

## Women in engineering in Turkey – a large scale quantitative and qualitative examination

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The underrepresentation of women in engineering is well known and unresolved. However, Turkey has witnessed a shift in trend from virtually no female participation in engineering to across-the-board proportions that dominate other industrialised countries within the 76 years of the founding of the Turkish Republic. This paper describes the largest known direct cross-sectional study of women in engineering in Turkey with over 800 participants. The methods include survey and facilitated focus groups. The study shows that women in Turkey choose engineering mainly because they enjoy the underlying mathematics and science. There is no gender bias on the part of teachers or fellow students; however, women students believe that they have fewer opportunities than male peers and acutely feel the lack of role models. Working professionals in industry or government perceive that women assume a more indirect, supporting role; however, women overall strongly affirm their selection of engineering despite some negative factors.

**Keywords:** women engineers; engineering in Turkey; engineering education in Turkey; survey; focus groups; cross-sectional study

### 1. Introduction

While the percentage of women studying engineering has risen over the past 20 years, it is still a low proportion across all degree levels and for most engineering majors. A few studies from the research literature highlight this. Byko (2005) interviewed women in science and engineering to investigate the challenges and opportunities in their life stories. Based on her interviews, she reported that parental support is the most important support so that a woman could feel ‘she could do anything she wanted to do’. Schaefer (2006) outlined an approach needed for women’s success in engineering. This approach centres on establishing good role models and to be honest and realistic about the hurdles young graduates face when entering the engineering workforce. The gender diversity issues were illustrated by seeing the numbers of women in engineering dropping drastically over the last 5 years at University of Wollongong in Australia. Sonnert *et al.* (2007) examined the effect on women’s percentages among undergraduate majors and among degree recipients of four factors: (1) the percentage of faculty who are women in the

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students' major science/engineering area; (2) the students' disciplines (biology, physical sciences, and engineering); (3) the type of institution in which students are enrolled; and (4) time trend (1984–2000). They concluded that over a 16-year period, the percentage of women majors in the sciences and engineering and those of women recipients of bachelor degrees in these fields and across departments have risen steadily. Secondly, this study concluded that gender segregation by fields is still in full force and shows no signs of abating. The effects of discipline and department are stronger than that of institution. The authors followed up in 2009 with an article which focused on programmes for undergraduate women in science and engineering (Fox *et al.* 2009). Using a comprehensive, quantitative, cross-institutional, and longitudinal method, two extreme groups of programmes were distinguished: those associated with the 'most successful' and 'least successful' outcomes in undergraduate degrees awarded to women in science and engineering. Using qualitative analyses of interview data with principals in the programmes in these two groups, the authors concluded that programmes that regard issues, problems, and solutions of women in science and engineering as institutionally oriented are associated with the most positive outcomes.

Figures 1 and 2 show Turkey's achievements in women in engineering academia and women in professional engineering positions relative to the USA. To emphasise a few statistics, in 1989, 24% of the Turkish engineering work force (The Turkish Chambers of Engineering 2004) and 23% of the engineering faculty members (The Turkish Council of Higher Education Statistics 2005) were women, and by 1994, these proportions had reached levels much higher than those of Ireland, the Netherlands, the UK, and USA (Hersh 2000). In 2005 in the USA, women accounted for 17.2% of the engineering undergraduates, 9.2% of the engineering faculty members, and 10.2% of the engineering work force (US National Science Foundation, 2003, 2005, 2006; The Turkish Council of Higher Education 2005); however, in Turkey the percentage of undergraduate women engineering students was nearly 22, the percentage of engineering graduate women students was 32, and the percent of engineering women faculty was about 28 (The Turkish Council of Higher Education 2005). These accomplishments are especially interesting since Turkey is a relatively newly established republic (just over 80 years old) and possesses a society with a cultural heritage of more traditional roles for women (Federal Research Division, Library of Congress 1996).

Considering the relevant literature, Tantekin-Ersolmaz *et al.* (2006) looked at the historic and current situations of engineering higher education in Turkey, echoing back to the formation of the Turkish Republic in 1923. Tuzel studied how women in male-dominated professions during the early years of the Turkish Republic faced discrimination (Tuzel). Kusku *et al.* (2007) studied

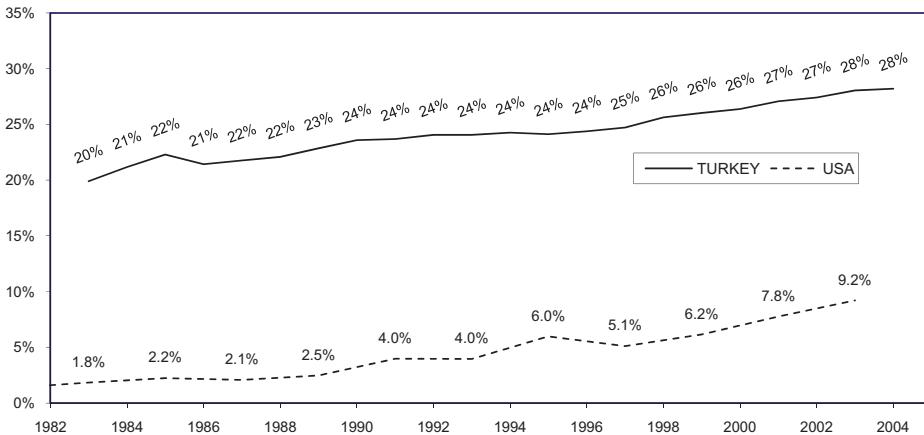


Figure 1. Percentage of women faculty members in engineering in Turkey and in USA over time (The Turkish Council of Higher Education Statistics 2005).

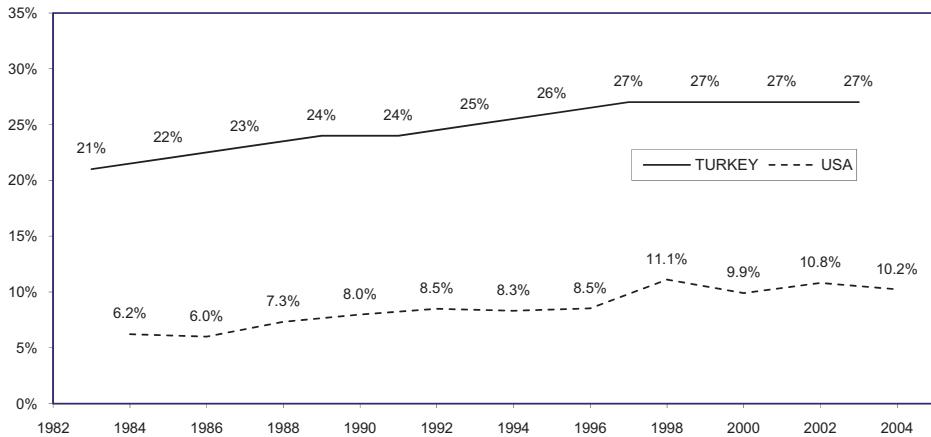


Figure 2. Percentage of women working in engineering in Turkey and in USA over time (The Turkish Chambers of Engineering 2004).

statistics and compiled surveys from both women and men engineering students at one university in Turkey to examine gendered prejudice. They concluded that men viewed women as less suitable for engineering, while females were essentially gender neutral on this point. They believed that large numbers and percentages of women in engineering are not enough to counteract the pervasive form of gendered prejudice. Zengin-Arslan (2002) examined women in engineering in Turkey based on average percentage of female students in engineering departments in Turkey in 1998. The aim of this article was to assess the gendered distribution in engineering departments in Turkey and show how this configuration was shaped and how influenced women's experiences with engineering departments. The paper stated that engineering departments can be grouped as 'Masculine Engineering' (mechanical, civil, electrical, petroleum, metallurgical), 'Feminine Engineering' (food, chemical, and environmental), and 'Mixed Sex Groups' (geological, industrial, nuclear energy, computer, aeronautical, mining, hydrogeological, and geophysical). Arslan and Kivrak (2004) examined the current position of women in civil engineering in Turkey based on data provided by the government and engineering societies considered. Their study concluded that women's priorities in the profession can be ranked as job satisfaction, permanent employment position, high salary, and prestige of position. However, women in construction were not happy because of the conflicts and barriers in that field.

The larger than that might be expected female participation in engineering in Turkey prompted our project. We were interested in knowing what prompted so many women to choose engineering studies. We wanted to know what factors played the most significant role in their choice of profession and what they thought of their experiences in the university and in the working environment. We hypothesised that the answers lie in the founding of the Turkish Republic when education, modernisation, and equality of women were hallmarks. Some relevant quotes from Ataturk (Mustafa Kemal), founder of the Turkish Republic: 'Teachers are the one and only people who save nations'. 'Everything we see in the world is the creative work of women'. 'Our true mentor in life is science'. 'The reason for the lack of success of our society lies in the indifference towards our women. Man comes into the world to live as long as his destiny allows him. To live is to act. So, if an organ of a society acts while the other lies idle, then it means that society is paralysed. A society must accept all the conditions and necessities on which its success in life depends. So, if science and technology are necessary for our society, our men and women must equally master them. As you know, division of labor is necessary in social life as it is in all the other fields. In general division of labor, women should not only carry out their duties, but they

should also take part in efforts for the prosperity and welfare of the society'. In a country which reveres these words, it is perhaps not surprising to find the largest percent participation of women in engineering.

Over a span of several years, extensive surveys and focus groups were carried out in Turkey with female engineers or aspiring engineers. Over 800 women took part in our study – the largest direct such study ever done in that region, to our knowledge. This study was cross-sectional, that is, a snap shot of women engineers at various points in their educational and professional careers, and was done in three parts in the following order: first, a survey was conducted at seven universities in Turkey to ascertain the current ratio of women in engineering by department (discipline) and to identify to the reasons why young women in Turkey chose engineering. Second, to expand the survey results, facilitated focus groups were held with over 70 women engineers at all levels (bachelors, masters, PhD, faculty members, and professional) in Turkey. Finally, Turkish female high school students were interviewed to examine the younger students' aspirations and motivations. The rest of the paper is organised as follows: in Section 2, the Turkish education system is described. Section 3 focuses on presenting and discussing the results of the survey. Results of the focus groups are discussed in Section 4. Section 5 contains a concluding discussion.

## **2. The national education system of Turkey**

To provide the proper context for the study that is the subject of the rest of this paper, we give an overview of the Turkish educational system. Although Turkey has a freely elected government, the educational system is mostly regulated on a federal level (The Turkish Council of Higher Education). State universities were established by the government; however, they have a degree of autonomy in teaching and research. Universities established by non-profit private foundations remain under supervision and control of the state, but are more independent than state universities. All institutions of higher education in Turkey accept students according to the results of the placement examination conducted by The Student Selection and Placement Centre (OSYM).

## **3. Survey undertaken and results**

The largest part, numerically speaking, of the study dealt with a survey that was distributed to six Turkish universities, the largest survey of its type in the region to our knowledge. The universities that participated are Middle East Technical University (METU) (Ankara), Bilkent University (Ankara), Gazi University (Ankara), Hacettepe University (Ankara), Bogazici University (Istanbul), Marmara University (Istanbul), and Istanbul Technical University (Istanbul). Collectively, these represent the larger and more prestigious engineering programmes in Turkey. A total of 671 female students who were attending these universities responded to the survey. The total engineering enrolment at these universities was approximately 23,000 students, of whom about 5000 were women. The students responding to our survey were mainly from Aeronautical, Civil, Computer, Chemical, Electric/Electronic, Environmental, Food, Industrial, and Metallurgy Engineering. Of these women, 21% graduated from a private high school, 60% graduated from a public high school, and 19% from another kind of high school (such as vocational, foreign language, or other specialised high school). The survey instrument consisted of 12 questions. The first five questions were demographic questions such as age, university, department, kind of high school, and whether the current major was their first programme of study. The next two questions dealt with influence and feelings in the classroom and school environment. A list of

reasons for choosing engineering was provided to be ranked by the respondents to discover why women chose engineering. Next, statements regarding the environment for women engineering students were presented and the responders assessed their reaction to each (strongly agree, agree, neutral, disagree, or strongly disagree). Finally, the last three questions dealt with the students' future plans in the profession and for further education.

Results are contained in Figures 3–9 for the simpler queries while Tables 1 and 2 show the more complex questions and their responses. Most students had attended a public high school. The mode age was 21 and the mode institution was METU. Regarding disciplines, 29% of women who responded to the survey were studying chemical engineering. This is consistent with other countries' experiences – worldwide chemical engineering attracts a greater proportion of women at the undergraduate level. Chemical engineering is followed by industrial and electrical in which 17% and 13% were enrolled, respectively with mechanical engineering slightly lower. The great majority of these students were optimistic that they could obtain good jobs upon graduation and 64% of women wanted to work in industry, while 19% would rather pursue a career in academia. The remaining 17% planned to work for the government or to start a business. Another point of

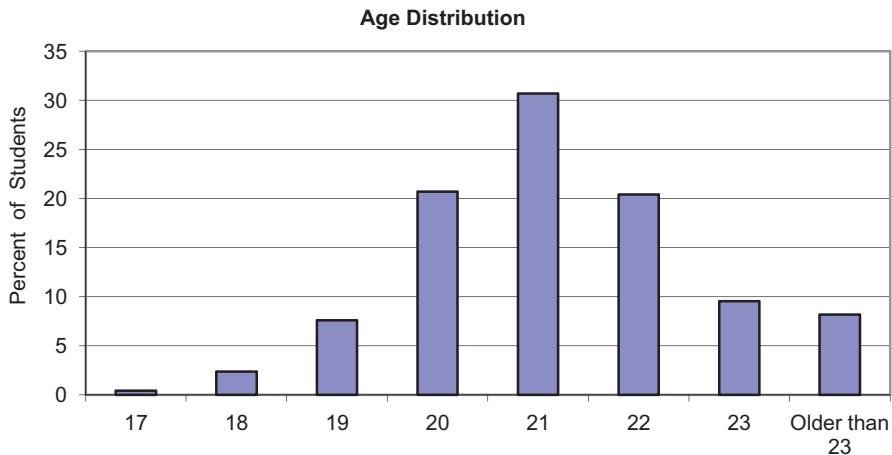


Figure 3. Age distribution of university students surveyed.

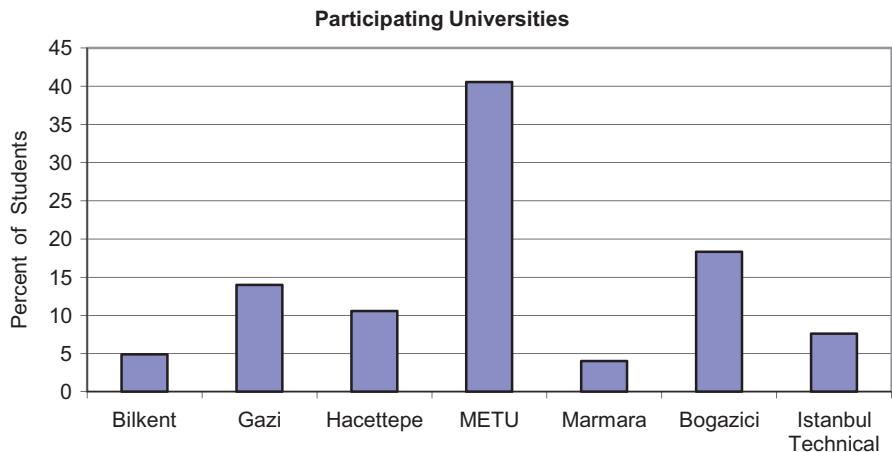


Figure 4. Percent of students surveyed by participating Turkish universities.

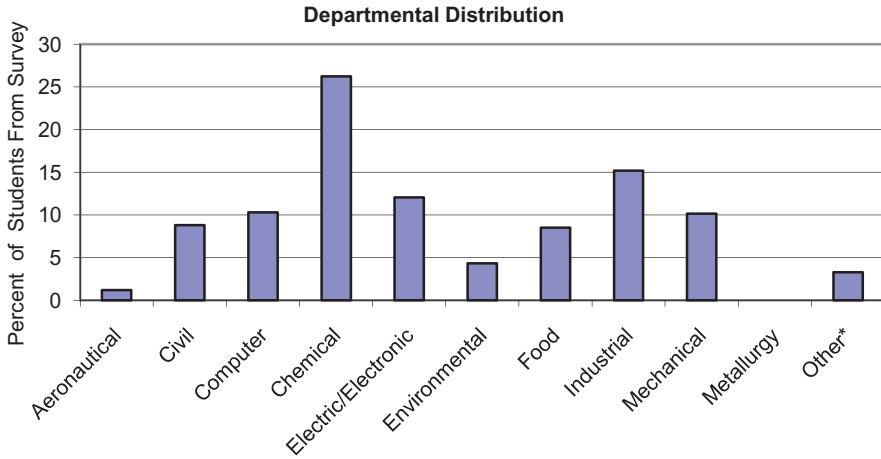


Figure 5. Percent of students surveyed by major.

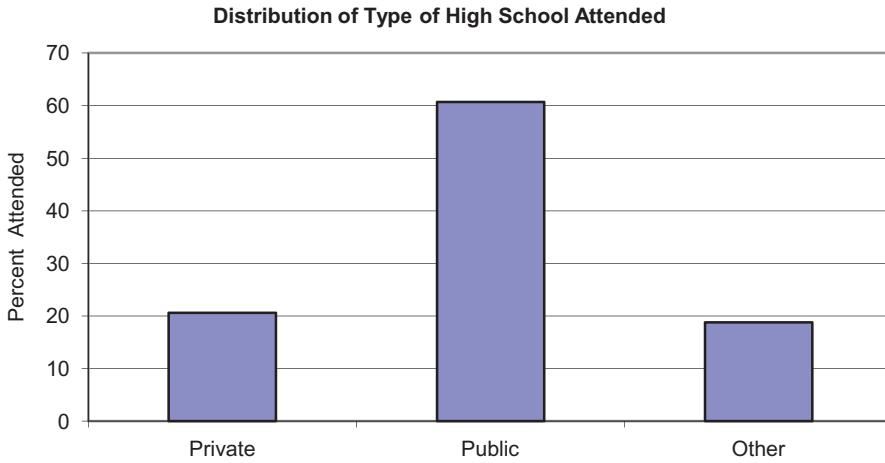


Figure 6. Percent of students surveyed by type of high school attended.

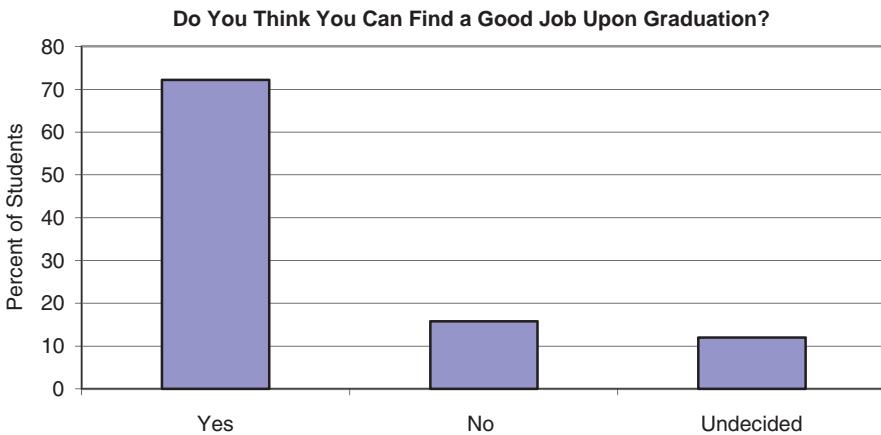


Figure 7. Responses to query on perceived employment outlook upon graduation.

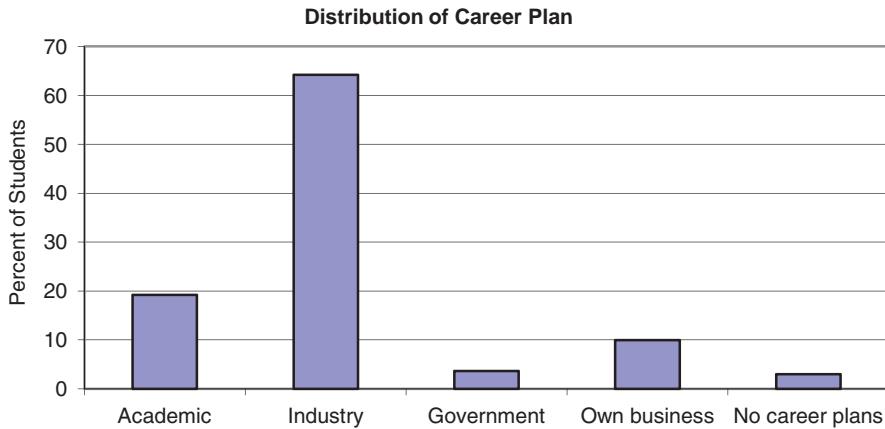


Figure 8. Planned employer type of students surveyed.

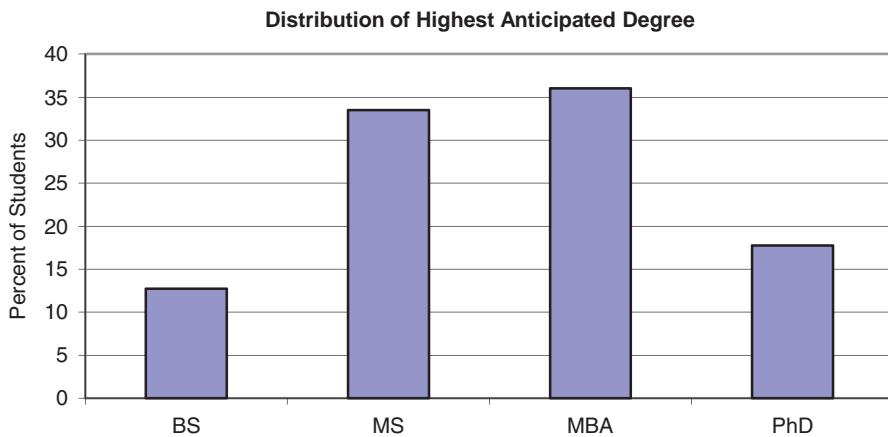


Figure 9. Anticipated final academic degree level achievement.

Table 1. Top five factors in choosing engineering – sorted by first choice.

Question 8: factor	First	Second	Third	Fourth	Fifth	Total in top five
Enjoy concepts	217	107	38	33	16	411
Good in concepts	114	159	62	36	17	388
Income	42	64	77	90	46	319
Credibility/prestige	42	66	90	70	42	310
To get a university degree	37	21	34	31	26	149
Fascinated by work	28	31	71	27	36	193
An engineer's suggestion	14	17	26	22	18	97
Family suggestion	12	21	34	29	20	116
Advisor/mentor suggestion	10	8	7	16	9	50
Prove women can work in field	9	11	28	30	30	108
Other	8	1	1	2	3	15
Friends suggestion	3	8	10	16	7	44
Participate in family business	1	2	3	1	10	17

Table 2. Reactions to statements – broken into agree and disagree and sorted by strongly agree.

Statement	Strongly agree	Agree	Total agree	Strongly disagree	Disagree	Total disagree	Neutral
My gender has not hurt my studies in any way.	371	110	481	24	33	57	66
I am glad that I chose to study engineering	352	198	550	31	30	61	28
Professors treat male and female students the same	351	192	543	15	61	76	30
One of my close relatives is an engineer	340	58	398	183	21	204	15
Male students treat female students the same as they treat male students	178	247	425	55	114	169	48
There is a lack of women engineering role models	169	250	419	37	57	94	111
I like the support of the other women engineering students when I have academic problems	153	181	334	69	43	112	183
I believe that male engineering students have more opportunities	124	240	364	137	92	229	49
My teachers and advisors in high school did not encourage me to choose engineering	73	85	158	280	121	401	74
A women engineering faculty member has served as a role model or advisor to me	63	122	185	201	81	282	150
My family tried to discourage me from studying engineering	53	60	113	439	51	490	30
The university does not provide enough support for women engineering students	45	75	120	282	122	404	112
My professors do not think I am as serious as a male student is	28	60	88	393	81	474	74

interest is the educational level the women plan to achieve. Only a small group, 13%, anticipated being satisfied with a bachelor's degree.

Forty percent of responders cited their main motivator for choosing engineering was that they enjoy the mathematical and technical concepts that engineering entails. Another major motivation, with 21%, was that they do well at these mathematical and technical concepts. Together, these describe aptitude and interest. Income and prestige, each with 8% of the top rated factor, were the other major reasons why women chose to pursue engineering. These four factors overwhelming dominated all the others in being selected among the top five by the respondents (Table 1).

Turning to Table 2, the results are interesting. While the majority feels that the educational environment has been gender-neutral, they perceive lesser opportunities than their male peers. The female students are acutely aware of the lack of female role models while they acknowledge the importance of support from their women peers. Most women had a close relative who practices engineering and most received support from their families to study engineering. While most were not discouraged from studying engineering by their teachers and advisors, a significant number were. This shows, perhaps, that the lower educational system is less enlightened than the families or the higher education system. Finally, nearly all affirm their choice of engineering as a major.

#### 4. Focus groups with women engineers and aspiring engineers

Focus groups allowed us to elicit information in a richer and more qualitative manner than by survey. All sessions were conducted in Turkish and facilitated by someone knowledgeable of the culture and educational system. Sessions were audio-taped for later analysis and summary. The procedure consisted of introductions and guided discussion rather than participants just answering questions. Before the meetings started, each woman read over a document that explained the goal

of the study and the subjects that were under investigation. A total of 156 women participated (84 high school students, 10 undergraduate students, 22 graduate students, 9 faculty members, and 31 working women engineers in government or industry).

#### **4.1. Undergraduate student focus groups**

Most cited similar reasons as to why they chose to be an engineer. The following are the responses, in the order of frequency: (a) like mathematics, (b) believe they will enjoy the type of work, (c) good income potential, and (d) the respect of the profession. Results show that most of the influence in choosing a major (in this case, engineering), before the student takes the Turkish university entrance exam came from teachers, parents, and the media. A large percentage of women have close relatives including parents, siblings, uncles, or aunts who are engineers and these relatives played a significant role while the young woman was choosing a major. Many of these relatives encouraged the women to pursue a career in engineering; thus, an important motivating factor for many women is the satisfaction of their relatives' jobs and the lack of gender bias in their counselling interaction with these relatives. In addition, relatives helped the students clarify their career goals by explaining to them 'what an engineer does' and 'what possible opportunities are available for them after graduation'.

When asked what an engineer does, responses were similar. Many responded that an engineer finds the best possible solution to a system's problems, or identifies and designs improvement to a current situation by using known techniques and available resources. Some of them thought that an engineer could work wherever analytical thinking is necessary. Engineers were also described as project managers or designers. In terms of getting a good engineering education, most of them were satisfied with their curriculum; however, a few complained that there is a lack of practice. Although they did not have detailed ideas about the work environment and graduate study, almost half of them planned to work for industry after graduation and the rest planned on furthering their education in diverse fields, including various kinds of engineering and MBA.

#### **4.2. Graduate student focus groups**

Not surprisingly, almost half of graduate students, especially those who were pursuing a PhD degree, were continuing with graduate level study because they plan a career in academia. A second reason for continuing at the graduate level was because of the theoretical studies and opportunity to learn more. A few felt that with an MS degree, one has a better chance to find a job in industry with a higher salary.

Almost all in the focus groups had already chosen a career path after graduation. The largest percentage planned to stay in academia to continue learning and teaching and to work on research projects. Some planned to work in industry because industrial companies pay more than universities do.<sup>1</sup> A few MS students planned to go abroad to get a PhD degree.

#### **4.3. Faculty focus groups**

The faculty focus groups comprised female professors from industrial, mining, electrical and electronics, computer, or aeronautical engineering departments, many of whom earned a PhD degree from either USA or the UK. Their positions included Assistant Professor, Associate Professor, and Professor, that is, all tenure stream ranks. Their common primary reason in choosing to stay in academia was the enjoyment of independent work. There were several other reasons that they chose an academic career: they like to learn, to create, to teach, to conduct research, and to interact with young people. They find academic life open to learning new things and applying

new ideas. Their time is more flexible; so they can have a more balanced lifestyle between family and work.

Faculty members who had worked in industry before starting an academic job commented on the working environment in industry compared with that in academia. Based on their industrial experience, they observed that men dominate the manufacturing or machinery departments while women were hired mainly into jobs that need careful documentation, such as quality control. On the other hand, there was no perceived gender difference in academia. While all believed that having women peers is very important, only a few thought that having a role model is important. Having women peers provides motivation and encouragement. If there are no women peers, conversations at social gatherings in the departments are always dominated by topics that typically interest men.

#### 4.4. *Engineers in industry or government focus groups*

Women engineers who work for government, such as ministries or the military, or for broad and large types of private industrial companies, such as software, pharmaceutical, and electronics companies, were the participants. Their years of experience ranged from 2 to 15. A large percentage of them earned a graduate degree, a PhD, an MS, or an MBA.

Their current jobs were the first choice for most of them. Only a few of them have changed jobs more than once. The reason for the job change was that either the new job better suited them or they had to do so due to accommodate their spouse's job. Specific jobs held by these women included business development, telecommunications, software testing, quality control and management, financial analysis, information technologies, wireless technologies, automation and robotics, project management and strategic planning, database management, marketing, operations research applications, nuclear research, product design, and development. These jobs were typically staff or administrative jobs rather than line or direct supervision jobs (verifying those observations by the faculty group who had previously worked in industry). These professional women aimed to move into more managerial positions.

#### 4.5. *High school student focus groups*

Eighty-four Turkish female high school students were interviewed in Ankara. The Turkish school system has 11 grades, with high school comprising the 9 through 11 grades. The students were all seniors (grade 11) from TED (Türk Eğitim Derneği – Turkish Education Association) Ankara College, METU Development Foundation School, Tevfik Fikret School, and Anittepe High School. The first three schools are private institutions while the last one is a public school. Some statistics about the schools are given in Table 3.

Each participant planned to major in engineering. In the private schools, the primary reasons for these women wanting to be an engineer were the wide variety of job opportunities available and the ease of finding a job. In addition, the young women felt that their strength in mathematics, science,

Table 3. Statistics of the high schools in the focus groups.

School	Overall population	High school population	Number of women students we met	Founded in
TED	5500	1650	25	1936
METU	1998	495	19	1989
Tevfik Fikret	1307	338	20	1964
Anittepe	1500	1500	20	1993

Table 4. Percentage of primary reasons to decide to be an engineer.

Reasons	High school							
	TED		METU		Tevfik Fikret		Anittepe	
	Most influential	Second most influential						
Job opportunity	40	8	37	16	30	15	35	30
Strength in math and science	32	12	32		30	10	15	
Prestige and income	16	0	16	5	20	5	45	

and technical concepts made engineering a good career choice. Secondary reasons why these women wanted to be engineers include the prestige and income that engineers receive. However, in the public school, prestige and income (45%) was the main reason with job opportunities being second with 35%. Table 4 summarises the primary reasons that these high school women decided to choose engineering.

In Turkey, seniors must take a university entrance exam that determines both the school they will attend and their major. At the entrance exam, students list which schools they want to attend, in order, and the majors they want to study, also in order. Their scores on the test determine which school and programme will accept them. The best universities and popular majors require a high score on the entrance exam. Since the entrance exam is given in mid-June, after their senior year, the young women have to decide on a major by then. Once accepted, it is very difficult to switch to a different major, or even begin school as undecided. Many of the women decided to pursue engineering as a major either in their junior or senior year of high school. However, a few of the women decided at the start of high school that they wanted to be an engineer. Since acceptance into school and major depends primarily on the entrance exam score, students must have alternative career options. Architecture was the top alternative choice in three of the schools, TED Ankara College, Ankara Tevfik Fikret School, and Anittepe High School. The second alternative to engineering in these three schools was Management. On the other hand, METU Development Foundation School had Management, Biology, and Industrial Design (each with 15.79%) as top alternative career choices.

Families, along with support from teachers and guidance counsellors, helped students identify their strengths, provided information on jobs, discussed the reputation of engineers, and discussed job opportunities of the future. A strong influence from both families and teachers helped students to decide on engineering as a major. Personal influence was more dominant in the private schools than the public. The students in Anittepe High School had a 50% split between being encouraged by teachers and family and not being encouraged.

Part of choosing a major involves knowing where and what kind of work is required. Many of the young women had relatives (parents, siblings, cousins, aunts, and uncles) that are engineers. Since many women knew an engineer, they had some general knowledge of what engineers do and where they work although they did not have detailed knowledge of the differences among engineering disciplines. Students' knowledge about the engineering profession was greater in the private schools than in the public. Many women had decided which type of engineering(s) they want to study. Industrial Engineering was the most popular one among the women high school students since its working areas are broad compared with other engineering disciplines. Many women stated that they plan to join a family business or work in industry.

## 5. Concluding discussion

Attracting the students to engineering is a challenge in contemporary society and the pool of women represent the greatest under-tapped resource. Turkey has been successful over the past 75 years in moving from being a society with virtually no female participation in engineering to proportions higher than those currently found in USA or Europe. Even though the Turkish Republic was founded with premises of valuing science and technology and women's equality, we wanted to investigate how this resonated to the women of Turkey today who had chosen engineering. We wanted to characterise their motivations, influences, experiences, and outlook.

Women cited math and technical ability and the influence of relatives and teachers in their career selection. Prestige and income were other major factors influencing women. Women want respect and support for themselves, which occur in a professional career such as engineering. While the university students feel that their male peers and their professors are not biased against them, they also perceive a difference in opportunities and a deficit of role models. They further cited the importance of support from women peers and relatively few experienced family or advisors who discouraged the study of engineering.

Many of the women who participated in the survey plan on furthering their education to a master's or doctorate degree. In Turkey, there has been a tendency for female engineering students with PhD degrees to prefer teaching and research in a university setting, making the percentage of women engineering faculty members much higher than that might be expected. Those in industry or government perceive differences in the types of job assignments they are given. Men are involved in the line jobs while women work in supporting roles (quality control, analysis, etc.). This is probably due to many, complex societal and cultural differences between men and women in Turkey.

Turkish women cite other women colleagues as very important. This would almost certainly be true in other countries as well. Women who feel isolated and alienated are more likely to leave the profession. Until the numbers are sufficient to ensure that most women engineers will have women colleagues, organisations such as International Network of Women Engineers and Scientists will play an important role to bring women engineering students and engineers together. However, one of the most optimistic statistics from our large survey of university students is the strongest affirmation (strongly agree or agree) to the statement 'I am glad that I chose to study engineering'.

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## Note

1. Most universities in Turkey are public and the government pay scales at public universities are significantly lower than what private industry or private universities offer.

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