

Gender effect in postgraduate studies at higher technical institutions in Russia, Austria and the UK

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ABSTRACT: This research dealt with the gender composition of postgraduate students and the reasons for pursuing a career in science. Statistics from Russia, Austria and the United Kingdom were analysed as these countries are among the leaders in engineering education. The analysis was at country, university and faculty level. To investigate the university level, data were compared from students' conferences held in the three countries, as well as the gender composition of postgraduate students of engineering at Saint Petersburg Mining University, Russia; the University of Leoben, Austria; and the University of Leeds, UK. Special attention was paid to the attitude towards female scientists among postgraduate students. The results suggest gender segregation persisted in engineering education in Russia, Austria and the UK in 2017-2018. Gender-based stereotypes persist in postgraduate engineering education: the perception of opportunities and career prospects differs between males and females, as does the motivation to pursue a career in engineering sciences. However, more young female scientists are being involved in engineering conferences.

Keywords: Postgraduate students, engineering education, gender segregation, motivation, attitude

INTRODUCTION

Since women increased their participation in labour markets in the middle of the 20th Century, women's involvement in industries has been widely discussed. Some sectors (e.g. services) have seen a substantial growth of women in the labour force, while in others (e.g. industry) women are still under-represented. Engineering is one of the professions, where the proportion of women is extremely low and this is a global trend. Gender-based preferences start in early childhood, continue at school and flourish at universities and during postgraduate studies.

The focus of the research reported in this article was to reveal the gender composition of postgraduate engineering students in Russia, Austria and Britain, and the students' reasons for pursuing a career in science. The analysis is done on various levels: country, university and faculty. Special attention has been paid to the attitude towards women scientists among postgraduate students.

Background

The modern history of women engineers started with Elizabeth Bragg who became the first woman to receive a Bachelor's degree in engineering in 1876 from the University of California at Berkeley, USA. However, she never worked as a professional engineer [1].

In 1898, Hertha Ayrton became the first female member of a British engineering institution. Dr Sally Horrocks believes that this marked not the start of women's contributions to British engineering, but was an important step in their efforts to take their place alongside men in the engineering profession. The first female engineering students entered British universities during the years shortly before World War I [2].

The first female engineer in Russia was R. Kanevskaya, who did railway engineering research in 1903. She studied in France as women could not get a degree in engineering in her home country at that time. The first polytechnic institute for women in Russia was established in 1906.

In Austria, women were allowed to enrol in an Austrian institute of technology for the first time in 1919. Martha Spiera was the first woman to complete the chemistry degree programme.

The situation has changed since then. Women have made their way in engineering, but remain severely under-represented: in the UK, just 12% of those working in engineering are female, compared with 47% who are women in the overall workforce [3]. Similarly in Russia, women comprise 53.1% of the workforce, but only 15.9% of engineering technical specialists [4]. In Austria, the figure is similar, i.e. 15% [5].

Women make a great contribution in engineering. They bring an alternative view of the world and produce a more diverse and inclusive workplace [6]. According to the UNESCO report, *Cracking the code: Girls' and women's education in science, technology, engineering and mathematics (STEM)*, higher education is popular among young women. Within the female student population in higher education globally, only about 30% choose STEM-related fields of study. Differences are observed by discipline. Female students' enrolment is particularly low in ICT (3%), natural science, mathematics and statistics (5%) and engineering, manufacturing and construction (8%); the highest is in health and welfare (15%) [7].

Nowadays, increased attention is paid to women's careers in technical professions, with research regularly carried out at the request of labour agencies, state governments and by scientific teams at technical universities [8-10]. Psychological and educational differences between students are also important subjects of study. Using comparative analysis, gender differences have been found in the level of satisfaction with university studies. Young men tend to be more satisfied with aspects directly related to studies, while girls have higher regard for the infrastructure of the university [11].

According to research results, a woman, under equal conditions, has to work more and harder to prove her professional competence [4][12]. An important factor in career development is the fact that, with equal professional education, women receive lower salaries compared to men. According to Russian statistics, the average salaries of women in technological professions are 28% less than for men, and in the IT professions 33% less [13].

The issue of gender asymmetry in engineering education at different levels - country/university/faculty - has not been explored sufficiently. Therefore, the comparative analysis of gender equality in science and STEM fields in various countries is of particular interest.

Postgraduate education is undergoing drastic changes caused by the global market and digitalisation. In recent decades, female names have become increasingly common among young scientists in very complex technical fields of research, where there were barely any women scientists a few decades ago. Saint Petersburg Mining University trains specialists in the technologies of mining and processing [14]. Women scientists conduct research in the fields of mineral processing [15], oil and gas engineering and hydrocarbon technologies [16-18]; open pit mining [19]; geo-ecology [20-21]; and the history of mineralogy [22]. Worldwide women scientists are involved in the development and implementation of technological innovations, digitalisation of production, as well as resource and energy conservation in the mineral resource sector [23].

METHODOLOGY

Universities are more popular with girls; they are more interested in getting a university degree in Austria, Russia and the UK. Girls account for the greatest numbers of university graduates in these countries. In spite of having access to engineering university courses, women are still under-represented (Table 1). In the UK, the percentage of female students studying engineering and technology degrees made up 19% of students between 2017 and 2018 [24]. In Russia, the gender gap is less striking - women account for 29% of students enrolled on engineering and technology university courses [25]. Austria takes a mid-position with 25% of female students [26].

Table 1: Engineering and technology students in higher education.

	Higher education engineering and technology courses 2017/2018	
	Female (%)	Male (%)
Russia	29	71
Austria	25	75
UK	19	81

In postgraduate education, in all three countries, women mainly are engaged in humanities research, while men do research in engineering. Women prevail over men in postgraduate studies in Russia and the United Kingdom, whereas in Austria postgraduate education is more popular among men (Table 2).

An analysis of the distribution of students by areas of training in Russia shows that at the postgraduate level, women predominate mainly in the humanities (75%), while men are more numerous in engineering (71%) [25]. There are a significant number of women (68%) among young humanities scientists in Great Britain [24]. Among the countries under analysis, Austria has the smallest number of women engaged in humanities research (61%) [26]. The numbers vary across the globe; for instance, in the United Arab Emirates (UAE), the percentage of women enrolled in engineering programmes reached 44.5 percent in 2017 [27].

Table 2: Distribution of postgraduate students across fields of study by gender [24-26].

Country	Proportion (%) of students earning PhDs		Humanities (%)		Engineering (%)	
	Female	Male	Female	Male	Female	Male
Russia	53	47	75	25	29	71
Austria	46	54	61	39	26	74
UK	59	41	68	32	26	74

In Russia, the number of women undertaking postgraduate studies in engineering is slightly higher than that in Austria and Great Britain, where the percentages are the same. One of the reasons is the tradition established in the Soviet era, when there was equality between women and men in science. A compelling fact: until 1977, the Constitution of the USSR contained the wording: *A woman in the USSR has equal rights with a man*, while in the newer revision, it was replaced by: *A woman and a man have equal rights*.

Thus, the comparison of female and male postgraduate students by areas of science shows a larger proportion of female scientists studying humanities. Male postgraduate students are more likely to choose technical majors.

To study the gender composition of postgraduate students at the faculty level, the engineering faculties of three flagship universities in Russia, Austria and Great Britain were analysed, viz. Saint Petersburg Mining University in Russia, the University of Leoben in Austria and the University of Leeds in the UK. The following data were obtained:

- At the School of Chemical and Process Engineering in the University of Leeds, 33% of postgraduate students were women and 67% men.
- The University of Leoben trains 15 (17%) female and 72 male (83%) researchers in the area of mining.
- At Saint Petersburg Mining University, the gender gap among postgraduate students in the Faculty of Mineral Processing is even more impressive: 25% of women and 75% of men. The data at the faculty level differ from data at the country level, but demonstrate the same tendency.

The data obtained eloquently indicate that a fairly rapid feminisation of the education system in general, and postgraduate studies in particular, has not reduced the gender imbalance in STEM areas. Thus, a comparative analysis of those entering postgraduate studies at higher educational institutions ranked among the best technical universities in Russia in 2019-2020 showed that, on average, there was one female postgraduate student per 3-to-5 male postgraduate students (Table 3).

Table 3: The female-to-male ratio of those admitted to postgraduate technical studies at Russian universities, 2019.

University	Gender composition (%)	
	Female	Male
1. Saint Petersburg Mining University	21.7	78.3
2. National University of Science and Technology	25.2	74.8
3. Bauman Moscow State Technical University	22.39	77.61
4. Tomsk Polytechnic University	32.78	67.22
5. National University of Oil and Gas <i>Gubkin University</i>	23.1	76.9
6. The Bonch-Bruевич Saint-Petersburg State University of Telecommunications	35.71	64.29
7. Saint Petersburg Electrotechnical University	17.3	82.7
8. Information Technologies, Mechanics and Optics University	13.51	86.49
9. Moscow Institute of Physics and Technology	12.9	87.1

The same trend can be seen in the composition of participants in international scientific conferences of young scientists held at technical universities in the countries under study. The analysis of the composition of the participants provides evidence of gender asymmetry in engineering.

The data show that the proportion of women participants is less than one third of men. However, in recent years (2016-2020), there has been a positive upward trend in the number of women researchers in complicated technical scientific areas (Table 4). This is evidenced, in particular, by published data on international conferences held at technical universities.

In some cases, gender parity or similar values are achieved. Thus, at the 15th International Forum-Contest of Students and Young Researchers, *Topical Issues of Rational Use of Natural Resources* under the auspices of UNESCO, held by Saint Petersburg Mining University on 13 to 17 May 2019, the share of girls participating was 46%. At the 11th All-Russian Scientific and Practical Conference of Young Scientists with international participation by *Young Russia*, organised in 2019 by Kuzbass State Technical University named after *T.F. Gorbachev*, 42% were female participants. The Young Persons' Lecture Competition organised by the Institute of Materials, Minerals and Mining can boast gender parity among its UK finalists in 2019.

Table 4: Emerging trend of participation by gender at engineering conferences for young scientists.

Conference	Gender distribution (%)	
	Female	Male
The 5th International Conference on Final Sinks (ICFS 2019) Vienna University of Technology, December 2019	40	60
XI All-Russian Scientific and Practical Conference – <i>Young Scientists</i> with international participation by <i>Young Russia</i> Kuzbass State Technical University named after <i>T. F. Gorbachev</i> , 2019	42	58
The XV International Forum-Contest of Students and Young Researchers <i>Topical Issues of Rational Use of Natural Resources</i> International Competence Centre for Mining-Engineering Education under the auspices of UNESCO, May 2019	46	54
The Young Persons' Lecture Competition by IOM3 (UK), 2019	50	50

SURVEY

Three hundred students were surveyed in 2018-2019: young scientists from around the world. The students were participants in the annual forum-contest under the auspices of UNESCO held at Saint Petersburg Mining University. The goal was to determine the motivation for postgraduate research, as well as the reasons for gender imbalance among young scientists at technical universities. Table 5 shows the reasons given for entering a postgraduate course. Most of the respondents mentioned both academic and non-academic reasons for enrolling in postgraduate studies, such as interest in research activities and advice from relatives, friends or acquaintances.

Table 5: Motivation to take a postgraduate course.

Reasons for taking a postgraduate course	Female (%)	Male (%)
I strive to engage in scientific activities	44	56
I consider the academic degree prestigious	37	63
I plan to become a university lecturer	14	7
I believe that postgraduate studies will help in developing my non-academic career	58	76
I am interested in the chosen branch of science	45	55
Other	12	18

It should be noted that the majority of students of technical majors, regardless of the university, are interested in the chosen branch of science and strive to develop a non-academic career. Gender differences in reasons for enrolment are of interest. Thus, 27% of Russian male postgraduates mainly wish to obtain special privileges provided by the university and the state, such as deferment of military service.

Developing a career as a university lecturer is of interest for only a small number of respondents, mostly women. The survey revealed an external motivation is not rare; many young people are pragmatic and seek to meet their academic and personal needs. Of respondents, 58% see themselves outside the academic environment in the future. Only 14% of women and 7% of men would like to work at university. However, more than a half of men strive to do research in their field.

Compared to postgraduate education, employment of women in engineering positions (regardless of having an academic degree) in industrial STEM fields is even worse. The analysis of the gender composition of those employed in STEM fields in the main jobs in the countries under study revealed a small number of women. Thus, in Russia the share of women among specialists employed in STEM fields is 15.9%, while in the UK it is 12%, and in Austria 8.4% (Table 6).

Table 6: Proportion of women employed in STEM (%) [13][28][29].

Russia (%)	Austria (%)	UK (%)
15.9	8.4	12

Comparison of the number of women undertaking postgraduate studies with the number of those employed in the STEM industry reveals that the gender imbalance is less pronounced in postgraduate education in all three countries under study.

Presented in Table 7 are the results of a survey conducted among 98 female postgraduate students of Saint Petersburg Mining University. The purpose of the survey was to identify the social and psychological reasons for the declining proportion of women in the professional areas of STEM.

Table 7: Social and psychological reasons for the declining proportion of women in the professional areas of STEM.

Statements	Number of female respondents who expressed the highest degree of agreement (%)
A man scientist will finish a project faster	35
Women are better team leaders	10
Women scientists receive patents less frequently	66
A man scientist is more likely to be cited	71
A male researcher is supposed to give the keynote at a conference	16
After completion of postgraduate education, female salary will be lower than that of your male colleague	85
Family life is more important than career	84

Among the reasons identified, the majority of young women scientists:

- are not confident in their professional competence;
- choose their future profession based on the possibility of devoting more time to family responsibilities in future;
- have a low opinion of their intellectual and leadership skills;
- do not believe in the possibility of their career advancement;
- are influenced by social stereotypes about gender roles.

The foregoing factors are, in the opinions of the authors, the social and psychological reasons for the small proportion of women who opt for a profession in STEM fields.

CONCLUSIONS

The results of the research suggest that gender segregation persisted in engineering education in Russia, Austria and the UK between 2017 and 2018. It occurs at different levels, from the faculty, the university to the country level. The proportion of engineering and technology female students in higher education in Russia, Austria and the UK was lower than 30%; the number in the UK being the lowest, at 19%.

A similar effect is observed in postgraduate courses: 26% of postgraduate students in Austria and the UK are female, compared to 29% in Russia. This slightly higher result for Russia may reflect the long-lasting tradition from the Soviet era when women were welcomed into science and engineering.

Gender-based stereotypes in postgraduate engineering education are still apparent: the perception of opportunities and career prospects differs between men and women, as does the motivation to pursue a career in the engineering sciences. The survey revealed that a smaller proportion of men than women plan to work at university but at the same time they are more passionate about their discipline.

The research suggests that often women prefer family life to work and choose a profession with flexible working hours. This leads to an underestimation of women's abilities, compared to men's abilities. However, an opposing trend can be observed, e.g. more young women-scientists are getting involved in engineering conferences. This gives hope that the creativity, professional and leadership skills of women increasingly will find their way into engineering education and the engineering profession.

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