

Gender Ratio in Biomedical Engineering

Vladana Djordjevic, Lenka Lhotska, Vaclav Gerla
Department of Cybernetics, Faculty of Electrical Engineering
Czech Technical University in Prague
Prague, Czech Republic
djordvla@fel.cvut.cz, lhotska@fel.cvut.cz, gerlav@fel.cvut.cz

Abstract—In last decades there were many discussions about status of women in technology and engineering. Ratio of male and female university students corresponds to gender ratio in population. However when we look at individual study fields there are great differences. In the paper we try to show the situation in the Czech Republic considering number of university students and gender ratio in the country. Although women present majority among university students in Czech Republic, their number in technical sciences and engineering is still very low. Special attention is focused on Biomedical Engineering Master Program at the Faculty of Electrical Engineering, Czech Technical University in Prague. The motivation for female students to enroll this particular program was addressed, together with their observations concerning teachers' and other students' attitude toward them. Also, these observations were compared with observations of male students. Students' feedback was obtained by questionnaires.

Keywords—women in engineering; female engineering students; gender ratio; biomedical engineering; electrical engineering;

I. INTRODUCTION

In last decades the effort to increase the number of women applying for studies at technical universities, and consequently for a job in the field of technology, can be seen in European countries. However, the advance in the decreasing of gender disbalance is very weak and the amount of female students in technical fields is still quite small. Reasons for this are for sure historical patterns and society prejudices that maintain and encourage gender discrimination.

The fact that there is a low percentage of women in the field of technology, engineering and science in the Czech Republic can be explained based on the results of two studies conducted by Public Opinion Research Centre and Ministry of Work and Social Affairs in 2006 and 2007. According to [1], Czech society is conservative considering the dividing the male and female roles in the society. Also, employment of a woman in any field of engineering is considered nontraditional [2]. This clearly points out to social stereotypes in this country, considering only the close connection of men and technology to be natural.

Nowadays, various organizations both on global/European and local level present role models – women who overcome gender stereotypes and become successful in the area of engineering. These organizations, as for example IEEE Women in Engineering, Women's Engineering Society (<http://www.wes.org.uk>) or Zkus IT (<http://www.zkusit.cz>) and

Zeny a veda (<http://www.zenyaveda.cz>) in the Czech Republic are dedicated to promoting and supporting women in engineering, as well as inspiring young women to achieve their potential as engineers, scientists and technical experts. Also, numerous programs within the Sixth and Seventh Framework Programmes of the European Union are dedicated to gender issues, e.g. PROMETEA (www.prometea.info) or DIVERSITY [3]. In general all of them have a common goal – reaching gender balance in engineering.

The aim of the paper is to present current situation in Czech Republic and gender disbalance at technical universities in this country, but also an example of good practice. Also, female engineering students' motivation to enroll a specific Master program – Biomedical Engineering (BMI) – was explored. Further on, this paper deals with comparison between female and male observations and perceptions if they are treated differently by teachers and colleagues. Both motivation and observation of treatment were analyzed according to students' feedback obtained by questionnaires. Similarly, perceptions of whether gender affects treatment was also addressed in [4] within the group of undergraduate students but with different engineering and nonengineering majors.

II. CURRENT SITUATION IN NUMBERS

A. Engineering faculties in general

This section provides an overview of gender balance among applicants, students and graduates at universities in the Czech Republic. In addition, gender disbalance among students at engineering faculties is given. The data provided in this paper refer to persons with Czech citizenship, and they were obtained from the Czech Statistical Office (<http://www.czso.cz>), Institute for Information on Education, which is run by the Ministry of Education, Youth and Sports of the Czech Republic (<http://www.uiv.cz>), and Eurostat (<http://ec.europa.eu/eurostat>).

Gender structure of enrolled students has not changed much over the last few years. In academic years 2006/07 to 2008/09 the percentage of female applicants and women enrolled in universities increased a bit. The overall number of women enrolled in universities expressed in percents is slightly higher than a number of enrolled men, as it is shown in Fig. 1. The total number of university students at all 73 universities (both public and private) in the Czech Republic for this period, including graduate students, is shown in Table I.

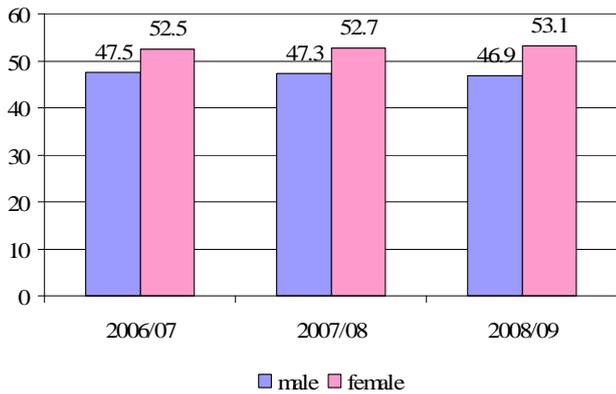


Figure 1. Gender structure of students enrolled in universities in Czech Republic in three successive academic years. Expressed values are in percents.

TABLE I. TOTAL NUMBER OF UNIVERSITY STUDENTS IN CZECH REPUBLIC

Year	2006	2007	2008	2009
No. of students	292 429	317 070	338 453	354 711

Gender structure of university students at Bachelor, Master and Doctoral (PhD) level is shown in Fig. 2. In the Czech Republic students can obtain Master degree in two ways. First option is to enroll in so-called long master studies, a 4-6 years long program which does not include a Bachelor level. The second option is to enroll in 1-3 years long program after already obtaining Bachelor degree. This program is called structured and data presented in this paper correspond to number of students enrolled only to this type of program. In the following text, terms Master studies and Master program are used for this structured Master program. It can be observed that at Bachelor and Master programs there is a greater percentage of women. At the PhD level, percentage of women among all students is increasing, but it is still lower than the percentage of men. These data include only full-time students (part-time students were not taken into account).

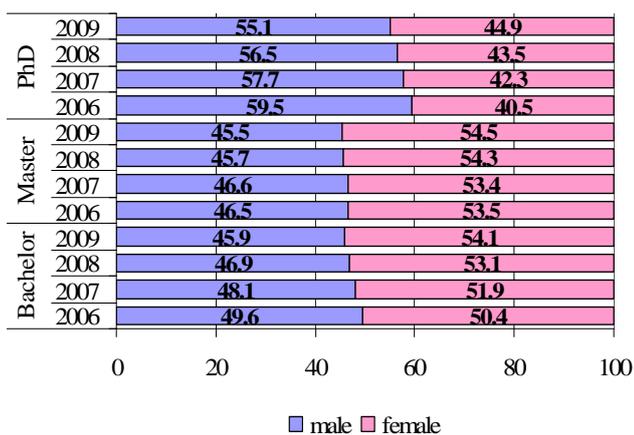


Figure 2. Gender structure of university students at Bachelor, Master and PhD level in Czech Republic in years 2006-2009. Expressed values are in percents.

Different situation is observed at engineering faculties at all educational levels. Fig. 3. illustrates gender structure of university students enrolled at technical faculties. It is clear that technical sciences are studied more by men: overall percentage of women is about 11% and slowly decreasing, while this percentage in male population is around 40%. The presented data are for the period of 2006-2009. Table II presents gender structure of university students according to the field of studies they have chosen.

Further on, the percentage of male and female students who obtained either Bachelor, Master or PhD diploma is shown in Fig. 4. Generally, more women are among university graduates at the first two levels, but at the PhD level men make approximately two-thirds of the total number.

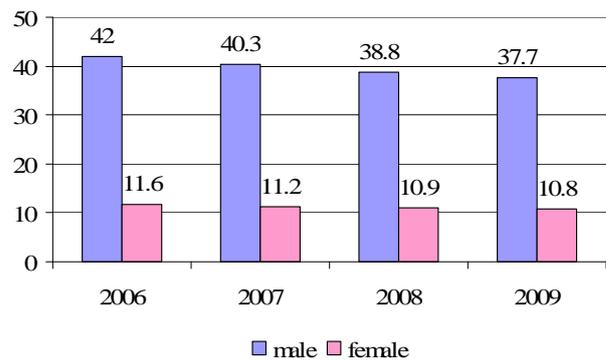


Figure 3. Percentage of male and female students enrolled at engineering faculties in Czech Republic in years 2006-2009. Percentage of students enrolled at other faculties is not shown. Expressed values are in percents.

TABLE II. GENDER STRUCTURE OF UNIVERSITY STUDENTS IN CZECH REPUBLIC ACCORDING TO THE FIELD OF STUDIES. EXPRESSED VALUES ARE IN PERCENTS.

Year	2006 ^a		2007 ^a		2008 ^a		2009 ^a	
	M	F	M	F	M	F	M	F
Gender								
Field of studies								
Group 1	9.4	6.3	9.4	6.1	9.3	5.9	9.5	5.8
Group 2	42.1	11.7	40.4	11.2	38.7	10.8	37.7	10.8
Group 3	7.3	13.8	7.1	13.3	7.2	12.9	7.1	12.7
Group 4	22.7	29.1	14	30	25.5	30.9	26	31.3
Group 5	20.6	41.7	20.9	41.6	21.3	41.9	21.6	41.8

a. As one person may enroll more than one faculty, total sums per columns do not have to be equal to 100% (a person is introduced only once in a given year).

Group 1 – Natural sciences;

Group 2 – Engineering/Technical Sciences;

Group 3 – Medical, Pharmaceutical and Veterinarian sciences;

Group 4 – Law and Economics;

Group 5 – Humanities and Arts.

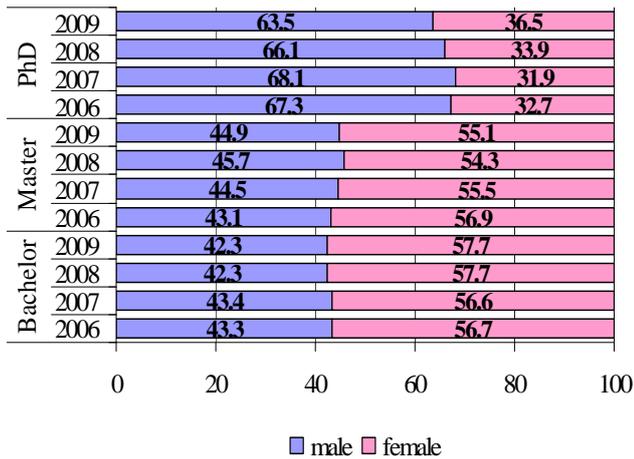


Figure 4. Gender structure of university graduates at Bachelor, Master and Doctoral level in Czech Republic in years 2006-2009. Expressed values are in percents.

Considering university graduates at different study fields and their gender structure, male graduates at engineering faculties are dominant both in comparison with number of graduates in other fields and with female graduates at engineering faculties. From 2006 to 2009 about 41% of all male graduates were students at engineering faculties, and for women this percent is much lower - about 11%. This gender disbalance is illustrated in Fig. 5, while Table III gives an overview of gender ratios in fields of different specialization.

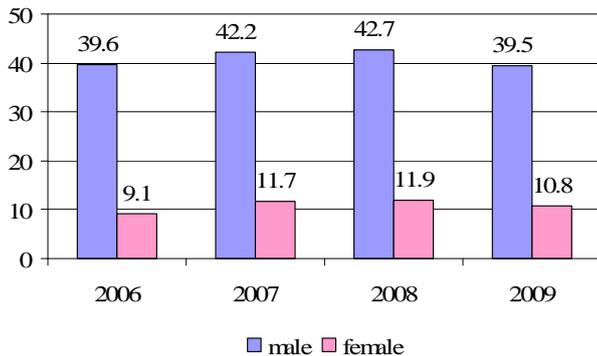


Figure 5. Percentage of male and female graduates at engineering faculties in Czech Republic in years 2006-2009. Percentage of graduates from other fields is not shown. Expressed values are in percents.

B. Faculty of Electrical Engineering, Czech Technical University in Prague

At present the Faculty of Electrical Engineering (FEE), Czech Technical University in Prague (CTU), has 1648 students enrolled at Bachelor, 1221 at Master and 463 at doctoral level. Overall situation at this faculty cannot be considered as good when it comes to gender ratio and number of female students. Distribution of male and female students at all three study levels is illustrated in Fig. 6. Presented data were obtained directly from the faculty in February 2011.

TABLE III. GENDER STRUCTURE OF UNIVERSITY GRADUATES IN CZECH REPUBLIC ACCORDING TO THE FIELD OF STUDIES. EXPRESSED VALUES ARE IN PERCENTS.

Year	2006 ^a		2007 ^a		2008 ^a		2009 ^a	
Field of studies	Gender		Gender		Gender		Gender	
	M	F	M	F	M	F	M	F
Group 1	10.2	7	8.9	6.7	8.7	5.9	8.3	5.5
Group 2	39.6	9.1	42.2	11.7	42.7	11.9	39.5	10.8
Group 3	6.9	13.2	6.8	12.6	5.9	12	6.5	12.3
Group 4	23.9	31.9	22.2	30.6	23.5	32.4	25.4	32.5
Group 5	19.8	39.1	28.4	48.7	19.5	38.2	20.5	39.4

a. As one person may graduate at more than one faculty, total sums per columns do not have to be equal to 100% (a person is introduced only once in a given year).

Group 1 – Natural sciences;

Group 2 – Engineering/Technical Sciences;

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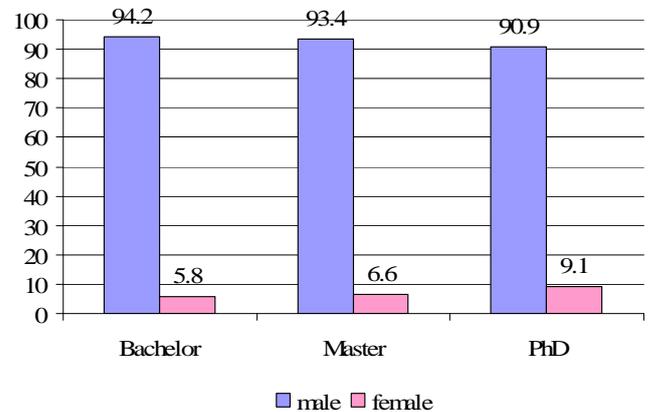


Figure 6. Percentage of male and female students at the FEE, CTU – current situation. Expressed values are in percents.

Currently, there are 24 active master programs with enrolled students. It is worth mentioning that at 7 of these programs there are no female students at all. At other 6 programs there is one female student. Table IV gives the overview of gender ratios at master programs, where number of female students is one or higher. From this table it can be observed clearly that the highest percentage of female students is at Biomedical Engineering. Thus this master program presents an example of good practice.

TABLE IV. GENDER RATIOS AT SEVERAL MASTER PROGRAMS AT FEE, CTU – CURRENT SITUATION. EXPRESSED VALUES ARE IN PERCENTS.

Master program	Gender	
	M	F
Wireless Communications	96.1	3.4
Biomedical Engineering	70.6	29.4
Economics and Management in Electrotechnics	89	11
Economics and Management in Electrical Engineering	91.3	8.7
Economics and Management in Power Engineering	84.1	15.9
Electroenergetics	95.2	4.8
Cybernetics and Measurement	96.7	3.3
Flying and Cosmic Systems	91.7	8.3
Multimedia Technology	92.2	7.8
Computer Graphics and Interaction	90.2	9.8
Robotics	95.7	4.3
Electric Power Engineering	90	10
Networks of Electronic Communication	97.3	2.7
Systems and Control Engineering	97.8	2.2
Telecommunication Engineering and Radioelectronics	90	10
Artificial Intelligence	97.9	2.1
Computer Science and Engineering	97.4	2.6

III. STUDENTS' FEEDBACK

In order to gather female students' feedback regarding their motivation to enroll Biomedical Engineering and observations considering teachers' and other students' attitude a questionnaire was designed. Namely, two versions of a questionnaire were made – for female and male students. Obtained answers were analyzed in order to make the comparison between observations of these two groups.

A. Questionnaire and Gathering of responses

Questionnaires were distributed during the class and their filling in was not obligatory. Students of the first and second year of master program Biomedical Engineering were addressed. Answers were obtained from 48 male and 21 female students, from the total of 65 male and 27 female students currently enrolled at this program in February 2011. Filling in the questionnaires was anonymous and with the possibility to supplement every answer with comments.

Version of the questionnaire for female students consisted of questions about:

- Motivation to enroll Biomedical Engineering;
- How they found out about this program;
- Attitude of teachers toward them and male students;
- Attitude of their colleagues toward them;
- Prejudices about women at technical faculties;

- What was their second career choice option and if they were familiar with other available programs at the FEE;
- Attitude of their parents/family to their career choice;
- Existence of study programs that are certainly not for women;
- Plans for doctoral studies.

Second questionnaire (for male students) was actually a modified version of the first one, and it consisted of less questions. The questions about Biomedical Engineering were left out because the motivation of male students to enroll this program was not of interest. Goal was to compare female and male point of view regarding position of female students enrolled at this program.

Both versions of the questionnaire had the same header for obtaining information about the student's average academic grade, age and current semester. Questions were given in a multiple choice form with possibility of adding comments. Final versions of questionnaires can be found at <http://bio.felk.cvut.cz/eegintro/bmi-female-english.pdf> and <http://bio.felk.cvut.cz/eegintro/bmi-male-english.pdf>.

B. Evaluation of students' feedback

Answers obtained by questionnaires may be summarized as follows.

About 75% of male students consider that teachers are treating female students differently, at least sometimes. Considering female students' observations, 13 out of 21 find their treatment different. This leads to the conclusion that teachers should improve their approach toward students as almost three-quarters of them think that they are treated differently based on the gender. On the other hand, most of the students do not perceive the difference between attitude of male and female teachers. About 73% of male and 94% of female students answered that they do not feel any difference between their male and female teachers concerning attitude toward students of different gender. Four students were excluded at this question because their answer was that they did not have a female teacher. The lack of presence of female teachers at technical faculties is not the subject of this paper.

When it comes to the attitude of their male colleagues, female students (90% of them) answered that they are considered as equal. Also, 88% of male students treat female students as equal members of a team. Answers of two students were not taken into account because they stated that they never had the opportunity to work with colleagues of different gender. It is important to notice that students are aware of the discrimination between genders but they are not supporting it neither making it on their own.

Also, in case that they could choose a member of a team or pair to work with, about 75% of all students says that gender is not important to them at all. However, 7 male students would choose to work in pair with a woman, and 5 others to work with a man, while 2 and 4 female students would choose to work with another woman or a man, respectively.

Considering the opinion if female students have to work harder and have better results and grades in order to show that they are as good as male students answers are divided, both with female and male population. Eleven out of 21 female students stated that they have at least once to work harder, while the rest think that this is not true. On the other hand, majority of male students (30 of them) again think that they are all equal, and that women do not have to make more effort than them in order to be considered equally good. The rest of the male students think that the difference exists and that women should sometimes work harder than them.

As already mentioned in the introduction, prejudices about gender based division of occupations are present in the Czech society. This was also confirmed by students' answers. Only about 4% of female and 33% of male students expressed their opinion that prejudices about women at the Faculty of Electrical Engineering do not exist. Prejudices encompass for example doubts about women professional competencies, their motivation to enroll these studies even their physical appearance. On contrary, great majority of students stated that their parents/family are satisfied with their career choice. Thus even with the existence of prejudices in the society male as well as female students are supported by their family members in their choice.

A conclusion can be made concerning students' attitude toward existence of master programs at the Faculty of Electrical Engineering that no women should enroll. According to 91% of male and 86% of female students, programs that are certainly not for women do not exist.

The set of questions that addresses particularly BME program was only part of a questionnaire dedicated to women. According to their answers, they found out about the existence of this program mainly from media/internet, or from their friends. Also, greater number of female students was interested in this program from the beginning of their bachelor studies compared with number that decided to enroll this program after seeing its presentation at the faculty. This points out that the approach of addressing students at secondary school and introducing this program to them brings good results in practice.

It is also interesting that 19 out of 21 BME female students would not enroll any other master program at FEE, they would rather choose another faculty. From one point of view this is a good fact for BME program but from another, it is bad for FEE.

Interdisciplinarity, modern concept of the program, perspective and developing field are all motivation for female students to enroll Biomedical Engineering. According to obtained answers, students enroll this program because they are directly interested in it. On the other hand, none of the female students stated that their motivation to enroll this particular program was other people's influence, or that they just wanted to have a master diploma, neither they think that it would be financially good for them. It can be concluded that they are motivated to enroll this particular program and interested exactly in it, seeing clearly biomedical engineering as their future work.

It is obvious from the statistics that the number of female students is much higher at the life science faculties. Thus introduction of these topics in purely engineering study may contribute to increased attractiveness of engineering study. This statement is confirmed by the numbers of students in chemical and biomedical engineering. There might be another aspect, which we did not tackle in the questionnaires, namely personalities in the individual fields. At FEE in biomedical engineering there are good examples in male/female composition of academic staff in comparison to other fields having only male members of academic staff. In biomedical engineering we have successful female researchers, PhD students and graduates. Thus the students have positive practical examples they can follow.

IV. CONCLUSION

This paper presents overall gender situation in high education in the Czech Republic, with focus on gender disbalance among students at engineering faculties. Also, special attention was focused on Biomedical Engineering Master Program at Faculty of Electrical Engineering, Czech Technical University in Prague, its gender ratio, female students' motivation to enroll this particular program and perception of whether male and female students are treated differently.

Although in the Czech Republic the majority of undergraduate students are female, at engineering faculties situation is opposite. Current situation at FEE shows that the gender ratio at BME Master Program is the best among 24 Master Programs with enrolled students. According to students' feedback obtained by designed questionnaires, female students at this particular program were motivated to enroll to it by interdisciplinarity of the program, its modern concept, perspective and developing field. Answers also showed that female students were not interested in other Master Programs at FEE, but particularly in this one. Another conclusion that can be derived according to obtained answers is that approach of addressing students as early as in secondary school and introducing this program to them brings good results in practice.

From students' answers it was possible to make the comparison between perception of differences. As majority of male students and their female counterparts stated that they observed that they are treated differently based on gender, teachers should improve their approach and attitude toward students. Regarding the prejudices about women in engineering, students are aware of their existence, but they personally are not making the discrimination. This is a very positive conclusion bringing hope that the situation in engineering fields generally will change, finally resulting in gender balance.

ACKNOWLEDGMENT

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