Team 2000: Women Engineering the Future

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Introduction

In Fall 2000, a team of four women created a unique Engineering 116 course for female students at the University of New Mexico (UNM). The underlying intent of the engineering project management course was to develop and foster successful traits and behaviors of the profession of engineers and computer scientists. The course, titled TEAM 2000: Women Engineering the Future, had as its primary function the development of a recruitment video for girls. The class offered entry-level and sophomore students a head start in team collaboration under the direction of advanced undergraduate female students in a project management environment.

Course Purpose

The course had a multi-purpose agenda – addressing both retention of women engineers in the school and offering the students basic engineering skills while raising awareness on the need to recruit girls into engineering. Tasked with designing a recruitment video, the students were directed to: 1) address issues of female pre-college attrition in the math and science realm; 2) portray challenges and opportunities for women at the university level and in the work world; and 3) create a strategy (story) that would encourage young girls to view engineering and computer science fields as viable and exciting choices for a career for themselves.

Within the UNM School of Engineering (SOE), students generally do not have an opportunity to work in project management teams until they are nearing completion of the program. The Instructors designed the team collaboration introductory course to provide a grounding in the most essential skills needed in the engineering work world. The course curriculum goal was: 1) to lay a foundation in general engineering project principles; 2) expose students to engineering design phases; 3) develop an understanding of concurrent engineering and design manufacturing; and 4) use the small task group to analyze best product solutions. Recognizing that small task teams are more functional than large teams, the instructors limited the size of the course. The plan called for three teaching assistants to lead up three task teams. Working with small numbers, there was no expectation that the course would lead to statistically significant results. The primary intent was to engage entering and 2nd year students in team relationships, which would help to build strong bonds with their School of Engineering peers and provide basic skills in engineering concepts and team cooperation.

Background on Video

In early January 2000, the SOE received a 1.7 million dollar gift from Ford. Of this total $250,000 was committed to women's programming/scholarship support. A small portion of this women's funding was allocated to Dr. Deborah Fisher, Civil Engineering Professor, for the production of a recruitment video for girls. The initial course planners, Dr. Fisher, Elaine Wonsowicz, and Norine Meyer decided that the most practical mechanism for designing the video was to create a one-credit course under the direction of the Project Investigator, Dr. Fisher, also an Instructor for the course. A portion of the funding covered the Teaching Assistant's (TA's) salaries and enabled the peer team leader groups. Three of the Instructors, Norine Meyer, Amy Strobel, and Cynthia Villanueva, carry out program responsibilities in advising and program planning within the SOE and worked as a team to design the course curriculum. Elaine Wonsowicz, Program Director of Engineering Student Programs in the SOE, served as a consultant on the project.

Justification: Female Underrepresentation

The Fall 2000 Engineering all-female course within the SOE was a break with tradition. Never in the history of the School had a course been designed with women in mind. In part, the Team 2000 course was a response to a student needs survey. In Fall 1999, the Diversity in Engineering Program carried out a survey to determine the types of programs our women students would like to see implemented within the School. The survey was distributed to 200 women SOE students with an 18% response rate. Students identified an Engineering course for women as one of the activities they would like to see implemented in the future. In general, the survey respondents expressed interest in activities that would connect them with other women both as role models and peer supports.

Women are underrepresented in the UNM School of Engineering. In 1998-99 women received 22.9% of the UNM School of Engineering undergraduate bachelor's degrees. In Fall 1999, while women students represented 23.4% of the overall undergraduate population of 1,533 students at SOE, only 16% of the 1999 beginning freshman group were women. At the present time, only five SOE faculty members are women.

Females are also underrepresented in the engineering field. "According to the Engineering Workforce Council (EWC), women in engineering received 16.1% of bachelor's degrees, 15.1% of master's degrees and 9.7% of doctorate degrees in 1994. The MentorNet Program, a national email-based program linking women students with professional role models, reports that women represent just slightly more than nine percent of all engineers and approximately 30% of scientists. Research tells us that with women still underrepresented in science and engineering, it is critical that programs for systemic educational reform be designed and implemented." [1] The Team 2000 Instructors believed that a female focused course would address educational reform issues and serve retention needs within the School.

In informal discussions with women SOE students, they mention their minority status in the School, indicating an awareness of their small representation. As engineering students, women at UNM often find themselves in classes that have only one or two female students enrolled.

Although these tend to be assertive young women, some have shared that it is difficult to be heard in situations such as labs when male students dominate the discussion. Many find it easier to express themselves in groups of women – which prepares them to enter mixed gender groups at a later stage with more confidence. Vickers et al. demonstrated that females are more likely to thrive in a single (female) gender program.[2]

In a citing gender differences, *Tech-Savvy: Educating Girls in the New Computer Age,* reported that girls "are not anxious or phobic about technology"…but just make the choice not to get invested in computers. The report states that girls respond well when they are "engaged in the design and creation of technology."[3] The Engineering 116 video design format allowed the young women an opportunity to explore and develop design elements and work within the synergy of a creative team process.

A 1998-1999 MentorNet evaluation report supports the theory that low self-confidence is a key factor in women exiting engineering and other scientific fields. Studies demonstrate that female students frequently experience a setback in academic and career ambitions in their college years, reflected in lower self-confidence about their chances for success and reducing the likelihood of completion of college programs.[4] Although increasing numbers of women are entering the engineering field,[5] reports that engineering is still based largely on male experience. Women are not formally excluded but remain a very small minority and to survive must often behave like young males.[6] In creating a female course, the Team 2000 Instructors desired to provide an environment in which women did not have to take on male characteristics, but could succeed by being who they are – women.

Young women entering engineering school face all of the usual hurdles confronting new students with the added stress of learning how to maneuver within a primarily male system. When incoming students enter into the SOE Pre-major Program, the majority of them are taking the required courses in areas considerably removed from the SOE cluster. Due to the disconnect from the Engineering School in the first two years, establishing supportive contacts early on can be a big boost and even the key to survival for our women students. Team 2000 Instructors expected that with advanced students as role models and team leaders, the female students would become familiar with what the School had to offer and develop an early identification as *engineering or computer science* students.

Females respond well to team situations in which they work together to solve problems. Relationship-building and communication are the foundation of team work and females tend to be good at it. In settings where males are not present, girls take stronger leadership roles and then later can enter mixed gender groups with more confidence. A 1995 publication, *Growing Smart: What's Working for Girls in School* offers compelling evidence that "innovative approaches such as team learning, all-girls classes, and greater hands-on access to computers and tools benefit girls' ability to succeed in school."[7] All of these factors played into the motivation to create a female-centered course looking at female recruitment issues. The Team 2000 Instructors anticipated that team collaboration and problem solving with other women students would result in a more confident entry into mixed gender engineering courses, stronger leadership ability in the School and a clearer sense of their own direction – all of which would be a boost to a successful entry into the work world upon completion of their program.

Methodology

The course was divided into two eight-week sections, the first-eight weeks – the Conceptual Design Phase and the second eight weeks – the Preliminary Design Phase. For each eight-week section the students received one credit for meeting once a week for one hour and forty-five minutes. Each student chose to enroll in the course for one or both sections, earning either one or two credits.

The instructors intentionally capped the course enrollment for each eight-week section at 20 students. A class of 20 students allowed the instructors to divide the class into three manageable teams. The intent of the course was to provide experiential learning to a limited number of students rather than to create a research design model. The instructors fully realized that a course this small in size would not produce statistically significant results.

Course Demographics

The course was open for all students to enroll in. Two males considered enrolling in the class one in each eight-week section, but changed their minds. The male student in the first eight-week section was a no-show and was subsequently dropped from the class and the male student in the second eight-week section was not interested in engineering, therefore dropped the course.

The three Teaching Assistants were upper-division engineering students. They took on a non-traditional TA role as a mentor and a leader for their assigned team versus the traditional TA role as a grader or lab assistant.

In the first eight-weeks the class comprised of eleven female students. In the second eight-weeks, seven of those students re-enrolled plus one new female student enrolled. (Refer to Table 1) At this point, it is important to reiterate that the intent of the course was to provide an experiential learning experience for a small number of students. There was no expectation that the results would lead to statistical significance. The purpose of the course (as stated earlier) was to both provide a team environment in which freshman and sophomore students would have an opportunity to deepen their connection with the School of Engineering and develop a basic understanding of engineering principles.

	Students	TA's		Students	TA's
1st eight weeks	11	3	2nd eight weeks	8	3
Hometown					
In-state	8	2		6	2
Out-of-state	3	1		2	1
Current Status in College					
Beginning Fresh.	5			4	
Freshmen	1			1	
Sophomores	4			2	
Juniors	1	2		1	2
Seniors		1			1
Degree Plan					
Chem E	1				
Civil E	2			2	
Comp Sc	3	1		1	1
EE	1	1		1	1
Mech E	4	1		3	1
Biology				1	
Ethnicity					
Asian/Pacific Islander	1			1	
Hispanic	3			3	
White (Non-Hispanic)	7	3		3	3
International				1	

Table 1: Course Demographics

Conceptual Design Phase

Although the "video design project" was not an engineering project in itself, the video served as a "widget substitute" enabling the instructor-team to address aspects of engineering design - just as another course might have focused on another widget model (i.e., a car, a computer or a bridge). The video proved to be an excellent tool to introduce the "phases" of an engineering project as well as team cooperation and decision-making.

Course Introduction. The first class focused on an overview of the engineering design process. Dr. Fisher incorporated lecture aspects of Civil Engineering and Mechanical Engineering course 455, a senior project engineering management course and created a comprehensive overview of the engineering design process. Specifically, the course examined the definition of engineering, the phases of an engineering project, and concurrent engineering. *Managing Engineering and Technology*, by Babcock, states that the Basic Engineering Equation is "knowledge of math and

science + materials, forces of nature, & economics = something that benefits humanity." In addition the students received an overview of historical and current statistical data trends of women in engineering. (Refer to the introduction section of this paper.)

Identification of Need. Each student was assigned to produce a one-page paper that included a literature review and personal anecdotes and which supported the need to produce a recruitment video for girls and/or women in engineering and computer science fields.

Team Building An integral feature of the course's goal was team work, therefore the instructors chose to devote an entire class to team building and group dynamics. The Team 2000 project consultant, Elaine Wonsowicz, led the groups through a hands-on team-building workshop, focusing primarily on specific stages of team building and teaching the students advanced group dynamic skills. The Team 2000 Instructors then divided the class into multidisciplinary, cross-functional teams that the students would be assigned to for the remainder of the 1st eight weeks. Each of the three Teaching Assistants was assigned to lead a team.

Planning. Each team was tasked with creating it's own storyboard for a video that would focus on recruiting young women into engineering and computer science fields. The initial planning involved a comprehensive examination of existing recruitment videos and a review of the historical and current data trends.

Research. Working in their assigned teams, the students conducted further research through literature reviews and surveys and identified their target population and audience. The audience and target population were based on potential effectiveness in increasing the number of women entering engineering and computer science fields.

Design. After determining the target population and audience, each team was responsible for developing the conceptual script, storyboard, budget, and timeline for producing a recruitment video. Each team was also asked to delineate the following key components:

a. Audience: The audience for this videotape is _____.
b. Program Goal: The goal of this program is to _____.
c. Objectives: After viewing this tape the viewer will _____.

At the end of the first eight weeks, each group gave an in-depth oral presentation on its storyboard, script, budget, and timeline. In the end, each group developed completely different storyline concepts and based on their group research, each group identified a different audience and target population.

Preliminary Design Phase

The first class in the second eight weeks consisted of watching video taped final presentations from the first eight weeks. There was one new student who registered for the second eight-week section. This allowed the new student in the class to review the storyline concepts. The students were tasked individually to find components that they liked or disliked in each video. The TA's and instructors were also tasked with developing a hybrid design from each video presentation.

From this assignment, a conceptual hybrid design was introduced to the class. The design phase of the video proceeded with the entire class targeting the same audience, goals and objectives.

Each class member conducted a target population survey, either by telephone interview or a personal interview. Survey results were incorporated into the final design aspects of the video. New multidisciplinary, cross-functional task teams were assigned. The teams were assigned to the introduction, middle and closing portion of the video and the development of a detailed storyboard and script. Following a presentation and class discussion on the overall process, the class was divided again into two new working teams. The first team was tasked with detailing the overall story, the vision for the video and character development and the second team was tasked with detailing the production schedule to hand the final production off to a professional videographer.

At the conclusion of the second eight-week section, the students presented their final design and a professional videographer will complete the project in the Spring 2001 semester.

Discussion of Video Process

Although the students put forth considerable resistance to aspects of the course during the sixteen weeks, the final hybrid video design was in basic agreement with the initial course goals and objectives. Initially student resistance was observed when they raised the question as to whether a video was even a good mechanism for implanting engineering and computer science as a career possibility. In recalling their own experience, several influential students felt that projects were the eye-opener to engineering careers – getting them excited about engineering by hands-on activities. Once the students realized that the course was about video design, they became invested in developing the basic conceptual designs.

During the first eight-week session, the team process was extremely effective. Individually each student had a different perspective, and in some cases a strong personal interest, regarding the best mechanism to recruit females into engineering and computer science fields. Despite the individual differences, the students respected each other and worked well under the leadership of their TA's.

During the second 8-week session, the team process was challenging for everyone. The students that stayed in the second 8-week session developed a vested interest in their own video, including the target audience and storyline. Therefore, a mild competition and discontinuity among team members developed. The students were at a standstill and did not want to let go of their individual ideas.

To enhance the learning experience, the instructors deviated from the course syllabus to address group dynamics issues and constructive criticism and put TA's more in charge of the overall process. This learning experience provided a safe and responsive environment for the students to receive constructive direction and in turn to provide constructive criticism to one another.

Toward the midpoint of the second eight-week session students learned to collaborate more effectively and worked together as a cross-functional team. At this point the students clarified

their own goals for the content of the video. These essential components of the video included the following:

Audience: 6th to 8th grade; middle school level
Goals:

- Dispel engineering stereotypes and myths
- Inspire middle school students to consider engineering and computer science as a career
- Recruit young women into engineering and/or computer science fields.

Objectives: The viewer…:

1. Will have have a realistic understanding of computer Science and engineering – based on facts – after watching the video.
    a. Not just for guys
    b. Not just for the computer geeks
    c. Lots of people contact and ways to help people
2. Will have specific ideas about career options in engineering and/or computer science fields after viewing the video.
    a. Glimpses of all engineering and/or computer science disciplines
3. Will know that women can do all types of engineering jobs after viewing the video.
    a. Scenes of women working on teams

Length: Eight Minutes
Evaluation Method: A pre – and post - questionnaire will be developed to assess knowledge before viewing the video and after.

Analysis of Post-Course Survey

In order to measure the impact that the course had on the initial goals and objectives of the course, we gave the students, teaching assistants, and instructors all the same post-course survey, inquiring about the degree of impact that this course had on various skills, etc. Impact was measured in six different areas that related to the course purpose. These areas were communication skills, knowledge of the various engineering disciplines, networking with other women, knowledge of project engineering management, team building skills, and an "other" category used to measure any course surprises or how course expectations aligned with actual experiences. Impact was measured on a scale of one to five, where one was negative, three was neutral, and five was positive. Two and four were reserved for "slightly" to left or right of neutral. Table 2 on the next page illustrates the results of this survey.

Who responded	1st 8-wk students	2nd 8-wk students	All Students Combined	TA's	Instructors	Overall avg.
# Responded	3	8	11	3	4	18
Question	<< Average Scores >>					
1. Communication	4.0	4.2	4.2	4.3	4.2	4.2
2. Engineering Disciplines	2.7	4.0	3.6	3.0	4.5	3.7
3. Networking	4.7	4.5	4.5	4.7	5.0	4.6
4. Project Engineering Management	3.3	3.7	3.6	4.7	4.5	4.0
5. Team Building	4.3	4.8	4.6	4.3	3.8	4.4
6. Other	4.0	4.0	4.0	4.0	3.5	3.9
Total Avg.	3.8	4.2	4.1	4.2	4.2	4.1

Table 2: Post-Course Survey Results

From the table, one can see immediately that the course had an overall positive impact from all parties concerned (3.8 to 4.2) and from all question areas (3.7 to 4.6). This was very encouraging. Also, note that the impact increased slightly for the students between the first and second eight-weeks sessions, validating the change in direction that the course took between the two sessions. In hindsight, we should have given this survey to the entire class after the first 8-week session, but we only gave it to the women from the 1st 8-week session that didn't participate in the second 8-week session. Note that the numbers in the table come from the small class size and are not intended to be of statistical significance. As was stated earlier, the class size was restricted so that the class could be broken in three manageable groups of 4 to 8 students.

Question #1 - Communication

Quantitative The communication question specifically referred to written and oral communication skills. The impact on communication skills remained high and the same for all parties (4.0 to 4.3).

Qualitative Specific comments from students indicated that assembling and making presentations was helpful both for getting over fear and for increasing knowledge in Power Point technology, surfing the internet for facts, etc. It surprised the Team 2000 Instructors that this was the first time that some students had made oral presentations. Comments on communication impact on the instructors were: 1) working with an all-women class was different and a positive experience; 2) necessity of good communication; 3) communication skills increased with knowledge of group dynamics; and 4) a shift in communication occurred from "course creation" in the first 8-week session to "task coordination" in the second 8-week session.

Question #2 – Engineering Disciplines

Quantitative It was surprising that knowledge of the various engineering disciplines increased dramatically between the first and second eight-weeks sessions (2.7 to 4.0). It remained fairly low, however when comparing students and TA's (3.6 and 3.0, respectively) with the instructors (4.5). The student/TA numbers might have increased had the second eight-weeks session been able to make more progress in the storyboard/script writing of the video. Due to a delay in team building, the second eight- weeks session got behind in the progress that they were expected to make.

Question #3 - Networking

Quantitative Networking was by far the highest score of all questions and was consistently high for all parties (4.5-5.0).

Qualitative Students commented that this was a positive benefit that has lead to staying in touch and study groups outside of the class. Students expressed validation when they learned that others of the same gender thought as they did. Students thought it nice to meet others from different majors. TA's and Instructors also saw networking as a positive experience, with such few available engineering females. Instructors got to know students on a more personal basis and gained an understanding of today's young female student. This proved invaluable in helping to serve these students.

Question #4 – Project Engineering Management

Quantitative Knowledge of project engineering management included knowledge of conceptual and detailed design phases of an engineering project, as well as the development of a hybrid design and project fast tracking which is accomplished with concurrent engineering. Knowledge gained in this area was higher for the TA's and Instructors (4.7 and 4.5) than the students (3.6). Student knowledge in this area did increase from the first (3.3) to second (3.7) eight weeks as the project progressed.

Qualitative Students stated that they realized the "chaotic" experience and difficulty of the process. Instructors had prior knowledge of this area that was reinforced. Instructors thought that the metaphorical comparison of an engineering product to a recruitment video worked extremely well.

Question #5 – Team Building

Quantitative The scores for Team building skills were higher for students and TA's than for Instructors.

Qualitative Students saw the course as a great team-building experience and thanked us for that. Students spent a lot of time with their teams and learned a lot about compromise, moving from small groups to larger groups, team leading skills, and organizing meetings (accomplish certain tasks in the given time). TA's had worked in teams in the past and will work with more in the future. Instructors rated themselves harder in this aspect, realizing that we had not sufficiently prepared the students to work together as a team in the second eight-week session. All teams were discovered to be different. There were complex group dynamics among students and unclear plans about carrying out tasks among Instructors. A confrontation absent an unclear plan for carrying out tasks resulted in the development of an Instructor team cooperation strategy.

Question #6 - Other

Quantitative The "other" question was used to capture any course surprises, any variation between course expectations and actual experiences, and any negative or positive reactions to the course. As in the case of team-building, students and TA's (4.0) scored higher than Instructors (3.5).

Qualitative Students reiterated the course positives of teamwork, project management, presentations, critical thinking. They stated that the effort was hard, but worth it. TA's thought that the Instructors expected too much at first. They also felt that we should have deleted the first eight-week session on concept phase and gone right into the detailed hybrid phase, with the idea that more could have been accomplished this way. Instructors identified quite a few surprises, some of which were gender inclusiveness, emotional attachment to conceptual designs, perception that we "male-bashed", perception that there will be no barriers to them in the future, the use of "he" in reference to characters that were both male and female, and perhaps most shocking and atavistic, the use of sex/good looks to sell the engineering profession. Surprisingly, at the end of the course, not one of the students wanted a male to represent their discipline, contradicting their earlier desire to be gender inclusive and subliminal. In summary, students resisted the Instructor's ideas, but actually incorporated them and fed them back throughout the semester. This information was very valuable for the Instructors.

Course Reactions

Some final observations to note were reactions from students and faculty. At the beginning of the course when we were advertising it, male students expressed that they felt excluded and were insistent on enrolling. We told them that males were not excluded. The first 8-weeks, one male wanted to enroll, but then never did. In the second 8-weeks, a non-engineering student insisted on enrolling and when I said that he could, although the course was geared toward pre-engineering students, then he didn't enroll. Also, one female student was initially inflamed by the subject of the course, feeling that girls were given an easy, belittling course subject matter by designing a recruitment video. The only reaction that we got from faculty was from a female faculty member who was totally against the course. She said the women should not be singled out like that. That we should be treated as males and the there was no need for such a course. There was no reaction at all from male faculty.

Conclusion and Post-Project Plans

As stated earlier, the Instructors designed the team collaboration introductory course to provide a grounding in the most essential skills needed in the engineering work world. The course curriculum goal was: 1) to lay a foundation in general engineering project principles; 2) expose students to engineering design phases; 3) develop an understanding of concurrent engineering and design manufacturing; and 4) use the small task group to analyze best product solutions. Beyond the academic curriculum goals, this course set out to support the retention of women engineers in the UNM School of Engineering and raise the awareness of the students of female engineering issues and the need to recruit girls into engineering and computer science.

The Team 2000 course successfully met the above goals and objectives. The Instructors carried out all of the above-stated curriculum goals and exposed the students to "real" engineering scenarios, allowing them ample opportunity to work out problems within teams, resolve intra-

personal issues associated with projects that are not selected, re-align into new teams and redirect energies toward another creative process building on previous experience. Observation along with qualitative and quantitative findings indicated that the students did benefit from working in an "all-female" engineering environment. Instructors observed noticeable positive changes in confidence, self-expression and ability to solve problems from the start point to the finish of the course, particularly with the Teaching Assistants. High ratings and comments on the "networking" question in the survey confirmed that the students did build relationships that extended beyond the course itself.

Unanticipated difficulties in bridging the first and second sessions brought several things to light. The Instructors realized that greater focus should have been placed on team building upon entering the second 8-week phase. The team alliances and identity established in the first 8-week product made it difficult to re-group, thus blocking progress on the final product. A second session of team building would likely have reduced some of those issues.

Follow-up to this course is expected to include a long-range comparison study of the female students who participated in the course to determine if these students persist at higher rates and demonstrate significant differences in success behaviors during their student years, i.e. leadership, grades, etc. Finally, this all-female course, a first in the School of Engineering, lays the groundwork for establishing similar courses directed at retention and enhancement of skills of women engineering and computer science students.

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