Does Gender Affect Student Perception of Engineering Courses in a Common First Year Program?

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Abstract

In the fall of 2000, Michigan Technological University started a common first year program for all engineering students. In conjunction with the student course evaluations, the students answered ten additional questions. These questions were used to evaluate their perception of the first year engineering courses. The responses were used to assess the students':

- comfort in using the material and software taught in the courses,
- experiences in working on a multi-disciplinary team
- perceptions of the semester design project
- self-assessments of their technical communication skills
- reporting of the time spent on this course and if they thought they spent too much time on the course

The students were asked to report their gender. When the data were analyzed, there were significant differences between the male and female students. For instance, the women tended to spend more time on homework and report that this amount of work was not excessive. The men reported the opposite. The women tended to rank their ability to use the tools taught in the class lower than their male counterparts. This statistic was contradicted with student performance. Typically, the female students out perform or perform at the same level as the men.

This paper discusses the surveys that have been completed over a three year period. It investigates how the data changed over time and how gender may have affected student response.

Introduction

Women and men face different challenges when they enter engineering school. In general, most men are more likely to succeed in engineering due to many factors. First, the traditional stereotype that men are good at math and science, while women are perceived to have less ability.¹ To help women succeed, researchers have suggested that students work in teams, receive encouragement, and learn via various instructional methods.^{1,2} Because men are expected to excel in math and science prior to college, this expectation follows them into the university where they have more confidence that engineering is the right career choice for them than women.³ Women have a tendency to doubt their abilities and frequently question their decision to study engineering. Therefore, men are more likely to continue studying engineering than women. Increasingly, students are required to work on teams within their engineering courses. At many universities, this experience begins in the first year. Men and women report differences in their teaming experiences. Many women report that men tend to take control of the assignments and meetings. They feel that their input and talents are less valued than the men's opinions. Men frequently report that women are too emotional and not interested in working on the physical/mechanical aspects of projects.⁴ Conversely, women enjoy working on teams because teams allow them to form relationships and learn through discussions with their teammates.⁵

To determine if first year engineering courses are meeting the needs of the students and to see if gender affected the perception of the courses, a student survey was developed. Basically, the first year engineering program wanted to determine if women and men were facing different challenges within the program. The faculty wanted to see if the first year engineering classes were meeting the needs of men and women without excluding either one.

Background

Michigan Technological University has had a common first year engineering program since the fall of 2000. Within this program, the students who are Calculus ready take two engineering courses: Engineering Analysis and Problem Solving (ENG1101) and Engineering Modeling and Design (ENG1102). Both courses involve students working on teams in an active learning environment. ENG1101 focuses on students learning basic engineering tools and applying them to engineering problems. In ENG1102, the focus centers around 3-D modeling and modeling a system using MATLAB. During an academic year, approximately 900 first year engineering students take ENG1101 and ENG1102.

Each semester, students review the overall course by completing a university student evaluation. Instructors are only required to have student evaluations completed in one section of each course they teach. For example, in the fall semester, most instructors teach between two and four sections of ENG1101, but they are only required to have students evaluate the course in one section. During the analysis period, the first year engineering program was structured such that during the fall semester there are approximately twelve sections of ENG1101 and four (trailing) sections of ENG1102. This structure was reversed in the spring semester where there were approximately three times as many sections of ENG1102 than ENG1101. Typically, for this

period, most first year engineering students took ENG1101 in the fall and ENG1102 in the spring.

In addition to completing the university evaluation, students answered ten additional questions. This survey information was analyzed for three semesters: Spring 2001, Fall 2002 and Spring 2004. The breakdown of the sections of ENG1101 and ENG1102 are listed in Table 1. The number of sections of each course that were taught are listed in the table. It shows the number of surveys that were completed each semester, along with the approximate number of sections where the surveys were completed. Because evaluations were not completed in all sections of the courses and some students elected not to participate, the number of surveys completed was significantly less than 900. To protect instructor confidentiality, the overall survey results are scanned for analysis. The student's section criteria is removed from the analysis. The average section size for ENG1101 and ENG1102 was 55 students.

Table 1: First Year Engineering Course Distribution

Semester	ENG1101				ENG1102			
	# of Sections Reporting	Surveys*			# of Sections Reporting	Surveys*		
		Men	Women	Total (# sect)		Men	Women	Total (# sect)
Spring 2001	3	115 (72%)	41 (26%)	159	9	444 (79%)	110 (20%)	562
Fall 2002	6	264 (79%)	61 (18%)	333	2	90 (77%)	26 (22%)	117
Spring 2004	3	140 (75%)	31 (17%)	186	6	239 (70%)	59 (17%)	341

*Note: Some students did not report their gender on the survey.

One of these questions from the university evaluation form was used in this analysis and is noted in Table 2. In addition to the university required questions, the first year engineering program added ten additional questions. The questions and ranking are shown in Table 2. Initial findings of student perception were published in 2002 for data collected in the spring 2001 semester.⁶ The survey questions addressed issues regarding the overall perception of the course, teaming, communication skills and the design project. In the fall 2002 semester, the survey was updated to include more teaming and communication skills questions. These new questions are noted in Table 2.

Table 2: Student Evaluation Questions and Ranking

University Question	Ranking
I wanted to take this course	Strongly Agree – Strongly Disagree (5 point scale)
First Year Engineering Program Question	Ranking
Taking everything into account, I consider this instructor to be an excellent teacher	Strongly Agree – Strongly Disagree (5 point scale)
Engineering Major	ME, Chem, Civ/Env, EE/CPE, Other
Taking everything into account, I consider this course to be an excellent course	Strongly Agree – Strongly Disagree (5 point scale)
Overall, I thought the team design project was a meaningful learning experience	Strongly Agree – Strongly Disagree (5 point scale)
The average number of hours per week I spent on homework in this course was	<3 hours, 3-5 hours, 5-7 hours, 7-9 hours, >9 hours
The total amount of time I spent on this course was	Excessive, Too Much, About Right, Too Little, Minimal
This course helped me to confirm/select a major (Fall 2002 and Spring 2004)	Strongly Agree – Strongly Disagree (5 point scale)
This course enhanced my ability to function effectively on a task-oriented team (Fall 2002 and Spring 2004)	Strongly Agree – Strongly Disagree (5 point scale)
My communication skills (written and oral) were improved through completion of the assignments in this course (Fall 2002 and Spring 2004)	Strongly Agree – Strongly Disagree (5 point scale)
I am confident in my ability to effectively utilize the software tools incorporated in this course (Fall 2002 and Spring 2004)	Strongly Agree – Strongly Disagree (5 point scale)

Engineering Major

The first item analyzed was the choice of engineering major. This is shown in Figures 1 and 2 for ENG1101 and ENG1102, respectively. The “Other” category contains the Geological, Biomedical, Materials and Undecided Engineering students, along with those students enrolled in the School of Technology. The distribution for each course was different because many students change majors and/or select majors during their first year. Theoretically, the distribution of major for the Spring Semester of 2001 should be the same as the data collected for the fall 2002 semester of ENG1102. In actuality, the data trends are the same, but the values differ slightly. This could be due to some students not reporting their major on the survey, some students changed majors between the fall and spring semesters, or the population changed slightly because students transferred into or out of engineering. Men and women do select engineering majors at different rates. The men tend to select mechanical and electrical/computer engineering. The women, on the other hand, tend to be distributed across the majors. This distribution could be skewed due to the low percentages of women enrolled in engineering, not all of the students reported their major and not all sections were surveyed. It is significant that for each semester of data, there were higher percentages of women than men enrolled in Chemical

and Civil/Environmental Engineering. Although, the data are not reported in this report, the fraction of women enrolled in Biomedical Engineering exceeds the fraction of men. These trends are typical of national data. In general, women select engineering majors where they perceive they can provide a benefit to people and/or society. Men select more “physical” majors where they can use their analytical and spatial skills.⁷

Figure 1: Engineering Major Distribution in ENG1101

Figure 2: Major Distribution in ENG1102

Workload Analysis

Students frequently comment on the work required in ENG1101 and ENG1102. To determine whether or not the students were being overworked, they were asked to report to amount of time they spent each week on the course. Both ENG1101 and ENG1102 are three credit classes. Students are expected to spend 2-3 hours completing homework and studying outside of class per credit hour.⁶ Therefore, the students should expect to spend 6-9 hours preparing for class and completing homework. Figure 3 through 6 show the student data from the questions listed in Table 2.¹ Most of the students, regardless of gender reported that they spent approximately 3-5 hours per week on homework and studying in ENG1101. For the most part, the students reported that the amount of homework was “about right”. The initial analysis of the data shows that the amount of time spent outside of class is less than what the guidelines are.

There were significant differences reported between genders. Approximately 37% of the women in 2001 reported that they spent more than 7 hours outside of class on the ENG1101 material, and 26% and 9% in 2002 and 2004, respectively. The amount of time the men spent on homework for the same semesters is different. Only 15%, 20% and 9% for 2001, 2002 and 2004, respectively, reported spending more than 7 hours out side of class. Figures 3 through 6 show that the amount of work students completed outside of class decreased over the three semesters that data were collected. This decrease is mainly attributed to fine tuning a new program and increasing the work time during class. The in-class work time affected more than just the amount of time students spent on the course. It also affected the students’ perception of the courses which is discussed later in this paper.

For all the data collected in ENG1102, a higher percentage of women reported that they were spending more than 7 hours per week on homework than men. The women reported at lower

¹ **NOTE:** For all of the following Figures and Tables, the overall data are not shown because the overall trends are essentially the same as the trends for the men. This is due to the high number of men relative to women.

rates than men that the workload was not excessive. Other researchers have reported similar trends.^{1,2} Women tended to spend more time on their coursework than their male counterparts. Because many women reported feelings of inferiority when asked about engineering, science and math, women may work harder outside of class.

Figure 3: The Average Number of Hours I spent on Homework in ENG1101

Figure 4: The Total Amount of Time I spent on ENG1101

Figure 5: The Average Number of Hours per Week I spent on Homework in ENG1102

Figure 6: The Total Amount of Time I spent on ENG1102

Teaming

A major component of ENG1101 and ENG1102 is teaming. At the beginning of the semester, students are assigned to teams. They learn about teams, team interactions and team roles and team challenges. In the second course, the students review teaming and discuss how their team worked or did not work. In both courses, the students work in teams in class, on team assignments and on a semester long design projects. With few exceptions, the teams are assigned such that no underrepresented group in engineering is on a team without someone similar to them. This structure is used to minimize the feeling of marginalization that many underrepresented groups in engineering report.^{1,8}

The team approach to learning provides an active environment in the classroom. Students not only talk within their team but they have discussions across team boundaries. These discussions center on the class activity and provide the instructor with the opportunity to work with teams that are having difficulties with the activity. Teams appear to benefit the women in the classes more than men. The women report that they enjoyed the team design project and working in a team more than men. Figures 7 through 10 graphically show how the students perceived their design project and team experience in ENG1101 and ENG1102, respectively. Figures 8 and 10 have only two semesters of data because this question was added to the survey in the fall 2002 semester (See Table 2). Every year, ENG1101 and 1102 are improved. One of the most significant improvements that relates to women in the engineering program is the inclusion of additional in-class work time. For each course, there are approximately three to five days of in-

class work days throughout the semester. On these days, the instructor and teaching assistant work with individual teams on portions of their design project, homework and analyses. These class sessions are dynamic and active. Teams ask other teams questions, along with the instructor and teaching assistant.

The students' perception of the design project in ENG1101 has improved over the three year monitoring period. During the survey period, the women stated that they felt the course helped them function on a team and the fraction of women reporting this has increased from 2001 to 2004. Unfortunately, the women report that their teaming experience is not as good in ENG1102. This can be attributed to the material covered in the course and is discussed later in the paper.

Technical Communication Skills and Computer Tools

A primary goal of the first year engineering program at Michigan Tech is to improve the technical communication skills of the students. Students learn how to communicate as an engineer through writing reports and memos. They give technical presentations both semesters. Survey questions were used to determine the student's perception of their communication skills. Figures 11 through 14 show the students' evaluation of these skills. Once again, there are only two semesters of data because these questions were added in fall 2002.

In ENG1101, the women were slightly more positive regarding the development and improvement of their communication skills than the men. This same trend was true in the use of computer tools learned in ENG1101. The tools applied to assignments in ENG1101 were Mathcad and spreadsheets. These tools were either familiar to the students and/or user-friendly to learn.

ENG1102 focuses on the application of I-DEAS to model 3-D systems, and Matlab to simulate a process. These tools are not as intuitive for the students to learn and use. Therefore, the confidence of the students to use these tools decreased between ENG1101 and ENG1102. A smaller percentage of women than men reported that they were confident in the use of Matlab and I-DEAS. Women students reported at higher rates that they were not confident in the use of these tools (The “disagree” and “strongly disagree” categories in Figure 14). This gender difference could be attributed to two observations: fewer women selected majors where they would be more likely to use these tools (Mechanical, Electrical and Computer Engineering), women tend to be less familiar with computers and software entering engineering school.

Figure 11: My Communication Skills (Written & Oral) were Improved through Completion of the Assignments in ENG1101

Figure 12: I am Confident in my Ability to Effectively Utilize the Software Tools Incorporated in ENG1101

Figure 13: My Communication Skills (Written & Oral) were Improved through Completion of the Assignments in ENG1102

Figure 14: I am Confident in my Ability to Effectively Utilize the Software Tools incorporated in ENG1102

Remaining Survey Analyses

The survey assessed the student’s overall perception of the course and instructor, whether or not they wanted to take the courses and if the courses helped them select/confirm their engineering major. Tables 3 through 6 show the data for these questions. In general, most of the entering freshmen want to take ENG1101, regardless of gender. Unfortunately, less students want to take ENG1102. This may be an artifact of ENG1101. In ENG1101, many topics are covered at a rapid rate. While solving engineering problems, students learn how to use:

- College of Engineering computing system
- Spreadsheets
- Mathcad
- Oral and written technical communication.

With all these topics, ENG1101 becomes a class filled with important information but it is very difficult to tie into one integrated course. ENG1102 is not disjointed, but students enter the course with that perception due to their experience in ENG1101.

Table 3: I wanted to take this course

	ENG1101						ENG1102					
	Spring 2001		Fall 2002		Spring 2004		Spring 2001		Fall 2002		Spring 2004	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Strongly Agree	11%	10%	14%	10%	19%	29%	5%	2%	12%	12%	9%	10%
Agree	43%	22%	41%	41%	46%	42%	22%	25%	41%	35%	35%	39%
Neutral	26%	39%	27%	36%	24%	29%	32%	29%	26%	23%	34%	27%
Disagree	7%	15%	12%	7%	9%	0%	24%	21%	13%	27%	13%	15%
Strongly Disagree	10%	12%	7%	7%	1%	0%	18%	23%	8%	4%	9%	8%
n	115	41	264	61	140	31	444	110	90	26	239	59

Within the survey, students are asked if the instructor and the course were excellent. In a recent paper, these items are tied together.⁹ The same holds true for ENG1101 and ENG1102. In ENG1101, the percentage of women ranking the course and the instructor as poor was lower than the percentage of men. The opposite is true in ENG1102. This could be due to the course content. The software packages in ENG1102 include MATLAB (used as a programming language) and I-DEAS (a 3-D modeler). Because these software applications are used predominantly in Mechanical and Electrical/Computer Engineering, the students in these majors should find the class more interesting and applicable. Both of these factors greatly impact the ranking of the course as excellent. Very few women enroll in these majors. Therefore, it was expected that a higher percentage of women would rank ENG1102 lower than their male counterparts. ENG1101, because it focuses on technical communication skills and developing teaming skills, fewer women rank the course poorly. Most women find communication skills more interesting and less difficult than the material covered in ENG1102. They enjoy the team aspect of the courses more than the men.

In ENG1101, students complete two technical presentations, an historical engineering event/invention and an Engineering Ethics Case Study. Student teams self-select the topic for their engineering history presentation from a list of several hundred topics. The topics range from mathematical, science and engineering equations to engineering inventions that have altered society (assembly line, solar energy, computers, etc.) (See the link to the pdf file on: www.geneng.mtu.edu/eng1101.html for the complete listing of historical topics). The breadth of these topics allows teams to select something that really interests them. Therefore, the presentations are good. During the time period of the survey, the Engineering Ethics Case Studies were all based on the standard case studies (ie: On-Line Ethics, NSPE Ethics Case Studies). The ethical issues in these studies are easy to delineate and analyze. Students commented that they would like more case studies that looked at open-ended issues and current topics. In the spring, 2005 semester, over twenty additional case studies were added to the choices for students. The complete list can be reviewed on www.geneng.mtu.edu/eng1101/fall04/ethics/ethics.html. These issues include the power outage in 2004, oil drilling in the Arctic National Wildlife Refuge and Technology in third world nations. The new cases address engineering issues that affect society and people. This is one area of engineering that women find interesting.

Table 4: Taking everything in account, I consider this instructor to be an excellent teacher

	ENG1101						ENG1102					
	Spring 2001		Fall 2002		Spring 2004		Spring 2001		Fall 2002		Spring 2004	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Strongly Agree	23%	24%	24%	39%	49%	58%	41%	43%	26%	23%	31%	25%
Agree	43%	46%	47%	30%	41%	42%	32%	27%	56%	54%	43%	37%
Neutral	21%	24%	21%	20%	7%	0%	16%	25%	16%	15%	20%	24%
Disagree	5%	2%	6%	8%	2%	0%	7%	4%	2%	8%	4%	8%
Strongly Disagree	4%	0%	0%	3%	0%	0%	4%	2%	0%	0%	2%	3%
n	115	41	264	61	140	31	444	110	90	26	239	59

Table 5: Taking everything into account, I consider this course to be an excellent course

	ENG1101						ENG1102					
	Spring 2001		Fall 2002		Spring 2004		Spring 2001		Fall 2002		Spring 2004	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Strongly Agree	4%	7%	6%	13%	11%	23%	3%	2%	6%	19%	7%	5%
Agree	47%	22%	35%	25%	48%	45%	21%	18%	43%	23%	35%	34%
Neutral	29%	39%	30%	28%	29%	29%	25%	21%	33%	38%	31%	32%
Disagree	11%	22%	14%	25%	10%	3%	27%	28%	12%	19%	17%	15%
Strongly Disagree	9%	10%	14%	7%	3%	0%	23%	31%	4%	0%	10%	12%
n	115	41	264	61	140	31	444	110	90	26	239	59

Many students enter the first year engineering program as engineering undecided students. Over 60% of entering college students change their major at some point in their college career.¹⁰ Therefore, students were asked if ENG1101 and ENG1102 helped them to select their major or confirm that they were in the “right” major. Men reported that ENG1101 did not help them with this decision, but ENG1102 did at higher rates than women. The opposite was true for the female students. They felt that ENG1101 helped them to select a major but ENG1102 did not. This difference could be due to many factors. First, as mentioned above, women and men did not perceive the first year engineering courses the same. Women were more positive regarding ENG1101 which could explain why that course helped them select a major. Men perceived ENG1102 as more beneficial; therefore, they reported that it helped them choose their major. Secondly, Figures 1 and 2 show that more women are in the “Other” category regarding engineering major. Most of the students within this category are undecided. The number of women in this category who were enrolled in ENG1101 is much higher than the number of women who are undecided and taking ENG1102. Therefore, several women made their decision regarding their engineering major while they were enrolled in ENG1101.

Table 6: This course helped me to confirm/select a major

	ENG1101				ENG1102			
	Fall 2002		Spring 2004		Fall 2002		Spring 2004	
	Men	Women	Men	Women	Men	Women	Men	Women
Strongly Agree	5%	8%	9%	19%	7%	12%	4%	5%
Agree	20%	18%	22%	29%	19%	23%	14%	14%
Neutral	37%	39%	36%	29%	37%	31%	38%	27%
Disagree	23%	26%	21%	16%	23%	35%	29%	36%
Strongly Disagree	14%	8%	11%	6%	14%	0%	15%	19%
n	264	61	140	31	90	26	239	59

Conclusions

The use of optional questions on the student evaluation forms within the first year engineering program has been analyzed to find the differences between the perceptions of the male and female students.

Women reported at higher rates that ENG1101 helped them to select a major than their male counterparts. Women reported that they enjoyed ENG1101 more than ENG1102. The data for men was the opposite. Women reported that they were able to use the software packages from ENG1101 better than they could use the ones from ENG1102; the men reported the opposing trend. This was most likely due to the material in the two courses. ENG1102 focused on software that was more applicable to disciplines that women traditionally do not choose (Mechanical, Electrical and Computer Engineering). Women found the teaming aspect to be a positive experience in both engineering classes. The men ranked teaming as a favorable experience, but at a lower rate than the women.

The Department of Engineering Fundamentals plans on continuing this survey to see if the trends change over time. This research will continue to seek out the qualitative and quantitative factors that effect and/or enhance the success of women engineering students.

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