Evidence from Poland on women in engineering education

Beata Ślusarczyk & Aneta Broniszewska

Częstochowa University of Technology
Częstochowa, Poland

ABSTRACT: Higher education is of utmost importance for the development of the intellectual potential in society. Gradually increasing the percentage of women in the total number of students in universities of technology might help overcome the stereotypes concerning the division of professions into *male* and *female*, and support the process of providing equal opportunities for both genders in the labour market. The number of women with tertiary education in engineering is increasing, which is connected with their looking for jobs in the areas which have traditionally been considered as *male* professions. The focus of this paper is on quantitative analysis of changes that have been occurring in the education of women in university engineering majors and the effect of the programmes that promote science and engineering majors among women, such as *Girls to Universities of Technology!* and *Girls to Sciences!*. The authors present statistical data that demonstrate the increase in the number of women studying in universities of technology compared with employment of women in engineering positions in selected sectors of the economy.

Keywords: Engineering education, higher education, women in engineering

INTRODUCTION

The intensifying processes of globalisation cause substantial transformations in education systems in order to ensure high quality of education at all levels. All the reform initiatives in higher education should be viewed from the standpoint of global transformations and the needs of industry, business, commerce and public services. The idea is a unification of educational systems and standards without sacrificing the quality of education [1].

Over the years 2000-2009 in the EU countries, the population of students increased on average by about 22% (with a growth rate of 2.7%), reaching a total of 19.5 million people [2]. In 2009, an increase in the number of university students was reported in all EU countries except for Spain and Portugal. These two countries saw an insignificant decline in the number of university students of 1.5% and 0.2%, respectively.

The number of students in Cyprus and Turkey increased almost three times, whereas it doubled in Romania. It is worth noting that in 2000, excluding Greece and Finland, Spain was the country with the highest number of students in universities. The increase in the number of university students was not constant in several countries. A substantial decline was reported in Bulgaria (almost 9%) and Austria (about 6%) over the first five years of the period studied.

In 2005-2007, decreases of almost 10% and 4% in the number of university students were observed in Greece and Sweden respectively, whereas in the last two years of the period analysed, the decline in this number was 4.5% in Ireland, Latvia and Finland and 11% in Hungary. In 2010, in each of the four countries of the European Union, such as Germany, Great Britain, France and Poland, the number of university students was over 2 million [3].

Over a third of university students in the European Union studied social and legal university majors. The students who decided to study engineering, production and civil engineering accounted for 14.7% of all the students. Furthermore, 14% of university students were reported as studying in the university major connected with health and social care [3].

Education is an important element that determines the changing role of women. As results from the study, recent years have seen significant changes in the hierarchy of values of women. After many years of effort, women began to have unlimited access to education at the turn of the 20th Century. At present, education and professional careers are priorities for women, not only in Poland and the European Union but also all over the world. The number of women

substantially exceeds the number of men in the most academic fields (Figure 1), including education and training, where women represent almost 77% of graduates, health and social care (74% of graduates), the humanities and arts (over 65% of total number of graduates), as well as in the field of social science and law (over 58%).

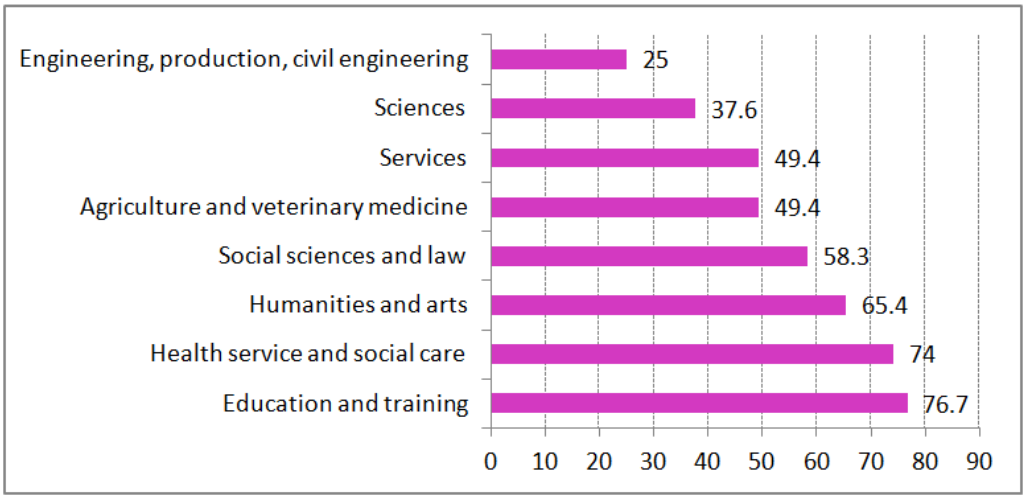

Figure 1: Graduates from universities in the EU - 27 according to university majors in the academic year 2009/2010 [%] (Source: authors' own elaboration based on European Social Statistics [3]).

The policy of encouraging women to participate in the labour market should involve an integrated approach that combines strategies for combating stereotypes concerning gender and discrimination factors [4]. The existence of deeply rooted stereotypes that are present in society that define the role of women and men points to a domination by men in the sector of information technologies, since they are experienced and have both knowledge and necessary qualifications. This often results from natural preferences of men, connected with learning sciences. Furthermore, women more often choose universities in the field of the humanities, which results in their working in education, services and health service.

ANALYSIS OF HORIZONTAL VOCATIONAL SEGREGATION IN POLAND

At present, the principle of equality remains merely a postulate, especially in terms of gender equality. Women continue to be in a worse situation in the labour market, for financial, social and professional reasons. The controversial gender inequality is also noticeable in the knowledge-based economies, where the value of creative potential is not connected with the gender of the person who generated this potential. Despite any changes that have occurred in Poland and abroad, vocational segregation continues to be one of the major global problems [5].

The transitions brought by the economic transformation in 1989 in Poland concerned in particular women and their vocational and professional activity. The unemployment rate that increased year by year was very important, especially from the standpoint of women. Before 1989, women in Poland were more vocationally active, whereas their position in the labour market was more stable than after the period of transformation [6]. However, men continued to be employed more often at managerial positions and the salaries earned by women were lower than those earned by men in equivalent positions.

Although gender equality is guaranteed in Poland by the Constitution, the stereotypical approach to the role of women remains widespread. The stereotype of gender significantly affects the vocational segregation in the Polish labour market and, consequently, feminisation of some of the professions and certain sectors of the economy can be observed. Table 1 presents data concerning participation of the people employed according to gender and selected divisions in the Polish Classification of Business Activities in 2014 (PKD in Polish).

The presence of feminised and masculinised sectors is clearly noticeable in the structure of employment for the specific year and the employed in specific sectors of PKD. Analysis of the data shows that women are employed less frequently in such domains of industry as civil engineering and the mining industry, where the number of female employees accounted for less than 10% of all employees. This seems logical due to the character of the work. The sectors which are more popular among women are health care and social care, education and financial counselling, although these professions are less profitable.

On the one hand, the choices made by women concerning their profession are natural and clear, since women are mainly not strong enough to work on building sites or to perform other physically demanding work. Although the traditional division into *typically* masculine and feminine professions remains in place, women are more and more confident in performing in professions which so far have been regarded as being the typical masculine domain. There are a number of positions in different sectors which can be held by women and are not connected with physical strength.

Table 1: Employees according to sex within selected divisions of the Polish Classification of Business Activities in the 2nd quarter of 2014.

Specification	Total [in thousands]	Men [in thousands]	Women [in thousands]	Women in total number of the employed [%]
Public administration and national defence; compulsory social security	1,049	526	524	50.0
Construction	1,225	1,038	87	7.7
Financial and insurance services	360	126	234	65.0
Professional, scientific and technological activities	564	279	284	50.4
Education	1,234	268	966	78.3
Mining and extraction	250	230	20	8.0
Hotels and food services	342	113	229	67.0
Information and communication services	367	247	120	32.7
Health and social care	927	170	756	81.6
Industrial processing	2,992	2,028	965	32.3
Agriculture, forestry, hunting and fishing	1,799	1,094	705	39.2
Transport and warehousing	908	712	196	21.6

Source: Authors' own elaboration based on Aktywność ekonomiczna ludności Polski II kwartał 2014 [7].

HIGHER EDUCATION AMONG WOMEN: ANALYSIS OF THE PHENOMENON

The number of people who start studying at universities has been gradually declining for several recent years. Studies have shown that the unemployment rate is higher in people with lower levels of education [8] since these people are characterised by lower mobility in the labour market, which reduces their chances to function in this market. Statistical data show that at the end of 2013, over 243,000 people with higher education were unemployed and, importantly, this number is increasing the fastest, with an increase of 12% per year.

Since the beginning of the system transformation, the number of university students had been increasing for several years (until 2006). The regular increase in the number of university students in the years 1990/1991 to 2005/2006 was a direct result of *the educational revolution*. The demographic situation and the increase in the number of universities in Poland led consequently to the constant increase in the number of candidates and people admitted to universities.

Higher education was considered to be an *investment* that guaranteed constant employment and professional perspectives. After reaching the highest number of university students in the academic year 2005/2006 (almost two million), the number of students started to decline. Between the academic years 2006/2007 and 2012/2013, the number of students in Polish universities decreased by over 264,000 to 1,68 million.

This has mainly been caused by demographic problems. However, it is also important that young people are choosing universities abroad more often. A forecast of the Ministry of Science and Higher Education shows that in the early part of the 21st Century, the number of university students will drop to fewer than 1.3 million, whereas in 2035, this number will not exceed 1.5 million people [9].

Higher education is open to women, which is supported by the fact that the group of people employed with higher level of education is dominated by women. Increasing the level of education among women opens up opportunities for better professional positions. Although women in many countries account for nearly a half of those employed, their representation among managers is not equally high. It should also be noted that women dominate among university students, also those in postgraduate studies. The structure of education of the men employed shows an opposite pattern: they are usually the people who finished programmes at basic vocational schools, post-secondary schools, secondary vocational schools and universities.

The woman's situation seems to be favourable against the background of changes that have occurred in higher education. Their number in universities of technology is systematically increasing. This tendency is positive since it is remarkable that women, despite achievements in the field of sciences, had for many years chosen university majors from the humanities.

The right to be educated at universities of technology was first given to women in the academic year 1915/1916 at the Warsaw University of Technology. Initially, the presence of women in universities was neglected, which is reflected by the speech of the first rector of this university, Zygmunt Straszewicz, at the inauguration of a new academic year with these words: *Gentlemen! Undoubtedly, each of us, sitting in a school bench, dreamed of academic freedom...* [10].

The first Master's degree in mining engineering was awarded by the present AGH University of Science and Technology in 1936 [11]. Women more and more often start jobs as academic teachers, which can be attributed to transitions that are occurring in society. This is supported by the fact that the first technical university to be headed by a woman is Czestochowa University of Technology. In April 2008, Professor Maria Nowicka-Skowron became the first female rector in a university of technology in Poland.

ANALYSIS OF VOCATIONAL STATUS OF WOMEN WITH HIGHER LEVEL OF EDUCATION IN ENGINEERING

Through coordinated promotional activities, oriented mainly at students in secondary schools, the tendency of the increase in the share of women among the students of universities of technology in the total number of students was stabilised [12]. A stable increase of the number of women in universities of technology has been reported since the academic year 2007/2008, when the percentage of the total number of university students was 30.7%.

At present, women account for 37% of the students in universities of technology and, year by year, the number of women who graduate from this type of university is increasing. In the academic year 2003/2004, women accounted for a third of the graduates from engineering university majors in universities in Poland (Figure 2). The data of the Central Statistical Office point to a specific tendency for changes that are occurring in Polish universities. The increase in the number of university students and graduates in the field of sciences is accompanied by the increase in the number of women in these majors.

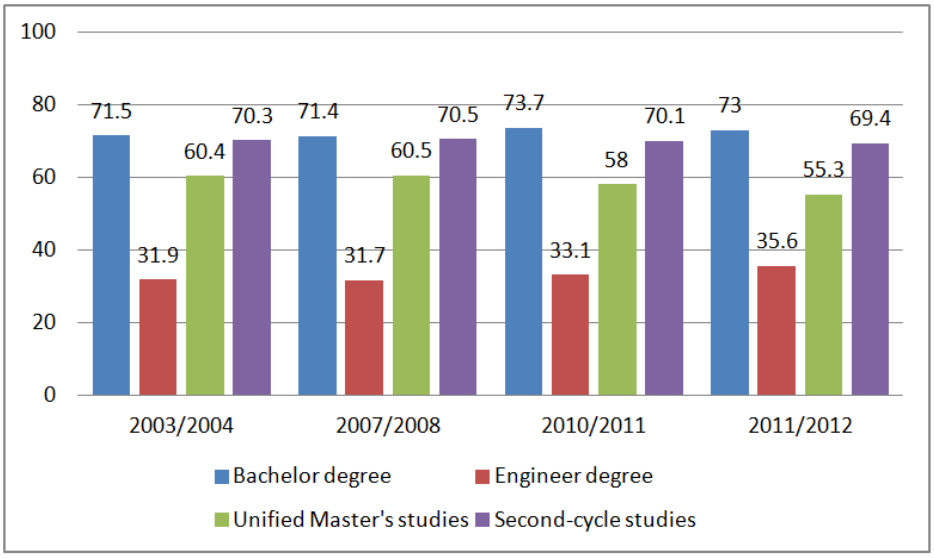

Figure 2: Graduates from universities in Poland according to the level of education [%] (Source: Authors' own elaboration based on the Central Statistical Office of Poland: Universities and their Finances (2004-2012), www.stat.gov.pl).

It can be observed that the changing level of education, starting from obtaining a Bachelor's degree through to graduation from the Master's course in engineering substantially increases the chances of becoming employed. The people employed with a Bachelor's degree account for about 64%, those with engineer degrees - 76.5%, whereas the graduates employed with the Master's degree account for 81%.

Among the technological and service-providing professions, more women than men show tendencies to accept the jobs below their level of education. Nearly a quarter of all women employed in these sectors in Europe have completed higher education. Furthermore, around 10% of men with higher education are employed as craftsmen and machine operators and in jobs that do not require higher education [2].

At present, gender does not represent a factor which predisposes a person to perform a job in engineering. Nowadays, many specialised positions do not require physical strength but rather technological knowledge. Professor Jan Krysiński, who inaugurated the initiative *Dziewczyny na Politechniki* (*Girls to Universities of Technology* said that ...*Society does not realize how the work of an engineer changed after starting the era of informatization and robotization. It has become a creative and fully supervising role. An engineer designs machines and equipment based on the most advanced computer software. (...) Shortly speaking, this job is now creative and rewarding* [13].

The data from the Bank Danych o Inżynierach (BDI, Data Bank on Engineers) show that in 2009 14.6% of those registered in the BDI database were women and, importantly, this number is increasing year by year [13]. Figure 3 below presents the data concerning employment of female engineers in selected sectors of the economy in Poland according to the studies from the year 2009.

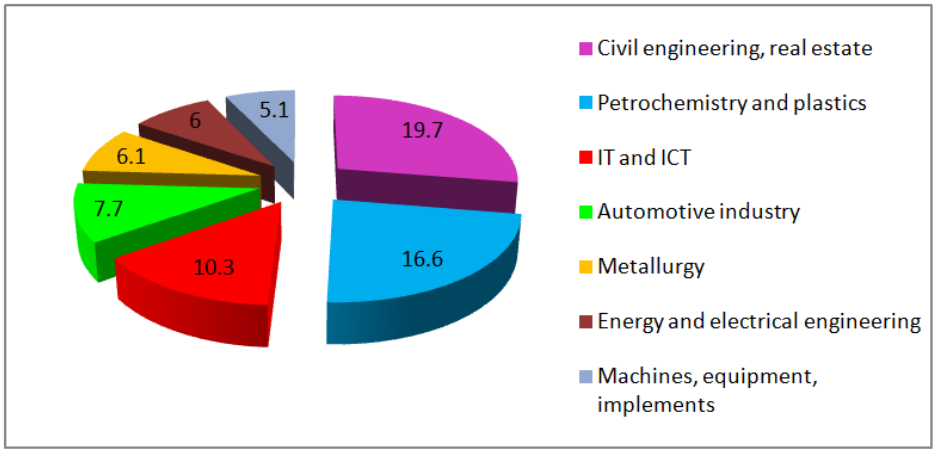

Figure 3: Employment of female engineers in selected sectors of the economy in Poland in 2009 [%] (Source: Authors' own elaboration based on *the* Data Bank on Engineers, www.bdi.com.pl).

Women in engineering are becoming more noticeable in the Polish labour market. Engineering studies offer more opportunities for women to find well-paid and interesting jobs. Women start jobs in the sectors previously dominated by men although the differences in salaries between the genders remain substantial. The fact is that lower salaries paid to women in engineering positions discourages them from starting studies in university engineering majors. However, cultural conditions and lower self-esteem in terms of professional value might affect the differences in financial expectations of women and men as early as at the stage of looking for a job [14].

According to the prognoses of the European Centre for the Development of Vocational Training, the demand for jobs for the countries of the European Union until the year 2020 (including Switzerland and Norway and excluding Bulgaria and Romania) will increase in the category of highly-qualified specialists in the field of engineering and specialists in sciences and health care [15].

The highest demand for employees will be observed in business and other services sector (over 14 million), whereas the most noticeable decline will be reported in e.g. mining and agriculture, as well as in the production industry, which might be a consequence of the increased role of the services and high technologies sector at the expense of traditional and agricultural sectors.

The study of the European Union concerning the information and communication technology sector showed that out of 1,000 graduates of the first-cycle studies or studies at the same level, the diploma in the field of ICT, only 29 were women, whereas only four women in 1,000 are actually employed in this field. The managerial positions are held by 19.2% of women compared to the mean from other sectors (45.2%). Furthermore, it is worth emphasising that the women in the ICT sector account for nearly a quarter of the entrepreneurs in Europe [5].

Graduates of high schools are more likely to choose non-engineering studies because physics and chemistry, essentials at technical universities, are difficult for them. Making the teaching of both these fields friendlier would make more young people, especially girls, interested in technical subjects and entourage them to continue an education in engineering studies [16].

In order to encourage students to connect their professional future with engineering sectors, a governmental programme concerning *ordered* university majors was created in 2008. The focus of the initiative was on contest projects connected with implementation of education in the university majors pointed by the Minister for Science and Higher Education. These majors, being a part of the so-called ordered majors include e.g. automation and robotics, biotechnology, material engineering and environmental engineering, mechanics and machine engineering, mathematics and mechatronics. Implementation of the curricula in these majors was aimed at making the didactic process attractive and contribute to increasing the number of graduates and improving the quality of education [17].

At present, the biggest programme that promotes engineering majors and sciences among women is the common project of the Conference of Rectors of Polish Universities of Technology and Foundation of Educational Perspectives *Girls to Universities of Technology!* Fifteen Polish universities participate in this initiative. The final point of the initiative is *Polish Open Day: Only for Girls*. The main aim of the programme is to break stereotypes in thinking and to encourage girls from secondary schools to start studies in engineering and sciences [18].

Strictly engineering majors are nowadays the most needed, the most prospective and viable as they open the international labour market. The idea of the initiative was started in 2006, being also the first, and the biggest project of this type not only in Poland but also in the whole of Central and Eastern Europe.

Since the beginning of the programme *Girls to Universities of Technology!* in 2008 (with a pilot implementation since 2007), the number of students rose in the universities of technologies. These universities were the only segment of higher education in Poland that reported such a noticeable increase in the number of people who studied since the academic year 2007/2008. Importantly, the number of men who studied at universities was maintained at similar level, whereas the number of women has been increasing (Figure 4).

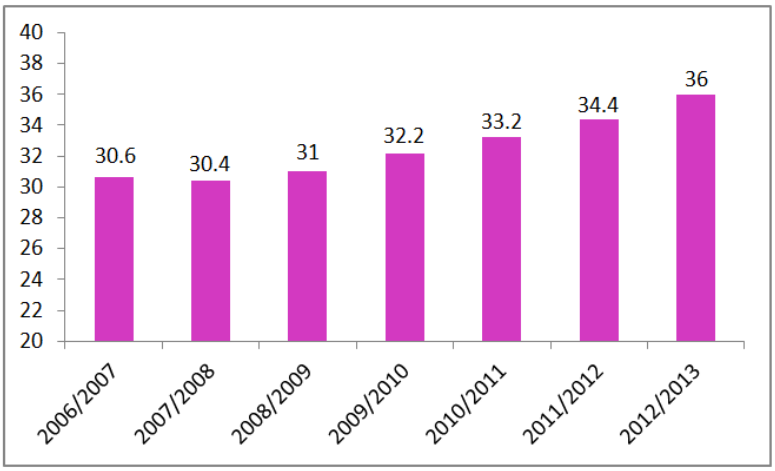

Figure 4: Share of women in total number of university students in Polish universities of technology in 2006-2013 [%] (Source: Authors' own elaboration based on Kobiety na Politechnikach [19]).

Through consistent and coordinated promotional activities, oriented mainly at students in secondary schools, the tendency of the increase in the share of women in the students of universities of technology in total number of students was stabilised. Since the initial moment of the initiative *Girls to Universities of Technology!* and its younger counterpart *Girls to Sciences!*, the number of women in public universities of technology has increased by almost 24,000. In the academic year 2012/2013, the share of women in the total number of students in Polish universities of technology accounted for 36%. In the same period i.e. since the beginning of the programme, the number of men has declined by nearly 9,000. This fact was mainly connected with liquidation of the compulsory military service.

Having compared the number of female students from the beginning of the campaign it has been noted that the number of women at universities that participated in the campaign increased more than at those that did not join it. The average increase in 2010-2011 was 2%. It is higher at some universities, such as Poznań University of Technology (3.7%), Rzeszów University of Technology (3.8%), Czestochowa University of Technology (4.7%) and Kielce University of Technology (5.6%). The growth in number of female students at technical universities that did not take part in the campaign was just 0.7% [16].

The German-speaking countries, such as Germany, Austria and Switzerland documented the effectiveness of the campaigns aimed at promotion of engineering university majors and sciences among women. The consequence of promotion of these studies using the programme *Girls' Day* was the change in educational choices of the candidates for studies, who expressed more interest in other studies than humanities. Over the years 2001-2012, the percentage of women who were educated in Germany in the university majors connected with engineering, production and civil engineering was at the level of nearly 19%, whereas in the majors concerning sciences and mathematical majors, women accounted for about 35% of the students [20].

CONCLUSIONS

The labour market is undergoing constant transformation. Several sectors are developing intensively and the demand for a qualified workforce in increasing. The most important objectives of the programme *Europe 2020* in terms of education in the European Union include first and foremost a limitation of the people who terminate education prematurely to below 10% [21]. As results from the data of the European Commission, the number of university students in universities in 2011 in the EU in the age range of 30 to 34 years accounted for almost 35%, whereas the prognosis for 2020 assumed that this factor will exceed 40%.

High demand for employees with higher education in engineering is one of the characterisations of the current Polish labour market. Regular studies of prospective tendencies in the European labour market demonstrate that the expected demand for labour in the countries of the European Union will increase in the category of expert engineers and specialists in the field of sciences. It is also expected that world and European tendencies will be oriented towards development of the knowledge-based economy and development of modern ICT technologies, which will cause the increase in the need for further education. Consequently, the increase in the demand for a flexible staff of qualified employees and positions that require higher professional competencies will be observed.

REFERENCES

1. Danilova, E.A. and Pudlowski, Z.J., Engineering education reform: the imperatives for ensuring its quality and outcomes. *World Trans. on Engng. and Technol. Educ.*, 6, **2,** 239-243 (2007).
2. Education, Audiovisual and Culture Executive Agency, Key Data on Education in Europe (2012), 10 November 2014, http://epp.eurostat.ec.europa.eu/portal/page/portal/education/publications
3. European Union, European Social Statistics (2013), 10 November 2014, http://epp.eurostat.ec.europa.eu/portal/page/portal/education/publications
4. Vravec, J. and Bacik, R., Discrimination of women in the labour market of SR and models of discrimination. *Polish J. of Manage. Studies*, 5, 280-293 (2012).
5. Irimie, S., Moraru, R.I., Cioca, L-I. and Boatca, M-E., Aspects of the gender inequality issue in knowledge society careers. *Polish J. of Manage. Studies*, 9, 43-53 (2014).
6. Rollnik-Sadowska, E., Przedsiębiorczość kobiet w Polsce. Warszawa: Difin (2010) (in Polish).
7. Główny Urząd Statystyczny, Aktywność ekonomiczna ludności Polski II kwartał 2014 (2014), 5 November 2014, http://stat.gov.pl/obszary-tematyczne/rynek-pracy/aktywnosc-ekonomiczna-popyt-na-prace/aktywnosc-ekonomiczna-ludnosci-polski-ii-kwartal-2014-r-,4,13.html (in Polish)
8. Ślusarczyk, B. and Kot, S., Logistics education as a way for unemployment reduction. *Proc. Inter. Engng. and Technol. Educ. Conf., Enhancing 21st Century Skills for Global Engineers and Technol. Professionals*, Kuala Lumpur, Malaysia (2011).
9. Ministerstwo Nauki i Szkolnictwa Wyższego, Szkolnictwo Wyższe w Polsce (2013), 5 November 2014, www.nauka.gov.pl/g2/oryginal/2013_08/010df9372ca1a016e6e9bf7746817b38.pdf (in Polish)
10. Kobieta inżynier…, 19 January 2009, www.wiadomosci.onet.pl/prasa/kobieta-inzynier/512yv (in Polish)
11. Rośnie liczba studentek na politechnikach, 23 October 2014, www.strefainzyniera.pl/index.php/artykul/66/inzynier-budownictwo#.VFdB_xbQsqM (in Polish)
12. Fundacja Edukacyjna Perspektywy, Kobiety na politechnikach (2014), 4 November 2014 http://www.dziewczynynapolitechniki.pl/2012/pdfy/RAPORT_2014.pdf (in Polish)
13. Kobieta Inżynier w 2009 r., 5 November 2014, http://www.bdi.com.pl/aktualności/kobieta-inżynier-w-2009-roku.htm (in Polish)
14. Kot, S. and Grondys, K., *Ciągłe Kształcenie Czynnikiem Wzrostu Potencjału Kapitału Ludzkiego*. In: Pabian, A., Nowe Kierunki, Metody, Techniki w Zarządzaniu i Marketingu. Czestochowa: The Management Faculty, CUT Publishing Office (2011) (in Polish).
15. Trendy na europejskim rynku pracy w perspektywie lat 2015 - 2020, 12 November 2014, www.portalwiedzy.onet.pl/7173,1275431,,1607709,,trendy_na_europejskim_rynku_pracy_w_perspektywie_lat_2015_2020,tematyczne.html (in Polish)
16. Porębska, A., Mitkowski, S.A., Dąbrowski, A.M. and Zegarmistrz, P., Female students AT technical universities - gender as the factor determining the choice of engineering studies. *World Trans. on Engng. and Technol. Educ.*, 9, **4,** 227-232 (2011).
17. Raport końcowy z badania ocena jakości i skuteczności wsparcia kierunków zamawianych ramach Poddziałania 4.1.2 PO KL (2014), 9 November 2014, http://www.ncbr.gov.pl/gfx/ncbir/userfiles/_public/fundusze_europejskie/kapital_ludzki/ewaluacja/raport_psdb_final.pdf (in Polish)
18. Informacja prasowa Dziewczyny na Politechniki! i Dziewczyny do Ścisłych! (2014), 4 November 2014, www.www.dziewczynynapolitechniki.pl/2012/informacja_prasowa/Dziewczyny_na_politechniki_2014v10.pdf (in Polish)
19. Kobiety na Politechnikach. Raport 2013, 5 November 2014, http://www.dziewczynynapolitechniki.pl/2012/pdfy/Raport_Kobiety_na_politechnikach_2013.pdf (in Polish)
20. European Commission, Eurostat, Share of Women Among Tertiary Students (2014), 31 October 2014, www.epp.eurostat.ec.europa.eu/
21. Komisja Europejska, Europa 2020. Strategia na rzecz inteligentnego i zrównoważonego rozwoju sprzyjającego włączeniu społecznemu (2010), 10 November 2014, www.ec.europa.eu/europe2020/europe-2020-in-a-nutshell/targets/index_pl.htm (in Polish)

BIOGRAPHIES

Beata Ślusarczyk has been an Associate Professor in the Faculty of Management at Częstochowa University of Technology, Częstochowa, Poland, since 2011. Since 2008, she has been Head of the Department of Eurologistics and Entrepreneurship within the Institute of Logistics and International Management at the Faculty of Management. She is a member of scientific boards of the journals: Advanced Logistic Systems, Journal of Applied Management and Investments and eXclusive Journal. She is also a reviewer of the following journals: Polish Journal of Management Studies, Supply Chain Management Journal and Journal of Organisation Review. Professor Ślusarczyk's research interests are in the areas of mechanism of globalisation, foreign direct investments, state aid, costs aspects of logistic performance, women entrepreneurship. She has published widely, and her publications include books, books chapters, refereed journal articles and conference papers, as well as conference proceedings and books reviews.

Aneta Broniszewska has graduated from the Faculty of Management at Częstochowa University of Technology, Częstochowa, Poland. Currently, she is a PhD student within the Department of Eurologistics and Entrepreneurship of the Institute of Logistics and International Management at the Faculty of Management of this University. Aneta Broniszewska's research interests are mainly in the areas of women's entrepreneurship and their activity in the labour market.