

# TEAM 2000: WOMEN ENGINEERING THE FUTURE

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**Abstract** — This paper describes a course offered to engineering female students at the University of New Mexico's School of Engineering. Students were tasked with creating a recruitment video for pre-college students addressing: a) female attrition in technical programs, b) challenges and opportunities of women in engineering, and c) educating on the diversity of options within engineering. The course applied a team collaboration model, utilizing female teaching assistants as team leaders. Initially, each team developed a conceptual design, projected budget and timeline. Next, task teams developed a hybrid design from the conceptual designs. Challenges included 1) gearing the teams to meet fast-paced session deadlines, 2) transitioning teams from identification with individual team design toward a cooperative hybrid design, and 3) finding middle ground between profuse creative ideas and realistic budget and time lines. The paper includes lessons learned, results from a follow-up survey of students, and implications for future courses.

**Index Terms** — Female engineering students, Freshman female engineering education, Mentoring female engineering students

## COURSE OVERVIEW

The purpose of the course was to 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 across disciplines.

## STRUCTURE AND DEMOGRAPHICS

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.

The course was open for all students. 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 (TA's) 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 was comprised of eleven female students. In the second eight-weeks, seven of those students re-enrolled plus one new female student enrolled. 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.

## CONCEPTUAL DESIGN PHASE

Although the "video design project" was not an engineering project 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 software, 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.

The first class focused on an overview of the engineering design process. Dr. Fisher incorporated lecture aspects of a senior project engineering management course (for Civil Engineering and Mechanical Engineering), 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

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humanity” (Babcock and Morse, 2002). In addition, the students received an overview of historical and current statistical data trends of women in engineering (Fisher et.al-2001).

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.

An integral feature of the course’s goal was teamwork therefore the instructors chose to devote an entire class to team building and group dynamics. The Team 2000 project consultant, Elaine Borrelli, 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 1<sup>st</sup> eight weeks. Each of the three TA’s was assigned to lead a team.

- Planning. Each team was tasked with creating its 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. 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: 6<sup>th</sup> to 8<sup>th</sup> 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 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.

## COURSE LESSONS LEARNED

In order to measure the impact that the course had on the initial goals and objectives of the course, we gave the students, TA's, 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 1 illustrates the results of this survey.

Who Responded	1 <sup>st</sup> 8 Wks	2 <sup>nd</sup> 8 wks	Sum	TA's	Instructors	Overall Avg.
# Responses	3	8	11	3	4	18
Question	<< Average Scores >>					
1. Communications	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. Net-working	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 1: Post-Course Survey Results (Fisher, et al., 2001)

From table 1, 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 1<sup>st</sup> 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 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 Surprising the 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 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 “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.

## **FOLLOW-UP ANALYSIS OF STUDENTS**

Four years after completing the course, a follow-up analysis was made of the “Team 2000” students. An overview of the “Team 2000” retention numbers for ten students in Table 2 appears in the following paragraphs. Both GPA’s and matriculation/retention of the “Team 2000” students are

compared with UNM students as a whole. Note that four of the ten “Team 2000” students are of a minority

Student #	Age	Ethnicity (*)	Math ACT (**)	Major (***)	When Started UNM SOE (****)	Matriculation	GPA	# Smstrs	Extra-Curricular/Leadership (*****)
1	23	H	21	ME	BF Fall-‘99	Grad May’04	3.18	9+1 summr	-Current SWE president -FSAE Team Had baby and is still in school
2	23	C	31	BBA-MIS	BF Fall-‘99	Grad Dec’03 Deans list – 3X’s	3.80 magna cum laude	9	-Student employee, 2 yrs -In ESP -Residence hall advisor-2 yrs
3	23	C	27	CE	BF Fall-‘99	Left UNM, Sprg ’02 Returned home Attend'g UN-Reno	2.84	5+1 summr	
4	22	H	21	BBA-HR	BF Fall-‘00	Grad May ’04 Deans list- 4 X’s	3.94	8	
5	22	C	32	ME	BF Fall-‘00	Deans list- 2 X’s	3.85	8+1 summr	
6	22	H	31	ME	BF Fall-‘00	Deans list- 1 X	3.20	8+1 summr	-Organized “Introduce A Girl to Engr’ing Day” 2001
7	23	A	22	ME	TR Spr’00 from NMSU - 12 Hours	Grad=May’04	3.10	8+2 summr	-Past SWE president
8	22	C	25	BIO	BF Fall-‘00	Not available	2.76	8+2 summr	
9	33	C	27	EE		Grad Dec’03 cum laude	3.52	12+2 summr	Cooped at Ford Motor Co.
10	22	C	15	Not Applicable		Susp'd May’02 from UNM-val Spr ’03, last semester attend. Got married	1.92	Not Applicable	IS-100 Math & Reading

Table 2 – Follow-Up Analysis of “Team 2000”

**KEY**

\* C=Caucasian  
H=Hispanic  
A=Asian/Pacific

\*\*American College Testing (total=34)

\*\*\*ME=mechanical engineering  
BBA=baccalunt business administration  
MIS=mgmt information systems  
CE=civil engineering  
HR=human resources  
IS=Introductory Studies  
BIO=biology  
EE=electrical engineering

\*\*\*\*BF=beginning freshman  
TR=transfer  
NMSU=New Mexico State University

\*\*\*\*\*SWE=Society of Women Engrs  
FSAE=Formula Soc. Of Automotive Engrs  
ESP=Engineering Student Programs

classification, which is representative of the new generation of in-coming diverse engineers.

Math entrance scores were varied among the group. Only 3 of the "Team 2000" students scored in the 90<sup>th</sup> percentile of the ACT (students #2, 5, and 6)

The average cumulative grade point average (GPA) of "Team 2000" participants is 3.20 as compared to a UNM cumulative GPA student average of 2.97.

Retention toward matriculation in SOE degrees is less than 40% for all beginning freshmen. Half of the "Team 2000" students will have completed their degrees by Spring 2004. These students took an average of 9.2 semesters to graduate, compared to a UNM SOE average of ten semesters.

Two of the students are non-progress students - Student #3 moved back home to Nevada. She was out of money and not able to live without parent support. She moved back to Reno because she could live at home and attend UN-Reno. She left in good standing in civil engineering mid way between her sophomore and junior year; Student #10 got married and went back home to the Belen, NM area where she attended UNM-Valencia unsuccessfully. The authors do not know much detail. She was suspended Spring 2002 and came back for one semester, earned C's and went away again. She is a classic "stop-out" case with female students once they get married. She may have home/family obligations. She was an "at-risk" student with very low ACT scores across the board. She was enrolled in two remedial classes her first semester at college (IS- Math and IS-Reading). Not fully prepared for college. ACT scores were in mid-teens in science, English, reading, math.

Two of the "Team 2000" students earned non-SOE degrees - Student #2 got frustrated with the Computer Science Department. She left in good standing. She went to the UNM business school and earned her BBA with an MIS Concentration. She left while she was a junior. She could have finished the coursework, but just got "turned-off." Student #4 is graduating Spring '04 with very outstanding grades. She has been on the dean's list four times. Her concentration in the business school is human resources.

At this writing 3 additional "team 2000" students earned will have earned SOE degrees by Spring 2004 (students #1, 4, and 7).

Half of the "Team 2000" have either been on the dean's list or graduated with honors.

Six of the "Team 2000" students demonstrated extra-curricular activities and leadership qualities.

## CONCLUSIONS AND FUTURE 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. Furthermore, a follow-up to this course four years later indicated a long-range success of the female students who participated in the course. The short-term benefits of communication, networking and team building paid off. Four years later it was determined that the "Team 2000" students persisted at a higher rate and demonstrated significant differences in success behaviors during their student years, with regard to GPA, retention, matriculation, and leadership. This first ever all-female course in the UNM SOE history has laid the groundwork for establishing a similar course in the Fall of 2004. Some of the "Team 2000" students have indicated an interest in serving as TA's (mentors) for the lower division females this Fall. A professional videographer was to complete the "video design project" production in the Spring of 2001, but costs were prohibitive. However, technology is such that now inexpensive web-streaming can be accomplished at a fraction of the cost. It is envisioned that this Fall the "video design project" will utilize web-streaming technology and will link the final product to UNM's SOE website.

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