2006-832: HOW WOMEN PERFORM ON INDIVIDUAL DESIGN PROJECTS COMPARED TO MEN

Richard Bannerot, University of Houston

Richard Bannerot is a Professor of Mechanical Engineering at the University of Houston. His research interests are in the thermal sciences and in engineering design education. For the past fifteen years he has taught the required "Introduction to Design" course at the sophomore level and has been involved in the teaching of the department's capstone design course. He is a registered professional engineer in the State of Texas.

How Women Perform on Individual Design Projects Compared to Men

Abstract

The relative performances of males and females are analyzed for two individual projects in a sophomore engineering design class. The first project could be described as creative design for both groups and required the building, testing and describing of devices to tell time using the sun. The females outperformed the males by a considerable margin in all aspects of the project. In the second project, requiring the explanation and demonstration of devices (elements of drive trains) largely unfamiliar (by their own statements) to the females, the females faltered only slightly, relative to the males. However, the females overcame their initial deficiencies in experience and produced overall performances comparable to those of the males. These results indicate that these females are as well, if not better, suited for open ended, problem solving experiences than their males counterparts.

Introduction

There is a leveling off in engineering graduates from universities in the United States at a time when engineers are in demand, and the demand for them is predicted to continue to grow. As a result, the demographics of the engineering workplace will need to change. One of the great untapped resources in this regard is women who traditionally have "under-chosen" (with respect to their fraction of the population) engineering as a profession. Women comprise about 20% of enrollment in the undergraduate engineering programs and only about 9% of the engineers in the workplace in the United States. [1] Some refer to institutional barriers[2], differences in learning styles, "tradition," or social issues[3] for this under representation. Much attention has been focused on encouraging pre-college women to enter engineering programs, and even more effort has been expended in retaining them [4-7]. However, all seem to agree that women are as academic qualified as men[8] for an engineering career.

In a companion paper[9] at this meeting the effect of the presence of women on the performance of design teams in a predominately male environment was examined. Overall performance was shown to have improved when women were part of the teams. Improvement was noted in all aspects of the project: improved testing performance, better quality artifacts, and improved communications. The objective of this paper is to demonstrate that women do as well and often better than men when it comes to individual design and "mechanical" projects.

The sophomore design class in the Department of Mechanical Engineering at the University of Houston requires a major design, fabricate and test (compete) team project which represents between 40% and 50% of the course grade. (More information on the course can be found in reference 10.) The course also requires at least one individual design project that represents between 15% and 20% of the course grade. This paper will report and compare the performances of women and men on two of these individual projects performed in the spring and fall semesters of 2003. For the first individual project, students (including ten women in a class on 38) were required to design, fabricate, and test two sun clocks to determine local time in

Houston, Texas. For the second project eleven of the 41 students were women, and they were required to develop and document a demonstration of an element of a drive train. The paper will present demographic, academic and experiential data on the students, results from student surveys on the projects, and grading information.

The Students

Table 1 presents information on the academic prowess, skill level, and class attitude for the student in the two classes. Generally the males and females match fairly closely with the males having a little more engineering work experience and females indicating higher academic achievement. Further, the males seem somewhat more comfortable in the class and have more experiences with "tools."

Table 1
Work Experience, Academic Background, Skills and Attitudes

	Spring 2003		Fall 2003	
	Male*	Female*	Male*	Female*
Number in class	28	10	31	11
Age (years)	23.0	24.2	22.4	21.3
General work experience (years)	5.1	6.79	4.29	4.25
Engineering work experience (years)	1.33	0.22	1.42	0.45
College experience (years)	2.57	2.88	2.06	1.85
HS gpa	3.13	3.63	3.41	3.82
UH gpa	2.90	3.30	3.01	3.34
SAT verbal	545	646	585	583
SAT analytical	637	676	616	658
I was looking forward to taking this class**	3.90	4.11	3.90	3.27
I am enjoying this class	3.71	4.11	3.60	3.45
I like to work in teams	4.29	3.78	4.16	3.82
I like working in my team*	4.38	3.89	4.19	3.73
I would like to change teams*	1.81	2.11	1.71	2.73
My team is efficient*	3.81	3.67	4.13	3.64
Learning to work on teams is important*	4.81	4.78	4.74	4.73
I am a hands on person	4.35	4.00	4.32	3.82
I have experience using hand tools	4.38	3.44	4.29	2.55
I have experience working in a machine shop	2.90	1.78	3.26	1.45
I have good drawing skills	3.38	2.78	3.47	2.91
Student has good drawing skills (instructor assessment)	2.51	2.94	2.88	2.97

*refers to the work on the another class project (a team project)
**averages for Standard 5-Response Likert Scale Survey (5 = Strongly agree, 4 = agree, etc.)

First Individual Project: Construction of a Sun Clock

In the spring 2003 the following (paraphrased) individual problem statement (For a complete description of the problem and its solution see reference 11.) was assigned:

> Design, fabricate and test devices that will use the sun to determine <u>local</u> time in Houston, Texas, between February 6^{th} and 8^{th} as accurately as possible. The "correct local" time is that provided by the US Naval Observatory for the central time zone.

In particular they were each to design and construct two devices:

- a vertically mounted device (for a south-facing surface) and
- a portable device for use on a horizontal surface.

Both devices were to be designed to read the time <u>directly</u> (i.e., without any "correction"), at times between 8 AM February 6^{th} and 5 PM February 8^{th}. Detailed instructions were given concerning the testing procedures and the alternatives for non-sunny days. Grading would be based on the accuracy of their clocks (30%); the creativity, robustness, and beauty of their devices (20%); and the quality of their written reports (50%). Ten females and twenty-eight males submitted their devices for testing on time. The grading (Extraordinary results were assigned grades above 4.0, i.e., A+.) of the project is provided in Table 2. Further details on the testing and grading for this project are given in reference 11. As seen in the table, the females outperformed the males by a large margin in all aspects of the project. Examples of the devices produced are shown in Figures 1 through 6.

As explained in reference 11, one aspect of this project was for the students to evaluate each others' artifacts and then to compare their evaluations with those of the instructor. The results were that even with explicit grading instructions, the students graded every one very high, especially their self-evaluations, and there was very little discrimination among the artifacts, i.e., everyone was (way) above average. (The students were told to assign only three or four grades above 90 and to assign 70 to the average artifacts.) Approximately 30% of each gender group (eight males and three females) did not provide self evaluations for their projects. However, of those that did, the females rated themselves only an average of 19% above instructor's rating

Table 2
Grading for the Sun Clock Project by Gender
(10 females and 28 males participated)

	Female	Male
Testing 30%	3.00±1.00* 0.67 - 4.00**	2.37±1.33 0 - 4.67
Artifact 20%	2.66±1.05 1.02 - 4.38	2.10±1.09 0.24 - 4.50
Report 50%	3.02±1.38 0 - 4.30	1.74±1.37 0 - 4.00
Project Grade	2.96±1.02 1.15 - 4.07	2.02±1.10 0.41- 3.78

* grading based on gpa of 4.0 =A, etc., and standard deviation

** low and high grades

Fig. 1: Sun Clock from a Female Student
(constructed from “found materials”; about an hour “fast”)

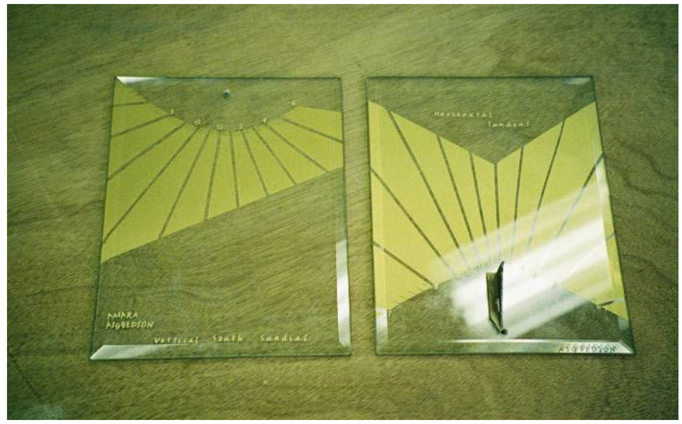

Fig 2: Sun Clock from a Female Student
(etched in glass: horizontal device on right had essentially zero error, but the other was about 40 minutes slow.)

Fig. 3: Sun Clock from a Male Student
(constructed from “scratch”; five minutes “slow”)

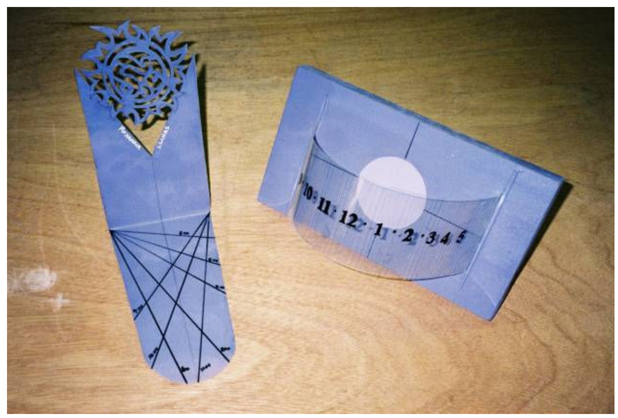

Fig. 4: Sun Clock from a Female Student
(vertical device on right produced an image (shadow) of of numeral on the “spot”; reversed AM and PM)

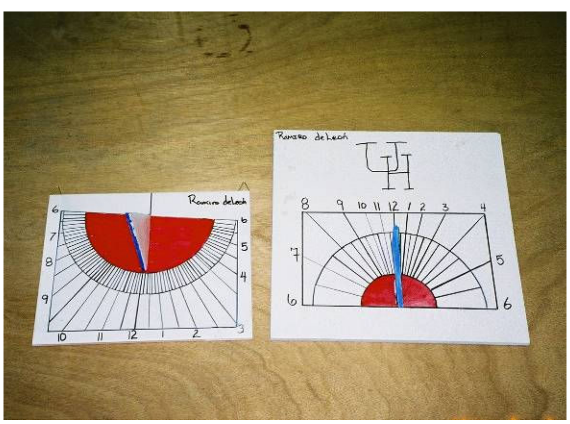

Fig. 5: Sun Clock from a Male Student
(glazed tile; vertical device on left correct to within

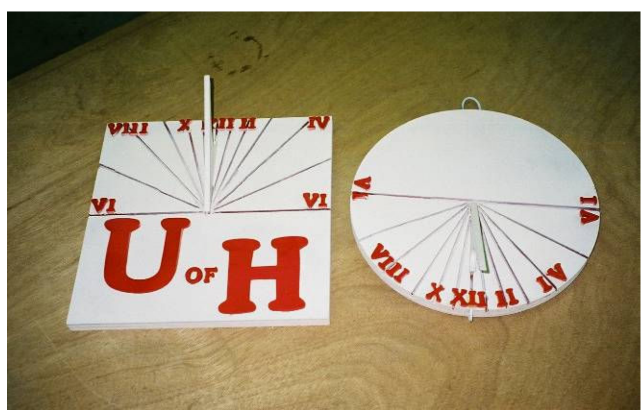

Fig. 6: Sun Clock from a Male Student
(wooden devices; both about 30 minutes “fast”)

minutes; the other one was 45 minutes "fast")

while the males rated themselves 67% above. A similar result (harsher female self criticism) is also seen in the last two rows of Table 2 where the students' self-assessment and the instructor's assessment of the students' drawing abilities were compared. (A more detailed analysis of this suggested lack of qualitative or subjective evaluation skills demonstrated by these engineering students is given in reference 11, but the separate reporting of male and female data was not given there.) On the other hand, the average grade assigned by the females for all the projects was 86.4 which was actually slightly higher than the average male assigned grade (85.5), and their average standard deviation for all grades was slightly less (5.79 compared to 5.95 for the males). The instructor's average grade was 68 with a standard deviation of 18. These results seem to indicate that the males and females have similar evaluation skills in general but that there is a significant difference in their self images or self-confidence in the area of design and construction. This result is somewhat surprising given that the females actually scored considerably higher than the males on all aspects of the projects. (See Table 2.)

Second Individual Project: Demonstration of a Drive Train Component

The statement of work was (greatly condensed here) (See reference 12 for details):

> Select an assembly or subassembly of a drive train. Obtain an actual, working example of that component and develop a table-top demonstration to explain its use and operation that would be of interest to a high school student. Finally, prepare a formal technical report on the project.

In reality they were to explain their exhibit to each other and to any other students wandering through the lobby of the engineering building the day the projects were displayed. The average grades for these two aspects of the projects were as follows: demonstration of a working example: females: 2.62/4.00; males: 3.09/4.0 and the technical report: females: 3.13/4.0; males: 2.99/4.0. The final grades for the project which included several other minor contributions including a proposal were: females: 3.02/4.0 and males: 3.11/4.0. The students in the class were surveyed after the project, and the results are provided in Table 3. Of special interest are the female responses to statements 2, 5, 6, and 7. The females were generally unhappy about this project, and several went so far as to say that they felt the project was "unfair" since the males knew "much more about that sort of thing." However, the females indicated that they "learned a lot" and would support more of the same (Statement 7). It is interesting that ten of the eleven females responded that they "strongly disagreed" that they "had considerable previous experience that was useful for this project" (statement 5). The eleventh only "disagreed." Nine of eleven "strongly agreed" (the other two "agreed") with statement 6 that they "knew very little about the topic of their project before this semester." The point is that despite their relatively poor showing (lower grades for the demonstration part of the project), the females apparently benefited greatly from the project. Incidentally, for the team design project in this semester, eleven teams were formed and five of them had female members. These five teams averaged 3.98/4.0 for the entire team project, while the six all-male teams averaged 3.20/4.0.

Table 3
Responses from a Survey of Participants in the Drive Train Component Demonstration Project.
(Student indicated the degree to which they agreed or disagreed with the statements on the left with a 5 for "strongly agree", a 4 for "agree", a 3 for "neither agree or disagree", 2 for "disagree" and 1 for "strongly disagree.")

Group	All	Males	Females
Number of responses	41	30	11
1. This was a worthwhile project.	3.83	3.87	3.73
2. I learned a lot from doing my particular project.	4.10	3.93	4.55
3. I enjoyed learning on my own.	3.88	3.93	3.70
4. I enjoyed sharing my knowledge about my project with others.	3.98	4.03	3.82
5. I had considerable previous experience that was useful for this project.	2.85	3.50	1.09
6. I knew very little about the topic of my project before this semester started.	2.95	2.27	4.82
7. I would support a "learning laboratory" in the Dept. where students could "interact" with various mechanical devices on their own time	4.29	4.17	4.64

Discussion

Females entering an engineering discipline may do so with a perceived "competitive disadvantage". The results of this paper strongly disputes this perception related to design and problem solving issues. The Sun Clock Project could be viewed as "creative" or "original" design, and both genders began on equal footing regarding background. The female students produced more functional and better looking devices. Their communications abilities (in the new-to-both-groups genre of technical writing) were much better than the males. The Drive Train Project could be viewed as a variant design project to many of the males and a second creative design project for the females since, by their own responses, they "knew very little about the topic" at the beginning. Yet despite this initial knowledge disadvantage, the overall performances by the females was nearly as good (3.02/4.0 versus 3.11/4.0) as the overall male performance. Hence, through two types of design experiences the females have demonstrated a superior problem solving ability.

Conclusions

The relative performances of males and females have been monitored and analyzed during two individual projects in a sophomore engineering design class. Generally, the females were shown to have better communication skills and were more successful in addressing a new technical problem (design and fabricating a sun clock). The females faltered slightly, relative to the males, only when faced with a problem for which they were at an "experiential" disadvantage, developing a demonstration for a component associated with a drive train. In spite of an initial deficiency related to their lack of preparation for the project, the females quickly overcame any difficulties and in the end performed just about as well as the males.

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