculty can model collaboration. When faculty from different disciplines participate together with students from various engineering departments in this collaboration, an added facet of interdisciplinary collaboration is also modeled. As Belenky writes, when students "are exposed to the methodologies of several disciplines, acquiring the analytical skills and methods of each, they experience themselves as investigators and search for truths that cut across the interests and biases that lie within a single disciplinary perspective." (1997, p. 140)

Collaborative ability, in addition to design skills and technical intelligence, is of growing importance for today's engineering graduates. Engineers of the future must not only be comfortable with technology outside of their own discipline, they must also be experienced with collaborative problem solving tools. A spirit of cooperation, rather than a spirit of competition will drive innovation. As Sally Helgesen writes in *The Female Advantage*,

> Fearlessness, a thirst for combat, single-minded devotion to an ideal, aggression, the ability to conceptualize the other as the enemy, the fierce need to prove oneself in contests – all these once served the evolutionary human purpose of mobilizing the strongest adult males to preserve and protect other members of the immediate tribe. But advanced technology has turned those virtues into liabilities; aggressive heroics now threaten the survival of the larger tribe, the human race. (1995, pg. 254)

The experience of working together to demonstrate the design process across disciplines is rewarding to female faculty, not only because it improves learning, but also because it offers opportunities for collaboration and mentoring between junior and senior female faculty members. Oftentimes, time constraints limit the extent to which such mentoring can occur, and yet when women work together on such projects as curriculum integration and the engineering design experience, such interaction brings with it opportunities for advising and encouraging one another. Anthropologist Helen Fisher asserts that women have an innate tendency to form "lateral connections." Fisher believes that while men seek higher rank to attain power, women seek connections with others as a source of power. (2000, p. 24).

Objectives

The primary objective of this work is to foster multi-disciplinary projects in the IME Senior Design Project Course for the purpose of enhanced student learning. This study capitalizes on the collaborative strengths of three female faculty representing the three engineering departments at Kettering University: Electrical and Computer Engineering, Industrial & Manufacturing Engineering and Mechanical Engineering. There is existing work being pursued at Kettering in the form of a grant from The National Science Foundation by Lucy King, et al. (2002). The authors cite the need for course and curriculum integration and it is the purpose of this paper to build on the work and extrapolate to the needs of female faculty. The result of the previous grant included teaming opportunities between industrial, manufacturing and mechanical engineering courses through an interdisciplinary design course.

A secondary objective of this work is to foster female faculty professional development. Many would agree that collaboration is second nature to women. This work provides an integrated mentoring opportunity for a female assistant professor to work with a female associate professor in another department. The result should be increased career satisfaction and likelihood for retention and promotion.

A third objective of this work is to add value to society through graduating engineers who understand and are comfortable with the integration of technologies. An increased understanding of the value of different disciplines will enable the engineering graduate to collaborate fully in their job after college.

At Kettering University, like many other engineering schools, each of the engineering departments provides students with a culminating experience in the senior year. This culminating experience is in the form of a Senior Project Design Class also referred to as the Capstone Project. Redesigning the IME Capstone Project was a primary outcome of this research. The collaboration between IME, ME and EE began by attempting to integrate the relationship between the three disciplines into the IME Capstone Course.

In an attempt to make the capstone project reflect reality, the outcome of the project had to be interdisciplinary in nature. In an attempt to make the capstone project interesting and mutually beneficial, the students were given a variety of project choices. All projects required a degree of interaction between the IE students with ME and EE students. EE professors and ME professors were identified as consultants or resources for information within their respective disciplines. Students were also responsible for adding resources to the reference room that proved useful to future capstone students. Four capstone project choices for the Winter 2004 semester were identified as described below:

1. Statistics - Design a survey for the purpose of creating a portfolio of interdisciplinary projects and interested participants. The project may be service to the community, beneficial to a student group, part of a class or integrated into the curriculum. Survey participants may be chosen from students, faculty, and corporate sponsors or another identified group. As part of the survey development, IE capstone students will interview ME and EE students for the purpose of capturing the right data. In addition, IE, ME and EE students and faculty are asked to complete the survey to determine wants, needs and perceptions.

2. Simulation – Design and validate two discrete event simulation models for the purpose of analyzing process flow. The first model represents the thesis process flow. The second model represents the graduate office process flow. Students must check each academic department to determine how the process varies. Students must interview staff within each department and respective offices to determine the process for each. After the initial model is validated, improvements are suggested using the model to quantify the effectiveness of any suggestion.

3. Ergonomics – Design an assistive device to reduce the effects of uncontrollable hand tremors on input devices. Students would design the device taking into account anthropometry of the subject, materials used in the product, damping characteristics and electrical signal pulse. They may begin by monitoring the electrical impulses and their frequency within the hand during a tremor using a signal device created by a EE consultant. They may further request ME assistance for ideas to dampen the noise created by a tremor as well as materials selection as it relates to damping. They will then draw upon IE skills in anthropometry. Finally, product design will be tested for valid function.

4. Work Design – Act as a consultant/mentor to the current IME361 Methods & Standards Class. Students enrolled in this class are expected to optimize the design of a padlock created from Lego building blocks. Capstone students would serve as advisors for the current students, answering any questions and relating personal experiences. Capstone students would also design a new product to be used in the next offering of the course, thus replacing the padlocks that have been used for several semesters. The new design must have at least two different options and approximately the same number of parts and level of complexity as the current locks. One additional requirement is that a torque-inducing hand tool must be used to either put together or take apart some lego pieces. Precedent and fabrication charts must be created as well as a bill of material for the new product.

Conclusions

Student satisfaction with the multidisciplinary format of their capstone projects was assessed via surveys and class discussions. A seemingly negative observation was made by some of the students. These students were disappointed with the multidisciplinary nature of their projects because they felt that it was more important to apply the tools learned within their own discipline than to experience how their discipline interfaces with others. They described their project results as being unrelated to what they had learned in previous courses. It would seem that the students did not value *breadth* in the capstone experience as much as they valued *depth*. They suggested that a project at a local company (as has been often the case) would be more meaningful. Perhaps if future students were given the opportunity to compare the multidisciplary on-campus project with a "real world" project, they would find that their need for breadth experience is indeed as great as their need for depth in their discipline.

A secondary benefit to this project has been the valuable collaboration between female faculty from different engineering departments and at various levels of seniority in the institution. An untenured female assistant professor may be more likely to find support through a mentor relationship with a tenured female faculty. That relationship will likely occur between different departments due to the low number of females in any one department. Finally, the value to society of an engineer who has the ability to collaborate with other disciplines cannot be measured but is invaluable to future success. The benefit of the collaboration on this study has provided the untenured faculty member within our team with networks within and outside our institution. The tenured faculty members in our collaboration have gained new teaching and research ideas based upon the technological interfaces between departments.

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