PERSPECTIVES FOR AERONAUTICAL RESEARCH IN EUROPE

PARE

CHAPTER 11

Increasing the Participation of Women in Aerospace

Final Report

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Chapter 11 – Increasing the Participation of Women in Aerospace

The aerospace sector seeks to attract and retain women for its future and growth, not only to face the gender imbalance (that generally affects the transports sector) but also due to the current global shortfall in the numbers of qualified employees that is imposing huge pressures on employers to recruit the greatest number of qualified employees (mainly pilots, mechanics and top managers that nowadays are still traditionally male-dominated areas).

Thus, greater participation of women in aeronautics is not only an enlargement of the workforce in numbers, but it is also an enrichment in quality and talent, which are the foundations of inventiveness and competitiveness, on which depend the continuing European leadership in an ever more competitive world with new challenges.

The combination of different talents in a cooperative and open-minded environment of equality also promotes the emergence of new ideas and allows pursuing them to active the best results in less time and with reduced effort.

The aerospace is not a gender-balanced sector, thus being a consequence - albeit not exclusively - of the existing gender stereotypes in education as such the factors that affect the professional career of women which may not be too apparent in childhood but may have effects in secondary school and university.

There are several factors that influence the participation of women in Aerospace: the women interest in the aerospace sector and the women's self – confidence in STEM (Science, Technology, Engineering and Mathematics) subjects (section 11.1); the educational context, specifically the gender stereotypes that women are exposed to (section 11.2); and the employment opportunities and labour conditions and practices for women (section 11.3). Considering these factors, the implementation of interventions that could enable substantial and sustainable changes regarding the increase of women interest and involvement in the aerospace sector is required.

This chapter addresses PARE's objectives 49 to 58, which were identified in Chapter 1.

11.1 Generating Interest in Aerospace and Building Confidence

*PARE Objective 49: "Counter family and societal bias discouraging girls from interest in vehicles, be it cars or planes".

Evidence suggests that women are underrepresented in some areas of work, notably those where some knowledge of STEM subjects is required. Main reasons for this pattern include a lack of encouragement from friends, family and teachers (section 11.1.1); a lack of awareness, this is, reduced prior knowledge of STEM as a career option (section 11.1.2); and a lack of young women's self-confidence in STEM roles (section 11.1.3).

Positive influences from parents, family and teachers

A *Study and work in the EU* Report from the European Institute for Gender Equality (EIGE) defends that positive STEM experiences and development of "STEM identities" start from an early age, even before children enter formal education (*e.g.* in providing caring toys such as dolls for girls and exploring toys such as cars and planes

for boys) through family relations (*e.g.* a strong bond with fathers increases women's likelihood to enter STEM studies). Two real-life examples illustrate the trend.

The first example concerns a distinguished lady professor at university, who became head of the department of electrical engineering and well renowned for her work on speech acoustics. Her father had a larger Mecano collection, built up during his entire life. When he became too old to use it, he offered it to a nephew, rather than to his daughter. It did not occur him otherwise, although he was a good and dedicated father.

The second example concerns a very bright and mature 6-year-old girl. Her father had a collection of model cars which she freely used in her playtime. Her father also had a collection of real cars, where she travelled in a child seat in the rear bench. As soon as the car stopped, and the father left for some activity, she would sit next to her mother on the driver position and try to drive the car. The father offered her a driving simulator, with which she would drive the car from the rear child seat, imitating the use of controls of the real car by her father. Once the father gave her a bigger car model and the mother objected: "Why are you giving our daughter a car? She is a girl: you should give her a doll". Well, the father had already given her many dolls, and this was the first car. If a boy wanted a doll what would be the reaction? As soon as the same girl grew up and the child seat became no longer mandatory, she objected successfully to its use. And when she was no longer legally confined to the back seat, she often wanted to take front passenger seat, in place of her mother that did not have a driver's licence. The daughter certainly will start driving the cars of the family as soon as legally possible.

On the other hand, in the past, separate boys and girls schools tended to put greater influence on girls away from science and technology, because they induced different choices: majority humanities for girls and majority science for boys. Nowadays, the practice of mixed primary and secondary schools means that there are similar opportunities for both boys and girls, as far as their choices are not too much influenced by educators, relatives and friends, and these young people have their own inclinations and are willing to follow them.

Therefore, the traditional attitudes of parents, family and school educators towards which toys girls should play and what careers are more suitable for girls can play a big role in the formation of girls' personalities and self-concept and therefore influence their future career choices. This influences girls and young women are having in their childhood, adolescence and young adulthood from parents, family and educators should be understood as soon as possible (Key Topic 11.1).

KEY TOPIC T11.1 – UNDERSTANDING THE INFLUENCES GIRLS AND YOUNG WOMEN ARE HAVING

To understand why more Europe's girls and young women aren't studying STEM, Microsoft commissioned a Europe – focused research in 2017 involving 11.500 school girls (ages 11 to 18) and young women (ages 19 to 30) from 12 European countries. The resulting report[1] gave answers to important questions regarding girl's interest in STEM subjects and careers, as well as recommendations for policymakers, educators and private sector executives on how to get and keep young women interested in these fields.

The Microsoft research concluded that most European girls become interested in STEM subjects between the ages of 11 and 12, but that interest drops off significantly between the ages of 15 and 16, this is, by the time girls are in high school (Figure 11.1). The Engineering UK Report 2018[2] reinforces this conclusion, stating

[1] https://news.microsoft.com/europe/features/dont-european-girls-like-science-technology/

[2] https://www.engineeringuk.com/research/engineering-uk-report/

that interest in engineering drops off for girls as they get older, but this is particularly pronounced for girls after the age of 16. This means there is a four – a year or five – year window of opportunity to nurture girls' passion for STEM subjects before they turn their backs on these areas.

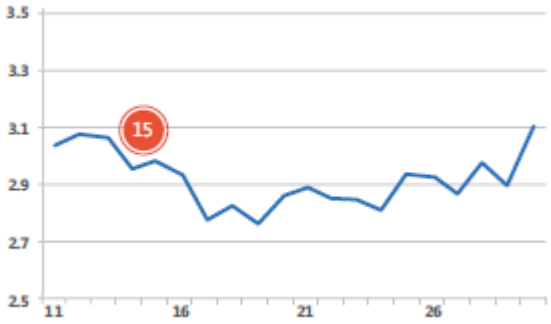

Figure 11.1 - 'Rate on a scale from 1 to 5: how interesting do you consider STEM subjects and at what age did you start feeling this way?'
(Source: Why Europe's girls aren't studying STEM report, 2017)

Taking this into account, during the research it was also assessed whether teachers are engaging their pupils in STEM subjects (Figure 11.2) and parents are encouraging their daughters to pursue STEM (Figure 11.3). The results vary widely from country to country, meaning that the girl's cultural and social environment has a major impact on their attitudes regarding STEM, both positive and negative. In some countries, the major barrier is confidence, while in others it is the peer approval or the lack of female role models.

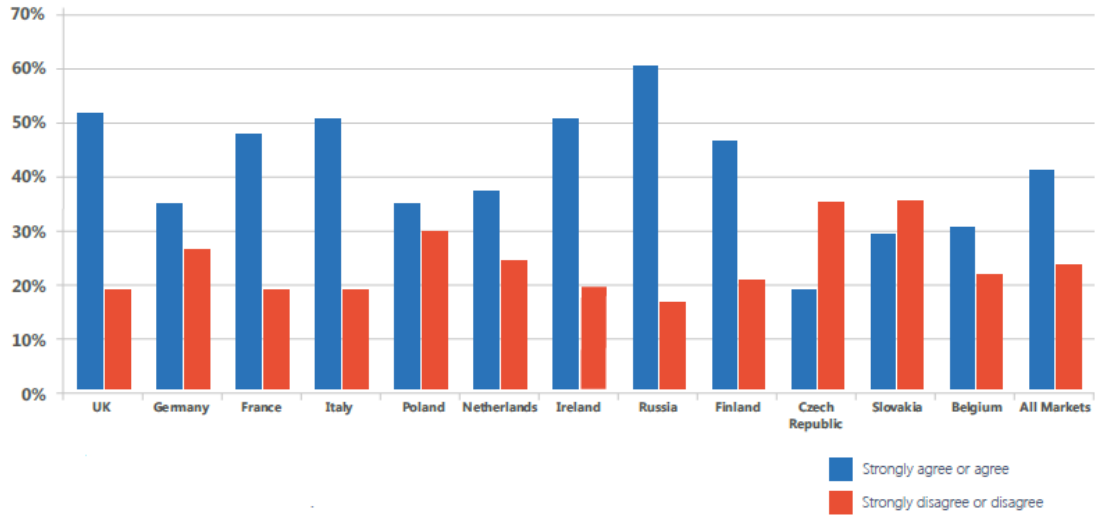

Figure 11.2 - 'Do you agree or disagree with the following statement: "My teachers always talk to me about STEM subjects and encourage me to pursue STEM'.
(Source: Why Europe's girls aren't studying STEM report, 2017)

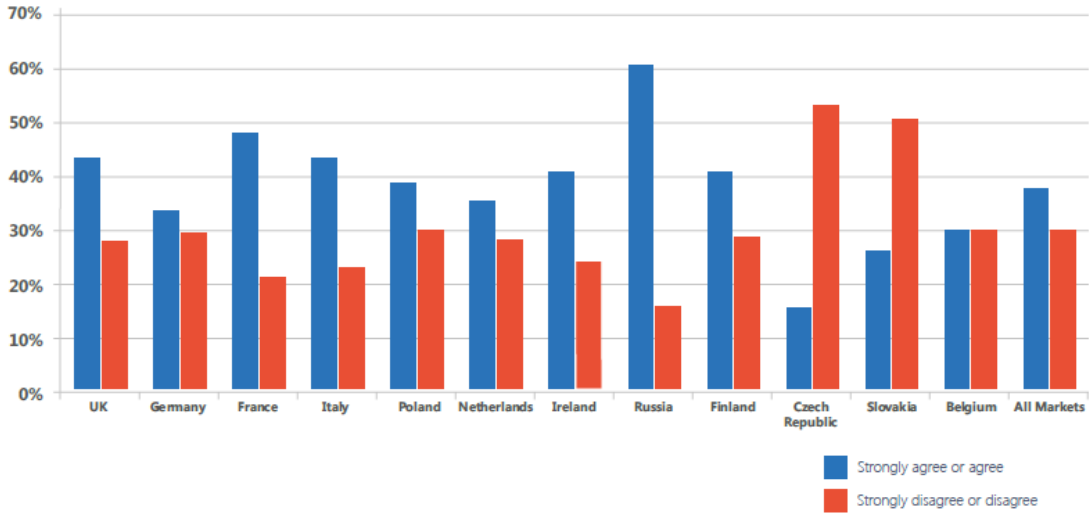

Figure 11.3 - 'Do you agree or disagree with the following statement: "Both parents often talk to me about STEM and encourage me to pursue STEM'.
(Source: Why Europe's girls aren't studying STEM report, 2017)

One of the main findings of the Microsoft research was that in general, schoolgirls and young women expressed a huge amount of confidence in their own STEM capabilities and between 46% and 68%, across Europe, of them rejected the idea that they will never be as good at STEM subjects as boys. Nevertheless, all of them acknowledged that men and women are treated differently in STEM – related roles and this perceived inequality is actually putting them off further STEM studies and careers. In fact, 59% of girls admitted they would feel more confident pursuing a career in STEM if they knew that men and women have equal opportunities. The results presented in Figure 11.4 corroborate this lack of confidence.

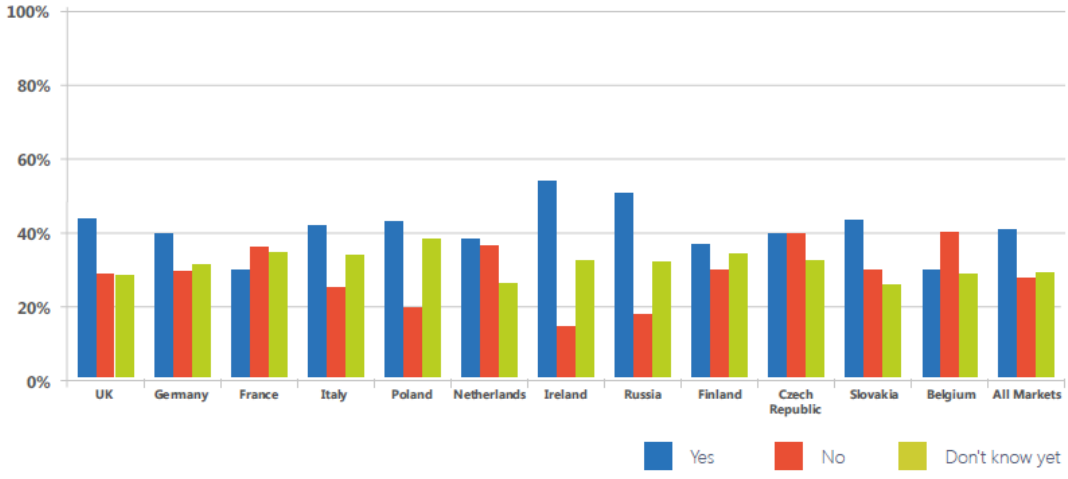

Figure 11.4 - "Can you imagine yourself pursuing a career in one of the STEM disciplines?'
(Source: Why Europe's girls aren't studying STEM report, 2017)

Taking into account the Microsoft report main findings, it is vital for teachers, parents and other family members to actively encourage any girl with an early interest in STEM before it starts to wane. The five

biggest factors identified in the report that can sustain a girl's interest in STEM subjects and careers are presented in order of importance in Figure 11.5.

1. **Female role models:** having visible female role models both in school and at home to help girls to picture themselves pursuing STEM – related careers

2. **Practical experience and hands-on exercises:** gaining practical experience and hands – on exercises during their education – inside and outside the classroom – to increase girl's interest in STEM subjects

3. **Teacher mentors:** having teacher mentors who talk to girls about STEM subjects, clarifying expectations and providing insights, and actively encourage them to pursue STEM subjects

4. **Real–life applications:** being able to conceive what they can do with STEM subjects, how they can be applied to real – life situations and how relevant they might be to their future

5. **Confidence in equality:** being confident that men and women will be treated equally while working in these subjects

Figure 11.5 – Five main factors that can sustain girl's interest in STEM subjects and careers. (Source: Why Europe's girls aren't studying STEM report, 2017)

Awareness - raising of STEM as a career option

The EC's Directorate-General for Mobility and Transport (DG MOVE) commissioned a study[3], addressing the extent to which the transport sector is, or is not, seen to be an attractive workplace by young people and what can be done to assist the recruitment of young people to the sector, including attracting more young women. The study involved a web-based survey of young women and men aged 16-25 across all 28 Member States (MS) regarding their perception of jobs in the transport sector.

The views of both young women and men seemed to be both complex and confused, partially due to the fact that they were poorly informed about what the sector does, what types of jobs there are and what part they might play in it given their educational background. When asked about the attractiveness of working in the transport sector, both groups had similar responses, with the majority in each group seeming to be attracted to the transport as an area of work

In terms of the relative attractiveness of the different transport modes (air, road, rail and maritime), both groups had an excessively positive view of the air transport due to the prospect of travel, good wages and the social aspect of the work and working hours. On the contrary, their views on road and rail transport seemed to be largely limited to daily experiences and were not so positive, with the road being considered to be noisy and dirty, based on motorway experiences, and rail being considered as unattractive due to strikes

[3] https://www.panteia.com/uploads/2017/09/DG-MOVE_Study-Attractiveness-Transport_-Final-Report.pdf

and poor industrial relations. Regarding maritime transport, young people had very limited knowledge and therefore couldn't give their opinion regarding its attractiveness.

On the other hand, when both groups were asked to reflect on specific jobs within the sector, "inbuilt" gender bias took action, with young women tending to prefer certain types of jobs, which reflects the massive imbalance between women and men, not only in terms of numbers but also in the types of jobs they fill. Young women expressed a greater preference for jobs that involved dealing with people as opposed to deal with machinery and equipment, such as working in human resources or as travel attendants.

For young women, the road and rail transport had a negative profile (with only 15% of them responding positively to the prospect of driving a truck, train, bus or tram), while air transport had a positive one being seen as prestigious and exciting. Within the aviation sector, interest in a pilot position was considered to be less gender-related, although under 20% of young female and over 30% of young men responded positively.

In terms of positive actions to create jobs within the transport sector equally attractive to both young women and men, approximately 70% of young women supported proposals to, for example: (1) set up promotional schemes; (2) present successful examples of women taking – up previously male-dominated positions; (3) improving the working environment; and (4) making any necessary changes in education and training. However, less than half that number of young men supported such actions, which means that perhaps there is important, first of all, to ensure that men understand that there are gender imbalances in the workplace and further engage them in becoming part of the solution.

Currently, across the European Union (EU), there are a wealth of communication campaigns and initiatives seeking to attract young people to take up jobs in the transport sector. However, there is also an assumption that some of the barriers to employment are related to a lack of or ineffective promotion of jobs and/or that there is a need to support and reinforce communication activities in this area. In fact, the EC's DG MOVE study suggested that this ineffectiveness may be due to the fact that the existent actions (*e.g.* raising – awareness of issues through an EU campaign) are unable to provide the level of tailoring and face – to – face engagement that is necessary to engage young people in applying for jobs in this sector.

Taking this into account, DG MOVE's study identified 10 specific communication good practices and strategies (Key Topic 11.2), from a shortlist of 25 communication initiatives implemented within the last two or three years in the EU, able to be transferable across the full spectrum of transport sectors in the MS and believed to promote transport jobs effectively to young women and men.

KEY TOPIC T11.2 – COMMUNICATION GOOD PRACTICES AND STRATEGIES TO ATTRACT WOMEN

Among each good practice and strategy, there were selected the most relevant initiatives concerning women attraction to the transport sector and further retainment. As some initiatives were implemented in an educational context, they will be presented in section 11.2. Also, initiatives oriented to promote jobs particularly in aviation to women are mentioned further in section 11.3. The others are presented below, jointly with the correspondent best practices and strategies identified, which are:

1. ***"Using research to confirm the approach"*** – generating new evidence to support the promotion and communication activities in order to better understand target groups, support the strategic business case and generate buy-in for action, and listen to the experiences of young people and staff

   Example of generating new evidence concerns the initiative 'Women in Motion', implemented in 2016 by an Italian rail operator with the goal of increasing the overall percentage of women employed by the company. To gain additional evidence to support the initiative, the company conducted two surveys:

- Internal survey and focus groups: targeting the company's staff to understand the issues that make the job unattractive to women;

- External survey: targeting female students in the last two years of high school to understand better the student's needs and encourage them to apply for jobs in rail;

The internal feedback allowed the company to have a better understanding of the main problems, while the external feedback confirmed that girls perceive that the rail sector is not a suitable workplace for girls and confirmed the lack of female roles. Based on this new evidence, the group defined the main problems, developed a strategy to challenge beliefs and selected 80 successful women employed as positive examples of young women working in the rail sector.

2. ***"Taking a strategic approach (a long term plan with specific targets)"*** – defining SMART (specific, measurable, achievable, realistic and timely) targets to steer communication efforts so that they generate the desired results, and having a very detailed level of planning and implementation

3. ***"Going into schools, colleges and universities"***- generating opportunities for direct face – to – face contact between students and companies in order to provide detailed information to young people regarding career choices in the transport sector

   Options include: (1) developing a plan of events in several schools; (2) working with career advisors; (3) training job coaches on company processes and taking them to schools; (4) bringing apprentices to talk to school children; (5) offering work experience to school children; and (5) helping schools to develop employability skills training/curriculum.

4. ***"Providing opportunities to experience the job"*** – enabling young people to experience a job of their interest, with the aim of giving them a better understanding of the diverse range of roles available across the different transport sector

5. ***Showcasing real people as role models"*** – providing young people with concrete examples of successful employees working in the transport sector, which show what it would be like for them, with the goal of really influencing them on the prospects of jobs in transport. One way to do this is by providing a platform for young people doing the job to tell others what it is about

6. ***"Working with men to engage women"*** – working with existing male workers to better understand the focus of recruitment promotion, since they can provide insights into the challenges of the work and how best to overcome them

   In many cases, there is a basic need to make changes to the culture at work so that it is a place where women want to work, which means men need to recognise the contribution of women and understand that for the company to remain strong in the future it needs female employees. In both Women in Rail (WR) and Women in Logistics (WiL) initiatives, which will be further detailed in the 9th good practice, there is made an effort to ensure representation of men in the networking group, being both men and women encouraged to act as mentors to women. Also, in the 'Au féminin' initiative, also detailed in the 9th good practice, it is extremely important to have men on board.

7. ***"Communicating with young people on their terms"***- using the channels and tools that young people use, e.g. social media, and trying to replicate the world that they live in, in order to attract their attention

Within the initiative Women in Motion, to target female students in the last two years of high school, which were one of the company's campaign target audiences, the company identified social media (namely Facebook, LinkedIn and Instagram) as a crucial communication channel. However, just posting information on social media does not guarantee that it will reach the consciousness of young people. The following campaigns took approaches which did resonate:

- Invest in Shipping – Swedish campaign that used YouTube personalities as elements of brand ambassadorship to encourage and promote engagement among their followers, ensuring that there is increased awareness of the opportunities that exist within shipping. This campaign took inspiration from an award-winning campaign in the technology sector ('Teknikföretagen'), in which a YouTube star active in fashion produced several videos encouraging girls to apply for vocational (technical) training and schools. The key metric for measuring the impact of the campaign was not the number of video views, but instead the number of applicants;

- 'Üstra rockt' ('Üstra rocks')' – implemented in 2015 by the German bus operator Üstra with the goal of attracting women to potential jobs in public transport, including driving and technical jobs, and empowering those who currently work there by raising awareness of gender issues among men. Within the campaign, six videos were disseminated via social media showing bus drivers dancing in skirts. By putting an emphasis on humour, the videos went viral on Facebook and Twitter, being the campaign successful in attracting young people.

8. ***"Building in careers advice provision to promotional strategies"*** **–** including a career advice aspect in the organisation promotional drive with the goal of raising young people awareness on the professional opportunities offered by the sector, this is, ensuring their sufficient understanding of what is involved in the wide range of roles available

   The local government body responsible for the transport system in London, Transport for London (TfL), recognised that careers advice is often not sufficiently tailored to suit the industry, and therefore worked, in 2017, with careers advisors / trained 50 job coaches on TfL processes and took them to schools. Additionally, as young women tend to gravitate towards HR roles at careers events, TfL takes time to explain other roles and literally takes potential recruits from the HR stand to another stand where there is currently a shortage. In this stand, there are advisors and apprentices who can provide a good explanation of what the work is all about and this has led to an increase in the number of apprenticeships in this area.

9. ***"Using networks & mentoring to support female retention"*** – using networks and mentoring as key mechanisms to support female employees in technical jobs, where women can be very few in number and therefore fell somewhat isolated, experience sexist attitudes and intangible or invisible barriers when it comes to promotion or wage increases

   The initiatives that took measures to support female retention are:

   - 'Au féminin' – a network created in 2012 by around 250 employees (mostly women and a few men) of the French national railway company SNCF, who attended a seminar on personal development on how to find one's place in a company. The initiative combines a support network for the development of women who are already inside the company with a proactive recruitment policy. SNCF aims at increasing the gender balance within technical jobs while promoting its image as a responsible employer by combining solidarity actions with a target human resources policy;

- Women in Rail (WR) is a networking group in the UK that connects women and men and supports mentoring, being created with the aim to improve diversity in the country's rail industry. WR provided, in June 2007, 300 mentorships. Mentees are women who are matched with a senior professional (male or female) outside the company, who they would not otherwise have the opportunity to be in contact with. Participating in the mentoring scheme gave women a confidence boost and inspiration, which is a crucial way of supporting the vast network of women working in the sector;

- Women in Logistics (WiL) is a networking group in the UK that aims at providing a platform for women to be part of the wider debate about logistics issues, focussing on three key activities: networking, mentoring and showcasing. WiL runs an annual awards event, which showcases very successful women, putting them in a position where they can be role models for other women in the sector, who can see what can be achieved.

10. *"Using existing resources & networks to increase cost effectiveness"* – making the most of what each organisation has in – house to help reduce the costs of the activities undertaken within the initiative

    Many of the teams behind the following initiatives were small (*e.g.* between one and five people), but they worked in a focussed way to harness the insights, ideas and efforts of their colleagues and partners including other organisations in the same sector:

    - Invest in Shipping – in this campaign, the whole sector joined forces to address the common challenge of recruitment. The close relationships formed between the industry, authorities and schools allow the campaign organisers good insights into the challenges and opportunities in the sector;

    - 'Üstra rockt' ('Üstra rocks')' – the initiative involved the company's own employees in developing the campaign solutions. Employees designed all the campaign's concepts and made the dissemination videos themselves;

    - Transport for London (TfL) – the small team at TfL responsible for developing the early careers' offering couldn't be as successful without the relationships built by working with local authorities across London and linking different TfL groups, including Women in Transport and Youth Ambassadors to specific schools.

The EC's DG MOVE study concluded that promotional efforts which engage young people on a face-to-face basis work well, particularly when they: **(1)** provide opportunities to explain what is involved in the range of jobs available; **(2)** help young people to understand the fit between their skills and transport jobs; and **(3)** give young people opportunities to meet others who are employed in these jobs. Regarding women attraction, promoting an increase in the number of female recruits only addresses part of the problem, and therefore the study identifies specific recommendations for transport organisations (Figure 11.6).

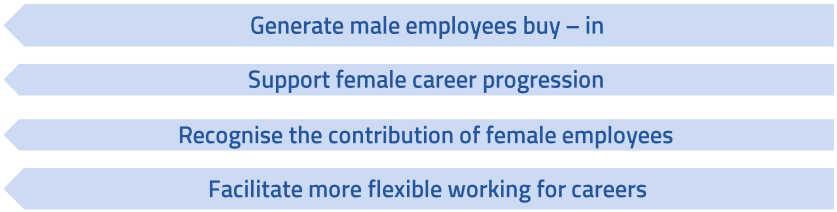

Figure 11.6 - Recommendations for transport organisations.
(Source: European Commission, 2017)

There are also successful campaigns oriented not to the transport sector, but to STEM in general. In the United Kingdom (UK), there is an initiative entitled Women Into Science and Engineering (WISE) that energises people in education, industry and business to increase the participation, contribution and success of women in STEM with the goal of achieving gender – parity in the UK's scientific, technology and engineering workforce – from classroom to boardroom. To do this, WISE members encourage girls to value and pursue STEM subjects in school and college and move into related careers. After attracting female talent into their companies, WISE members strive to retain and progress that talent.

Within Microsoft Europe-focused research, a series of recommendations across the public and private sector were developed, which were separated per targeted audience. Figure 11.7 included key actions recommended for the private sector.

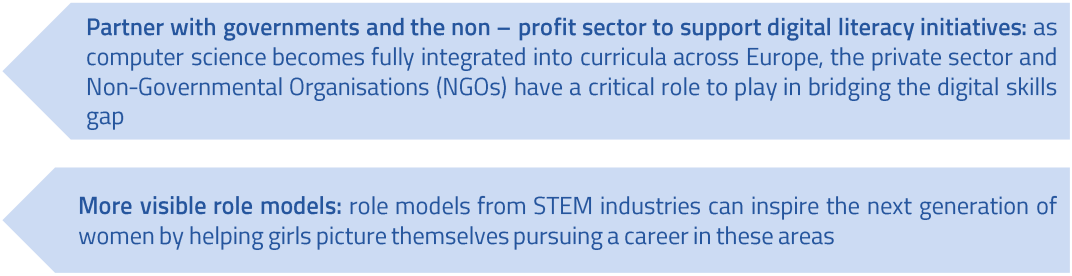

Figure 11.7 - Recommendations for the private sector in general.
(Source: Why Europe's girls aren't studying STEM report, 2017)

Increasing women's self - confidence in STEM fields

Self-confidence is viewed as one of the most motivational factors that influence the ability and attitudes toward science.

A factor against STEM is that it is not a "soft skill", but rather a "hard skill" built-up on persistent work over the years. STEM is an equally "hard skill" for male and female students and perseverance exists in both genders. However, stereotypes on men predominating in STEM may undermine the perseverance of women and lead them to abandon an activity on which they are fully capable.

In fact, women's low self-confidence in STEM is due to gender-stereotypes in science, *i.e.*, the dominant association of science as masculine (which makes women start doubting they won't perform some tasks in STEM fields as well as boys) and the existent gender-imbalance in STEM roles (which leads women to fear being treated differently than men and/or feeling they don't belong). These two factors demotivate women to aspire to STEM careers and make it challenging to see STEM as a potential career choice.

The following study[4], involving 1.327 Swedish secondary school students, corroborates this theory. The study explored why more boys are attracted to STEM subjects at university and more girls are attracted to subjects in the HEED (Health Care, Elementary Education and Domestic) spheres. This difference was partially explained by "social belongingness": teenagers felt they would fit in better in subjects that had more of their own gender.

But another important factor was "self-efficacy": the belief that one can succeed in a domain. People tend to approach domains, where they feel, are competent and avoid those in which they do not. Boys and girls both had high self-efficacy in the HEED subjects, but boys chose not to pursue them. The researchers suggest that this may reflect the low social value and rewards associated with careers in these spheres.

In contrast, girls on average had much lower self-efficacy ratings in STEM, despite outperforming boys across school subjects. Even in one of the most gender-neutral countries in the world and despite the evidence of their own marks, girls still seem to be succumbing to the stereotype that girls aren't as capable in these subjects.

GENDER-STEREOTYPES IN STEM

According to the Organisation for Economic Cooperation and Development (OECD)[5], in OECD countries (currently 36 member countries, of which 23 are European countries[6]), fewer than 1 in 3 engineering graduates and fewer than 1 in 5 computer graduates are girls, most likely due to stereotypes and expectations rather than performance differences in mathematics and science. For example, at age 15 only 4.7% of girls (compared to 18% of boys), even among the top performers in these two subjects, reported being expecting to have a career in engineering or computing.

EIGE defines gender stereotypes as "preconceived ideas whereby females and males are arbitrarily assigned characteristics and roles determined and limited by their gender"[7]. Gender stereotypes develop due to complex socio-cultural factors (i.e. nationality, social status, age, etc.) and can have both a direct and indirect impact on gender segregation. They also impact the choice of study fields or occupations that women and men take by driving interest towards specific subjects that are deemed "appropriate". People's choices can, therefore, be interpreted as a sign of what the culture accepts and enforces as appropriate gender behavior in relation to a specific field of study or occupation, which highlights the influence of the cultural context in the creation of gender stereotypes.

In UNESCO *Cracking the code* report[8], it is stated that studies have shown that stereotyped ideas about gender roles develop very early in life. It is found that girls and boys often have different toy preferences by the end of the first year of their lives, they understand gender stereotypes and want to behave like others of the same sex by as early as age two, and they learn to adjust their behaviour according to internalised gender stereotypes by age four. Gender stereotypes about STEM specifically are prevalent throughout the socialization process, during which girls learn and develop gender roles.

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[4] https://link.springer.com/article/10.1007/s11199-016-0694-y

[5] http://www.oecd.org/gender/data/whereareto morrowsfemalescientists.htm

[6] Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom

[7] https://eige.europa.eu/thesaurus/terms/1222

[8] https://unesdoc.unesco.org/ark:/48223/pf0000253479

Therefore, the pre-conceptions or assumptions about the roles of activities of men and women should be countered for girls and boys as soon as possible (Key Topic T11.3).

KEY TOPIC T11.3 – COUNTERING PRE-CONCEPTIONS INDUCED BY SOCIETY ON GIRLS AND BOYS

According to a research article[9] from Leiden University, when addressing gender stereotypes in science education, it is important to consider stereotypic education materials and gender-biased teaching. For instance, in schools, it is frequent the assumption that "girls are diligent, neat and calm while boys are loud, laidback and naturally clever" and the presence of only a male version in science school books instead of both (*e.g.* he/she) in the images and text.

In fact, the EIGE *Study and work in the EU* Report defends that the participation in STEM is traditionally associated with various stereotypically masculine identity traits and roles and is enforced by the long-lasting historical and cultural idea that science is male-gendered. This stereotypical association stems from the association of men with objectivity and rationality, while irrationality and emotionality are purportedly women's attributed.

There are two predominant stereotypes with relation to gender and STEM - "boys are better at math and science than girls" and "science and engineering careers are masculine domains". Other common preconceptions are that "science is for men, not for women" and that women have a disinclination to science, by her selves or compared with men. In fact, there are countries where the majority of women choose science and they are not necessarily the nations rated as the most gender-equal.

This dominant association of science as masculine and the fact that scientists are usually described or drawn as males makes it particularly challenging for girls to see STEM as a potential career choice and, on the other hand, may equip boys with easily available and pre -established roles in science and technology. Women are also found to be less likely to aspire to STEM careers due to expectations of feeling less good in contexts with unfavorable gender stereotypes.

Similar associations could be made with fields and professions associated with caring and educating, which are traditionally seen as a potential career choice first and foremost for girls. Overall, the EIGE report defends that gender expectations are stricter for boys than girls and that cross-gendered pathways are currently more acceptable for girls than for boys.

Within the Microsoft research, schoolgirls were asked if they agreed or disagreed that STEM subjects are modelled for boys being that all examples that were ever given to them about STEM were mostly about what boys liked. The results were similar across the participant countries, with more girls disagreeing than agreeing, except for Germany. 33% of German girls believe that all STEM-related examples in school are crafted towards boys' interests, slightly more than the percentage of girls that disagree. In Finland and Russia, there is a bigger perception of STEM subjects being gender-neutral, due to the fact that in these two countries, there was a bigger difference between the percentage of girls that agree and the ones that disagree.

Stereotypes can also make it challenging for individuals to remain in their chosen career pathway. Students who differ from what is considered normal within their field experience more challenges in being academically and socially accepted as well as in developing an identity of belonging to the discipline. Likewise, in the labour

[9] https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0165037

market, deviation from the "norm" is not tolerated, *e.g.* women working part-time is typically viewed as an enabling factor in terms of work and family balance. The equivalent choice among men, however, is often met with strong resistance as it deviates even further from the "norm".

Mass and social media are also considered to play an important role in the socialization process, influencing opinions, interests and behaviors. Gender stereotypes portrayed in the media are internalized by children and adults and affect the way they see themselves and others. Media images of STEM professionals may be particularly salient for girls during adolescence as they actively consider future professional identities and options.

Particularly in television and movies, the under-representation of female scientists compared to male scientists leads to girls losing interest in STEM subjects as they get older. For example, some studies have found that when women are shown in television advertisements that allege sex-based abilities in math, they report being less interested in majoring in or pursuing careers involving technical or quantitative skills.

Gender stereotypes on social media platforms can also have a harmful effect. For instance, a recent study of social media users found that gender stereotypes and negative messages about STEM were prevalent and often transmitted by girls and young women themselves. Female social media users were more likely than male users to post or support posts promoting negative views about STEM subjects, especially mathematics. In this study, 75% of all self – mocking mathematics messages were posted by girls and one – third of student's social media shares about women and girls in STEM were sexist.

As seen before, gender stereotyping and gender – imbalance affects women's self - confidence in STEM. There is also a correlation between both factors, being that gender stereotypes can have an impact on gender segregation, and gender segregation by itself is considered, according to the EIGE *Study and Work in the EU* report, to further reinforce gender stereotypes.

Gender – an imbalance in STEM roles

EIGE defines gender parity as the relative equality in terms of numbers and proportions of women and men and is often calculated as the ratio of female-to-male values for a given indicator[10]. It is an essential issue to understand whether and how economies and societies thrive. In addition, it has a great influence on the growth, competitiveness and future-readiness of economies and businesses worldwide.

For instance, EIGE commissioned a study on the "economic benefits of gender equality" in the EU that had as one of its outputs a briefing paper[11], in which it is stated that closing the participation of women in STEM will have a strong positive gross domestic product (GDP) impact at EU level. Closing the gender gap in STEM would contribute to an increase in EU GDP per capita of 2.2 - 3.0% and would increase total employment in the EU by 850 000 to 1 200 000 jobs by 2050. In monetary terms, closing the STEM gap leads to an improvement in GDP by EUR 610 – 820 billion in 2050.

A report on gender segregation[12], which is the concentration of one gender in certain fields of education or occupations, prepared by the EIGE and entitled *Study and Work in the EU: set apart by gender* shows that the share of women in STEM occupations in EU – 27 was less than 15% in 2014 and in ten years (from 2004 to

[10] https://eige.europa.eu/thesaurus/terms/1195

[11] https://eige.europa.eu/publications/economic-benefits-gender-equality-eu-how-gender-equality-stem-education-leads-economic-growth

[12] https://eige.europa.eu/publications/study-and-work-eu-set-apart-gender-report

2015) has only increased one percent. Analysing by country, Bulgaria (26% share of women), Lithuania (21%) and Portugal (21%) had the most balanced STEM workforce while in Luxembourg (10%), the Netherlands (9%) and Austria (10%), the gender segregation was the highest. Even the highest share (26%) is far from balanced and there is a large gap to close.

In the UK, according to a report made by the Deloitte UK[13], in 2016, women made up just 14.4% of individuals working in STEM occupations and in 2013, only 30% of women with STEM qualifications were working in STEM-related industries. This report concluded that more women typically work in jobs where the importance of "soft skills" is high, but where technical or "hard skills" are not as important. Men, on the other hand, typically work in occupations where there is a more even blend of cognitive, social and technical or "hard skills".

Gender segregation also varies across STEM occupations within a country (Figure 11.8), being that gender segregation among stationary plant and machine operators is the most varied, ranging from being predominantly men – dominated in Luxembourg to predominantly women – dominated in Bulgaria and Lithuania. On the other hand, there is little difference in the degree of segregation across EU countries in the occupations: building and related trades, electrical and electronic trades and metal, machinery and related trades; being almost exclusively men – dominated.

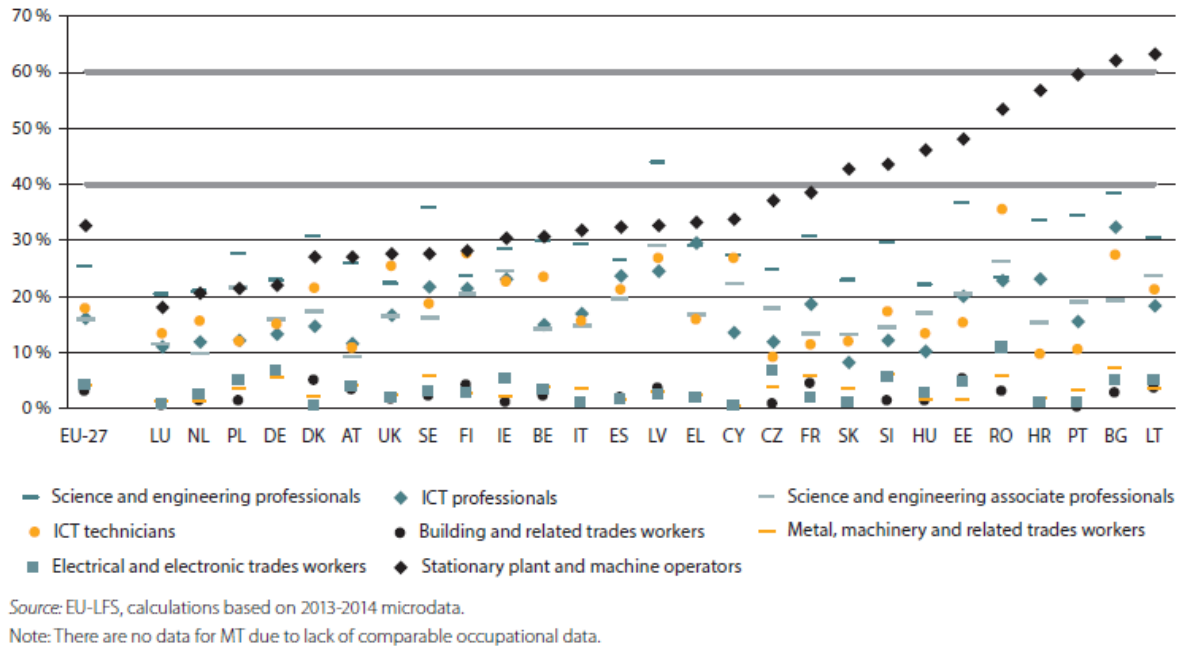


Figure 11.8 - Gender segregation across STEM (share of women) occupations (% 2013 – 2014). (Source: Study and work in the EU Report, 2018)

Regarding science and engineering professionals and associated ones, the highest share of women is observed for Latvia (about 44%), while Bulgaria has the highest share (about 33%) of women among

[13] https://www2.deloitte.com/uk/en/pages/growth/articles/technology-career-pathways-gender-pay-gap.html

Information and Communications Technology (ICT) professionals and Romania has among ICT technicians (about 36%). Nevertheless, the latter occupations are still men - dominated in all EU members.

According to the EIGE *Study and Work in the EU* report, gender segregation narrows life choices, education and employment options leads to unequal pay and limits access to certain jobs while also perpetuating unequal gender power relations in the public and private spheres. Also, it is one of the reasons behind skill shortages and surpluses and thus has large, though often still unaccounted for, effects on numerous policy initiatives, including those to stimulate economic growth and to reduce long – term unemployment.

Policymakers have long ago recognized the need to eliminate occupational segregation, by promoting the participation of women in jobs that are men – dominated. They can contribute to the achievement of gender equality in STEM by an effective gender mainstreaming (Key Topic T11.4).

KEY TOPIC T11.4 – IMPORTANCE OF GENDER MAINSTREAMING FOR GENDER EQUALITY

According to the EIGE[14], gender mainstreaming is a strategy towards realising gender equality and combating discrimination that involves the integration of a gender perspective into the preparation, design, implementation, monitoring and evaluation of policies, regulatory measures and spending programmes. As policies focus on the general public, they often impact women and men differently. Therefore, this strategy is fundamental to ensure that policymaking and legislative work is of higher quality and responds more effectively to the needs of all citizens.

Gender mainstreaming has two dimensions: (1) it requires both the integration of a gender perspective within the content of the different policies (gender-responsive content of each policy); and (2) the addressing of the issue of representation of women and men in a given policy (gender representation in a policy area). Both dimensions need to be taken into consideration in all four phases of the policymaking process. A brief description of each phase of the gender mainstreaming cycle, as well as the methods and tools that should be used within each phase are presented below (Table 11.1).

METHOD / TOOL	DESCRIPTION
1st Phase - Define: defining the precise policy needs to be addressed by the public intervention in a specific policy field	
Gender statistics	Statistics that adequately reflect differences and inequalities in the situation of women and men in all areas of life. Statistics Databases: • EIGE's Gender Statistics Database;
Gender analysis	Critical examination of how differences in gender roles, activities, needs, opportunities and rights affect women, men, girls and boys in a given policy area, situation or context. Frameworks: • Harvard Analytical Framework; • Moser Conceptual Framework; • Levy conceptual framework; • Capacities and vulnerabilities approach (CVA); • Social relations approach;

[14] https://eige.europa.eu/publications/what-gender-mainstreaming

METHOD / TOOL	DESCRIPTION
	• Gender analysis matrix framework; • 4R Method;
Gender impact assessment	Assessment of the impact or effects of any policy of activity implemented to the state of equality between women and men. Toolkit: • EIGE Gender Impact Assessment Guide;
Gender stakeholders consultation	Consultation of gender experts, women's organizations and other civil society organizations on the topic at hand to share and validate findings and improve the policy or programme proposal. Tools: • Online surveys; • Town - hall meetings; • Focus group discussion; • Individual Interviews; • Nominal group technique; • Delphi survey;
2nd Phase - Plan: planning the implementation phase of policies or programmes from a gender perspective	
Gender budgeting	Gender – based assessment of budgets, incorporating a gender perspective at all levels of the budgetary process and restructuring revenues and expenditures in order to promote gender equality. Tools: • *Ex ante* gender impact assessment; • Gender perspective in performance setting; • Gender perspective in Resource Allocation[15];
Gender procurement	Introduction of gender equality requirements in public procurement, this is, in the subject of the contract itself.
Gender indicators	Tools for monitoring gender differences, gender – related changes over time and progress towards gender equality goals. Indicators can be quantitative (based on statistics broken down by sex) or qualitative (based on women's and men's experiences, attitudes, opinions and feelings).
3rd Phase - Act: ensuring that all who are involved are sufficiently aware about the relevant gender objectives and plans	
Gender equality training	Any educational tool or process that aims to make policymakers and other actors in the EU and MS more aware of gender equality issues, build their gender competence and enable them to promote gender equality goals in their work at all levels. Toolkit: • EIGE Gender Equality Training Guide;
Gender – sensitive institutional transforming	Process that aims to integrate gender equality into the regular rules, procedures and practices of an institution, leading to its transformation of an institution, thus also impacting on the organisational culture. Toolkit: • EIGE Gender Institutional Transforming Guide;
Gender awareness - raising	Increasing general sensitivity, understanding and knowledge about gender (in) equality, through the use of different communication channels, such as large –scale

[15] http://www.oecd.org/gender/Gender-Budgeting-in-OECD-countries.pdf

METHOD / TOOL	DESCRIPTION
	media; social media and social networks; public events; printed materials; static and travelling exhibitions and display; and political advocacy and lobbying.
4th Phase - Check: monitoring ongoing work and evaluating both ongoing and *ex post* work	
Gender monitoring	Systematic and objective assessment of the design and planning (objectives, results pursued, activities planned), the implementation and results of an ongoing activity, project, programme or policy from a gender perspective. To build up a gender sensitive monitoring set of indicators, each dataset should be disaggregated by sex.
Gender evaluation	Systematic and objective assessment of the design and planning (objectives, results pursued, activities planned), the implementation and results of an ongoing or completed activity, project, programme or policy from a gender perspective. Widely used evaluation criteria are relevance, efficiency, effectiveness, impact and sustainability.

Table 11.1 - Gender mainstreaming phases, methods and tools[16].

According to the 2019 *Report on equality between women and men in the EU*[17], the European Commission (EC) continues to focus its mainstreaming activities on bringing about a behavioural change regarding gender equality and fighting stereotypes. Within its funding programme for research and innovation, Horizon 2020, the EC finalised the HYPATIA project in 2018, aimed at fostering partnerships among schools, science museums and centres and industries to offer gender-inclusive STEM education to young people, especially girls.

The work of the EU platform entitled "Women in Transport – EU Platform for change[18], launched in November 2017, has continued and new members have joined in 2018, including members from the main employers' and workers' organisations in the transport sector, MS' representatives, the EU Agency for Railway and the Shift2Rail joint undertaking. The Platform serves as a forum to discuss and exchange good practices on how to increase women's employment and equal opportunities for women and men in the transport sector, being members encouraged to take concrete actions to meet this objective.

Regarding air transport, the EC is actively encouraging aviation stakeholders to bring concrete actions to the Platform to improve employment and working conditions to attract and retain women in aircrew professions[19].

According to the EIGE *2019 Report on equality between men and women in the EU*, EIGE has prepared a report on 'Gender equality and youth: opportunities and risks of digitalisation', which recommends that the EU institutions and MS incorporate a gender perspective into all digital initiatives focused on young people and recognises that digital media offers a powerful tool for mobilisation in support of gender equality. Regarding Microsoft Europe – focused research, recommendations for policymakers are presented in Figure 11.9.

[16] https://eige.europa.eu/gender-mainstreaming/methods-tools

[17] https://ec.europa.eu/info/sites/info/files/aid_development_cooperation_fundamental_rights/annual_report_ge_2019_en.pdf

[18] https://ec.europa.eu/transport/themes/social/women-transport-eu-platform-change_en

[19] https://ec.europa.eu/transparency/regdoc/rep/1/2019/EN/COM-2019-120-F1-EN-MAIN-PART-1.PDF

Integrate digital literacy into the broader curriculum: integrating coding and computer science education into the curricula to drive interest in STEM

Create more opportunities for computer science teaching in and out of the classroom: cross – industry initiatives like Europe Code Week, Hour of Code and Girls in ICT Day are helping to introduce young women to a more digital way of thinking and ultimately nurture a passion for STEM education

Place a greater focus on STEM education as part of the Digital Skills strategy: the EC adopted its New Skills Agenda for Europe, which recognises the current mismatch between the skills employers need and hose jobseekers have, and recommends a minimum level of digital skills for all jobseekers

Figure 11.9 - Recommendations for policymakers.
(Source: Why Europe's girls aren't studying STEM report, 2017)

11.2 Changes in the educational context

*PARE Objective 50: "Give girls and boys in primary schools the same opportunities to choose their games and entertainment".

*PARE Objective 51: "Encourage more girls to take aeronautical engineering degrees".

Gender segregation in STEM fields is reflected in or a consequence of gender segregation in STEM education (section 11.2.1) and for that reason, in order to understand segregation in the labour market, a deep understanding of what influences the educational differences of girls and boys during their school and college years is needed.

Research suggests that there is little or no difference in boys' and girls' average ability at STEM subjects, which means that in order to attract more girls to STEM subjects at schools and universities, the solution is to tackle the stereotypes that they are exposed to from primary and secondary education until university graduation rather than of performance differences in STEM subjects (section 11.2.2 and section 11.2.3).

Gender segregation caused by stereotyping in education creates gender inequalities in and beyond the labour market, acting as a barrier to increasing women's labor market participation – narrowing life choices and employment options and possibilities. Therefore, it is fundamental to tackle these gender stereotypes by making changes in the educational, taking into account the use of appropriate role models, the influence of the peers, the recruitment and retainment of students, and the enhancement of classroom activities and contents (hands-on and project-based learning).

Gender imbalance in STEM education

According to Eurostat Statistics, in the EU – 28, there were 29.1 million pupils in primary education in 2016, from which approximately 49% were girls and young women, which means that gender parity was almost achieved in primary education. Regarding secondary education, in the same year, there were 20.5 million pupils in lower secondary and 22 million in upper secondary, where the gender distribution was balanced across MS (Figure 11.10).

In post-secondary non-tertiary education, which is the level of education that starts after the completion of upper secondary education and generally serves to broaden rather than deepen the knowledge, skills and competencies already gained through the successful completion of the level before, there were 1.6 million pupils in the same year. From post-secondary non-tertiary graduates, there was, on average, more female than male graduates, which varied between EU MS (Figure 11.11).

In tertiary education, according to OECD's "Education at a Glance 2017" report[20], in 2015 and in OECD countries, more women than men graduate from tertiary education, with an average of 57% of first-time graduates. Despite being the majority of graduates, women were underrepresented in engineering, manufacturing and construction (on average 24% of entrants) and ICT programmes (on average 29% of entrants), while men are underrepresented in degrees in education (on average 22% of entrants) and health and welfare (on average 24% of entrants).

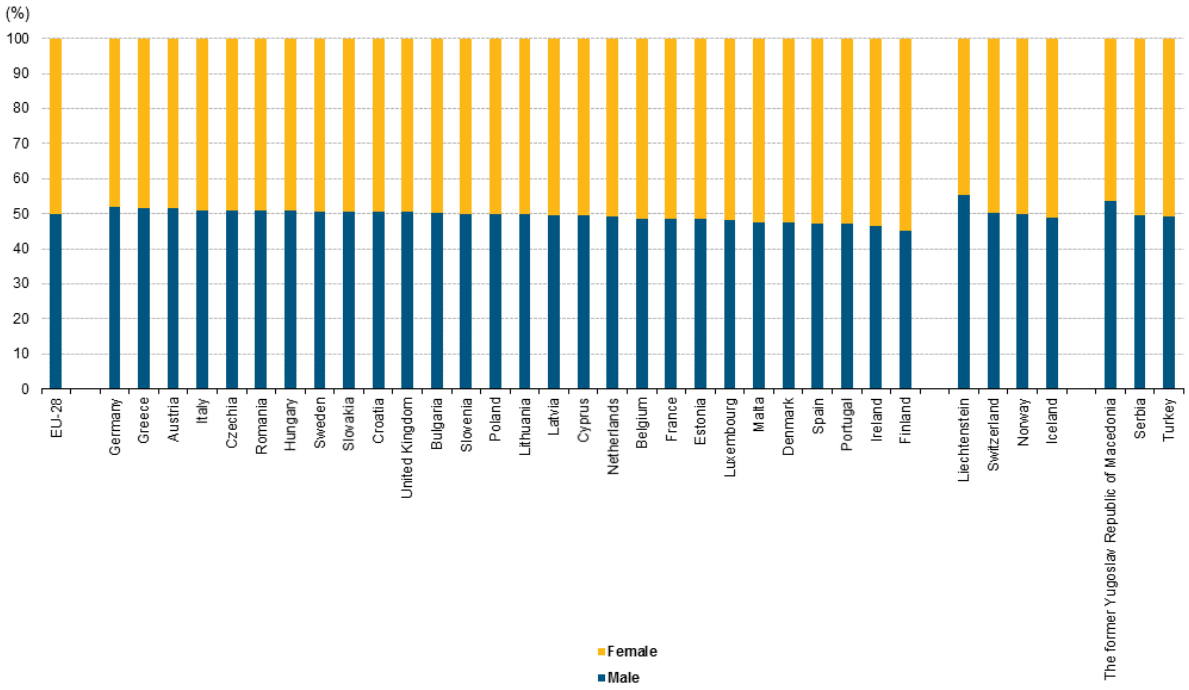


Figure 11.10 - Distribution of upper secondary education graduates by sex, 2016. (Source: Eurostat)

[20] https://www.oecd-ilibrary.org/docserver/eag-2017-en.pdf?expires=1561558391&id=id&accname=guest&checksum=D782967C4EF82EE058B80ABD7037A3D6

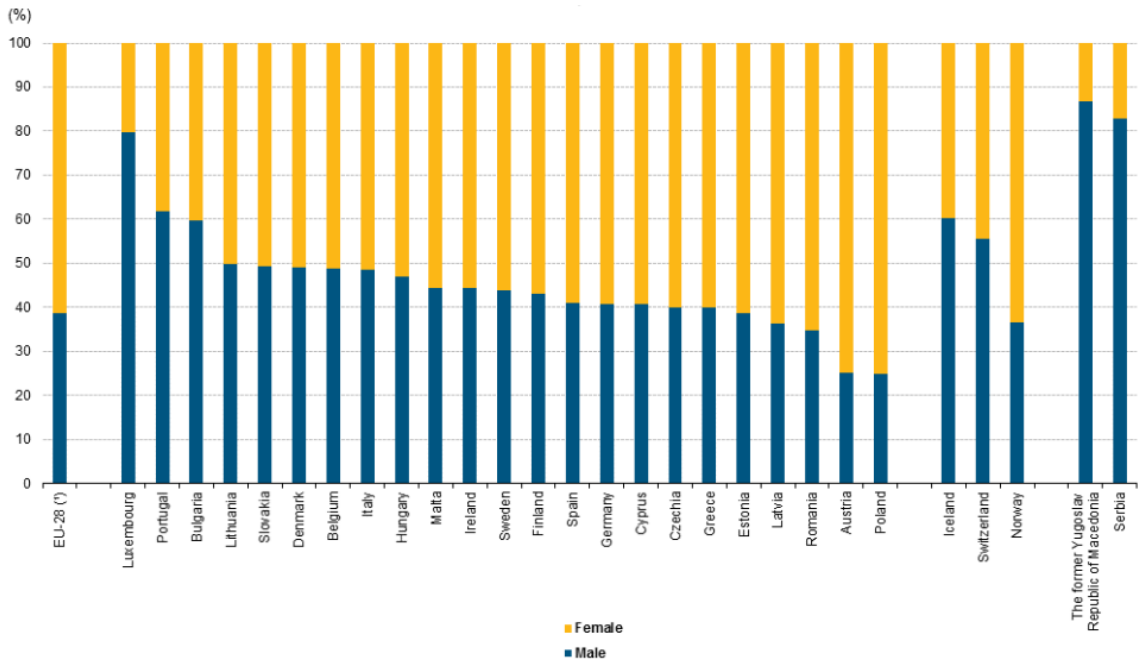
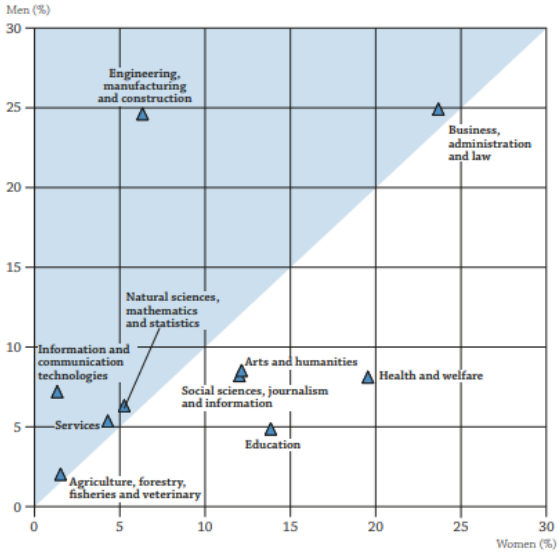


Figure 11.11 - Distribution of post-secondary non-tertiary education graduates by sex, 2016. (Source: Eurostat)



This means that, in OECD countries, tertiary education is marked by a large gender gap by field of studies (Figure 11.12) and men are more likely to obtain a degree in a STEM field of studies. In 2016, natural sciences, mathematics and statistics were the only STEM field of study where gender parity is achieved, with 50% of women.

Figure 11.12 - Distribution of tertiary graduates, by gender and field of study (2016). (Source: OECD's "Education at a Glance 2018' report)

In the EU-28, in 2016 there were 19.6 million students in tertiary education (54.1% were women), of which 7.3% were following short-cycle tertiary courses, 61.3% were studying for Bachelor's degrees, 27.6% for Master's degrees and 3.9% for Doctoral degrees. One year later, the share of women of all tertiary graduates was 57.6% and the gender statistics within the different levels of tertiary education are presented in Figure 11.13.

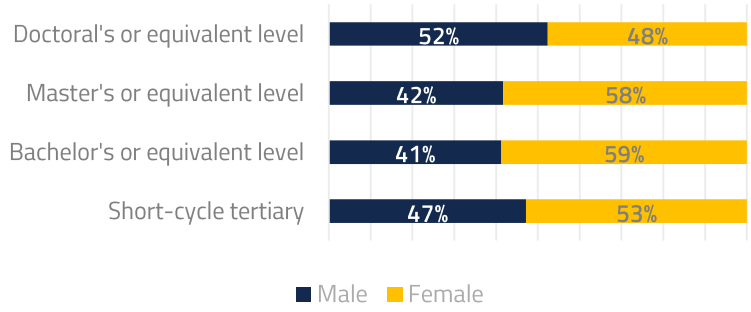


Figure 11.13 - Distribution of tertiary education students by level and sex, 2017. (Source: Eurostat)

In 2016 (Figure 11.14), across the EU, almost 32% of all students in tertiary education were studying social sciences, journalism, information, business, administration or law, with women being over-represented (57.6%). The second most common field of education was engineering, manufacturing and construction-related studies which accounted for 15.7% of all tertiary education students, of which 25.9 % were women, a percentage slightly bigger than the average percentage in OECD countries.

Among the remaining fields of education shown, the highest share of female students was recorded for those studying education (where 78% of all students were women), while women accounted for almost two thirds (64.5%) of all students studying arts and humanities. By contrast, within natural sciences, mathematics, statistics and information and communication technologies the share of men in the total number of tertiary students was 61.1%.

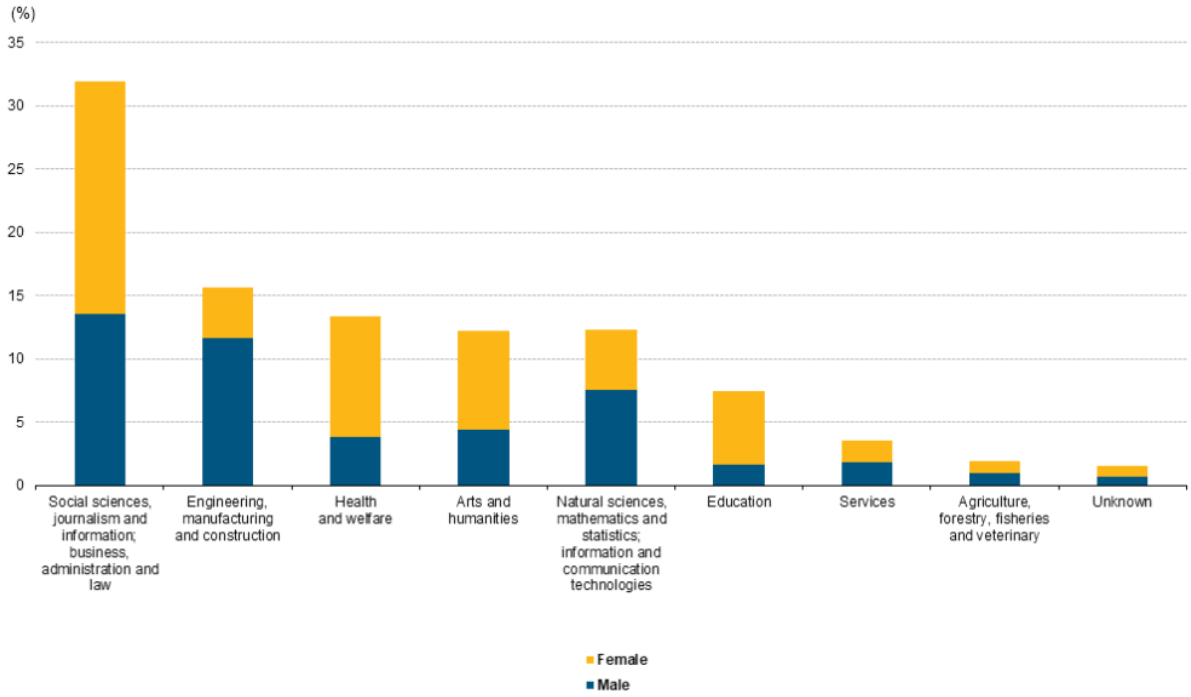


Figure 11.14 - Distribution of tertiary education students by field and sex, European Union, 2016. (Source: Eurostat)

Taking this into account, in the EU, it is clear that STEM fields are much more prevalent among men, whereas social sciences, health and humanities are much more common among women. Following the importance of educators in influencing girls and young women in studying and pursuing STEM fields, teacher's gender in the several levels of education is also analysed (Figure 11.15). In 2017, there was a clear dominance of female over male teachers in primary and secondary education in the EU. On the other side, in tertiary education (including aerospace academic careers), males are dominant, but the gender scenario is more balanced than in other education levels.

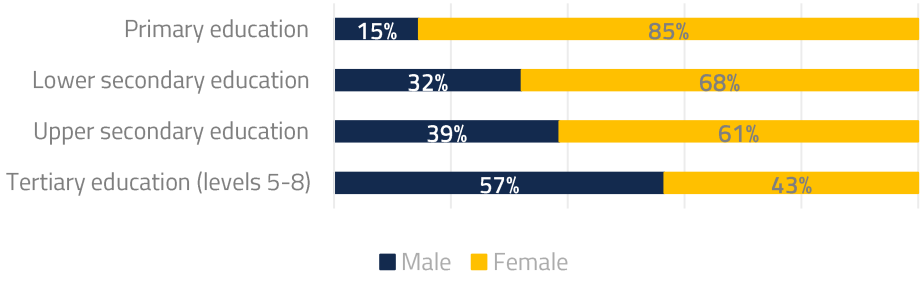


Figure 11.15 - Distribution of teaching staff by gender, 2017. (Source: Eurostat)

This results may justify the high share of female students in the field of education (78%) in the fact that girls and young women have several female educators as role models while growing up. At the same time, it emphasizes the importance of female teachers' attitudes regarding gender stereotypes and their responsibility in supporting female pupils that are into STEM.

The imbalance in numbers between the genders can be due to choices made in academic subjects at school and further in university (which will be further analysed), which in turn may be attributable largely to gender stereotyping from an earlier age. Nevertheless, there are a number of good practices and strategies that can be used to tackle the gender – imbalance in STEM subjects (Key Topic T11.5).

KEY TOPIC T11.5 – GOOD PRACTICES AND STRATEGIES IN EDUCATION

From the selected initiatives concerning women attraction to the transport sector, several were implemented in an educational context, mainly in primary and secondary schools. The following initiatives originated DG MOVE's 3rd good practice – ***"Going into schools, colleges and universities"*** and, even though they were oriented for children in general, they can serve as an inspiration for initiatives to attract girls to STEM subjects:

- 'Zeebenen in de Klas' ('Sea legs in class'): implemented in the Netherlands with the aim of getting children excited about working in maritime transport. The initiative involved over 300 school visits to 200 schools, interacting with a total of 10.000 children. Each visit consisted of a guest lesson from a ship worker, who tried to convey his/her experience of working in the sector in a fun and inspiring way for children;

- Five employee volunteers from the Raben Group in Poland conducted visits to kindergartens and schools, and together with the local police, talked about safety and the importance of transport. The idea was to "put transport into pupils and children DNA" to be able to draw on their knowledge and potential interest later in their lives.

Also, as said before, the initiative 'Women in Motion' (DG MOVE's 5th good practice - ***"Showcasing real people as role models"***)involved the selection of 80 successful female employees of an Italian rail operator as positive examples of young women working in the rail sector. Afterwards, these women, all under the age of 45,

visited girls in high schools and told them their personal story and experiences, trying to overcome the stereotype of girls and proposing the rail industry as a valid career option. Within these visits, girls had the chance to establish personal contact, ask questions and get more insights about all the different career pathways girls can follow in the rail industry.

Another example[21] of using female role models to encourage girls to study STEM subjects at university and enter STEM careers is Speakezee, a web platform that connects academics and non – academic audiences, such as Universities and Schools. As part of a campaign to coincide with International Women's Day, Speakezee is working with the Institute of Physics and the Association of State Girls' Schools (ASGS), which is the leading state girls' school organisation in the UK, to send young female graduate STEM students into schools to talk to and inspire girls to consider pursuing STEM topics at A-level.

Therefore, some measures have been adopted so far in Europe to minimize the existing gender differences, thus influencing girls' and women's participation, progression and achievement in STEM fields. Other examples[22] include:

- Making available on the internet and to primary school's children stories and cartoons where girls drive cars and fly aeroplanes as much as boys do and let them play with vehicle models or ask for them as presents;

- Developing a toolkit for primary and secondary school teachers to fight gender stereotypes and raise awareness about transport professions among young people, *e.g.* including flight experiments equally accessible to boys and girls in the primary and secondary school programmes and activities;

- Identifying good practices on how to organize rosters in the best family-friendly way, to be made available to all stakeholders;

- Reinforcing and accelerating visits to universities and industry, role models of success stories and the same fascinating technologies.

However, as it is necessary to reduce even more the gender-imbalance in STEM-related subjects, recommendations for educators identified in Microsoft Europe-focused research are presented in Figure 11.16.

[21] https://www.theguardian.com/science/head-quarters/2018/mar/08/bridging-the-gender-gap-why-do-so-few-girls-study-stem-subjects

[22] https://doi.org/10.1504/IJAM.2016.079953

Using new technology to spark girl's interest: introducing technologies can help female students to create and explore virtual words, learn basic coding and develop social skills

Future – proof teacher training programs and make teaching more collaborative, immersive and social: all teachers need to feel comfortable and supported in bringing technology into their classrooms to make learning more engaging

Introducing more creative and hands – on experiences in classes: young girls love creativity and practical experiences

Classes must be gender neutral: a gender neutral environment in classes help young women to participate and feel engaged

Figure 11.16 - Recommendations for educators.
(Source: Why Europe's girls aren't studying STEM report, 2017)

Choices and performance of girls in primary and secondary schools

After analysing the gender imbalance in STEM, it is necessary to understand better the choices of girls concerning STEM subjects and their performance in primary and secondary education to assess whether girls ability at these subjects is a factor influencing these choices (Key Topic T11.6).

KEY TOPIC T11.6 – PERFORMANCE AND CHOICES OF GIRLS CONCERNING STEM

According to the Deloitte UK report[23], in 2016, almost as many girls as boys sat the General Certificate of Secondary Education (GCSE), a qualification in a specific subject typically taken by school students aged 14 – 16, in STEM subjects (Figure 11.17). However, three times more boys than girls took computing and 50 per cent more boys than girls took design and technology. Mathematics, additional science and biology were the only STEM subjects with slightly more girls than boys.

Even though being underrepresented in general, the number of girls awarded A* - C grades was 20 percentage points higher than for boys. Significantly, girls perform better than boys at GCSE in all subjects, including most STEM subjects, being Mathematics the only exception, where boys marginally outperformed girls, for the first time.

At A - level, which is the level that students who pass on the GCSE exam go to, the gender differences in subject choices are more pronounced (Figure 11.18). Boys remain much more likely to pursue STEM subjects, being that 40 per cent more boys than girls took STEM subjects in 2016, but their performance is still not as strong as girls (Figure 11.19).

[23] Note: in the Key Topic T11.6, the reason for using UK statistical data is due to the fact that were only found statistics regarding girls performance concerning STEM at secondary school in UK reports.

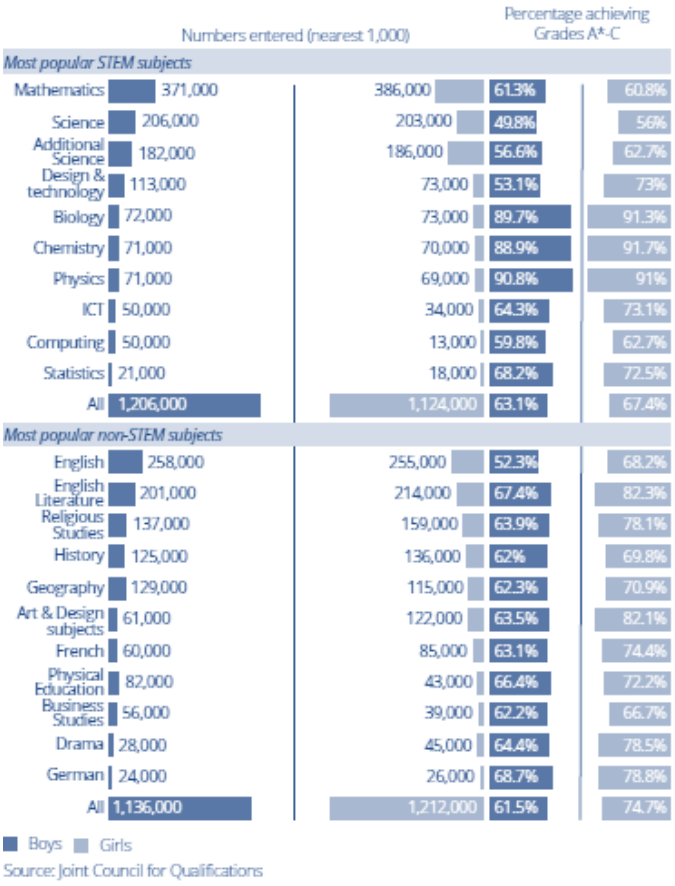


Figure 11.17- GCSE results 2016.
(Source: Women in STEM, 2016)

Subjects with the highest proportion of girls	Total numbers (to nearest 1,000)	% male	% female
Performing Arts	2,000	10.2	89.8
Welsh	1,000	20.8	79.2
Sociology	34,000	23.1	76.9
Psychology	59,000	23.7	76.3
Art & Design subjects	43,000	23.9	76.1
Communication Studies	1,000	26.9	73.1
English	85,000	27.1	72.9
Religious Studies	27,000	30.4	69.6
Drama	13,000	30.7	69.3

Subjects with the highest proportion of boys	Total numbers (to nearest 1,000)	% male	% female
Computing	7,000	90.2	9.8
Physics	36,000	78.4	21.6
Other sciences	3,000	75.3	24.7
Further mathematics	15,000	72.5	27.5
Economics	29,000	67.7	32.3
ICT	9,000	64.2	35.8
Design & Technology	13,000	61.4	38.6
Mathematics	93,000	61.3	38.7
Physical Education	12,000	61.1	38.9

Source: Joint Council for Qualifications

Figure 11.18 - Gender differences among subjects entered at A-level in 2016.
(Source: Women in STEM, 2016)

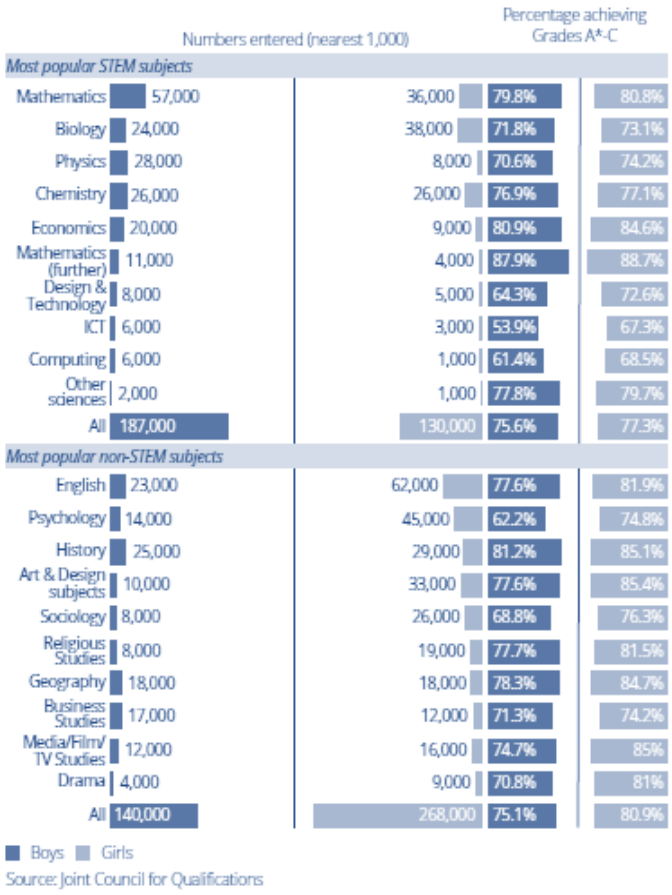


Figure 11.19 - A-level results 2016.
(Source: Women in STEM, 2016)

The fact that, in 2016, almost as many girls and boys sat GCSE in STEM subjects and more girls than boys were successful and then, in A-level, 40 per cent more boys than girls took these subjects corroborates with the findings of the Microsoft research that girl's interest drops between the ages of 15 and 16 and is not a cause of girls' performance in these subjects. As highlighted in the Microsoft research, it is probably related to girl's acknowledgement that there is gender inequality in STEM – related roles and also that men and women are treated differently in these roles.

As students choices in secondary school influence their future choice in university, being that those who have studied STEM subjects for A-level are more likely to move on to STEM-related degree programmes, girls are more likely to choose university degrees where science and maths do not feature.

Choices and performance of women in university

For a long time, most women who choose Engineering at university opted for Chemical Engineering, where in many cases the majority of students were female. In contrast, few girls chose other branches of engineering like civil or mechanical engineering. The anecdotal explanation that chemical engineering is closer to cooking carries no substance and is just one more form of biased judgement. The real explanation may be that in former times a lady civil engineer might feel uncomfortable among uneducated construction workers, and a lady mechanical engineer might not be at ease in a factory shop full of rough workers, although some could brave the situation successfully. A better prospect for women inclined towards science would be to work in a chemical laboratory or medical profession less influenced by the preconceptions and discriminations of society.

The situation has improved significantly in both respects. More branches of engineering put more emphasis on office and laboratory work, like engineering design and informatics. The attitudes of the society have improved with regard to gender equality and respectful treatment, though not to the extent of overcoming all barriers.

A real life example illustrates this. A distinguished male university professor that leads an initiative to increase the interest of women in STEM and encourage applications to enter engineering degrees at university. He has found most reluctance from female secondary school teachers. A possible reason is that they had negative experiences or perceptions, and did not want to expose young female students to similar situations. The reality or perception of unequal treatment may have a snowball or domino effect from one generation to the next. It is necessary to reverse the reality and perception of unequal treatment of women in STEM, so that the present generation can in good conscience take a positive and encouraging position towards the next and future generations, reversing the snowball or domino effect from unfavourable to favourable. Gender discrimination may propagate itself through memories of unfavourable experiences and this needs to be reversed by an overwhelming record of successful outcomes.

Although women perform as well or better than men in STEM subjects, several external factors influence their choices in other directions (Key Topic T11.7).

KEY TOPIC T11.7 - PERFORMANCE AND CHOICES OF WOMEN CONCERNING STEM SUBJECTS

According to the EIGE *Study and work in the EU*Report, in ten years (2004-2015), women's share among STEM graduates in the EU has fallen from 23% to 22%. However, gender segregation is much stronger in vocational (technical) than in tertiary education in almost all EU countries. Overall, only 13% of EU graduates from STEM vocational education are women, whereas 32% graduate from STEM tertiary education.

Among these female graduates, only one-third work in STEM occupations, compared to one in two men. Among vocational education graduates, the gap is even greater, with only 10 % of women but 41 % of men working in STEM occupations. Among those moving away from STEM, 21 % of women at the tertiary education level work as teaching professionals and 20 % of women with vocational STEM education work in sales.

The EIGE *Study and work in the EU* report also demonstrates that the chances of employment for women graduating from male-dominated files of education are significantly lower than those of men. In 2014, the employment rate of women graduates in STEM at tertiary level was 76% in the EU, which is more than 10 percentage points lower than the employment rate of men with the same qualification and 3 percentage points lower than the average employment rate of women with tertiary education.

According to the Engineering UK Report 2018, in the academic year 2015/2016, women comprised only 16.0% of first-degree entrants in engineering and technology entrants, being the STEM field with the second lower proportion of female first-degree entrants, only computer science had a lower proportion (Table 11.2). This contrasts with the number of women starting STEM first degrees (50.1%) and first degrees overall (56.1%) in that academic year.

From all these female entrants, 15.6% qualified with a first degree engineering and technology and in aerospace engineering specifically, all 11.6% female entrants qualified in that academic year. Regarding outcomes and progression, the report states that in the academic year 2015/2016 there were notable gender differences, with higher proportions of women than men that continued or qualified at first degree level. This high performance academically suggests that women must remain a priority target group in terms of potential recruits to the engineering workforce in the longer term.

STEM Subject	Male (%)	Female (%)
Physical sciences	58%	42%
Mathematical sciences	62.6%	37.4%
Computer science	85.1%	14.9%
Engineering and technology	84.0%	16.0%
Aerospace engineering	88.4%	11.6%
Civil engineering	81.7%	18.3%
Mechanical engineering	90.4%	9.6%
Naval architecture	84.5%	15.5%
Electronic and electrical engineering	87.2%	12.8%
Production and manufacturing engineering	78.1%	21.9%
Chemical, process and energy engineering	73.3%	26.7%
Architecture, building and planning	62.6%	37.4%
Agriculture and related subjects	29.9%	70.1%
Biological sciences	38.4%	61.6%
Medicine and dentistry	42.5%	57.5%
Subjects allied to medicine	18.7%	81.3%
Veterinary science	19.3%	80.7%

Table 11.2- First degree entrants by STEM core subject, subject area and gender in the academic year 2015/2016. (Source: Engineering UK Report, 2018)

According to statistics made available at the WISE campaign website[24], the number of women in UK graduating in a core STEM subject, such as: physical sciences, mathematical sciences, computer science, engineering & technology and architecture, building & planning; has been growing through the last years (Figure 11.20), with an overall increase of over 1.000 women graduating in core STEM subjects between 2017 and 2018. In each specific core STEM subject, the number of female graduates increased, except in mathematical sciences. Overall, in 2018, 26% of graduates in Core STEM subjects were female. However, analysing by core STEM subject, the percentage in the academic year of 2017/2018 was: 42%, 39%, 15%, 15% and 36%, respectively.

The Deloitte UK report concludes that, since girls are significantly underrepresented in STEM subjects at school, at university and consequently in working life, there is potential talent among girls not being fully exploited, which could help fill skills shortages existing in STEM-related occupations.

[24] https://www.wisecampaign.org.uk/statistics/core-stem-graduates-2018/

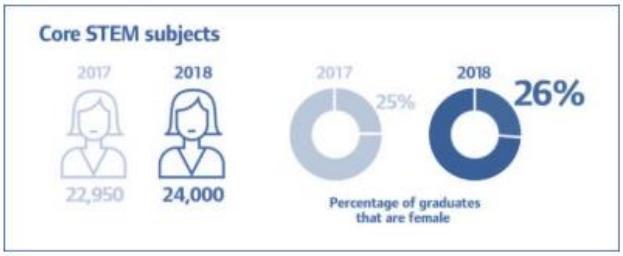


Figure 11.20- Evolution of women in core STEM subjects from 2017 to 2018. (Source: WISE 2019)

University environment influence on women persistence in STEM fields

According to the article[25] "Girl Power" published in 2018 in the *Social Sciences* open access journal, women in engineering majors enter college with the same levels of interest and intent to persist in the major as male peers, yet fewer women complete undergraduate degrees in STEM fields and persist into related careers (National Science Board 2016). Overall, research shows that women who have positive experiences in STEM majors via supportive faculty members and peers, research experiences, or participation in engineering organizations are more likely to continue taking STEM classes, complete degrees and continue on to post-baccalaureate STEM careers in comparison to those who do not (Beyer 2014; Gayles and Ampaw 2016; Hughes 2010; Kezar and Holcombe 2017; Litzler and Young 2012; Marra et al. 2009; Neumann et al. 2016; Ro 2011).

Additionally, many women in science and engineering report experiences with discrimination and bias that make it difficult to persist and succeed in their majors. Women in science and engineering have a long history of feeling marginalized, isolated, and subject to stereotype threats within their majors, a feeling that tends to grow over time (Marra et al. 2009; Neumann et al. 2016). Favouritism and differential treatment also detract from positive experiences that increase persistence and academic success for women, as male and female faculty in science and engineering have been found to favour and be more responsive to male students in comparison to females (Milkman et al. 2015; Moss-Racusin et al. 2012). Further, reports of bias in the form of sexual harassment from classmates and faculty are all too common for undergraduate women in science and engineering (Morris and Daniel 2008).

The report also defends that differential treatment and bias towards women in science and engineering also have negative underlying consequences for women's perceptions of their own abilities. More recent work suggests that women underestimate their performance on engineering tasks compared to men (Woodcock and Bairaktarova 2015). Additional research has shown that unwelcoming environments contribute to decreased self-confidence, self-efficacy, the tendency behave in self-limiting ways that negatively impact overall success and persistence for women in science and computing (Haines et al. 2001; Morris and Daniel 2008), with gender discrimination related to lower academic performance (Beyer 2008).

11.3 Improvement of the employment context

*PARE Objective 52: "Provide women with attractive careers in aeronautics in industry and academia."

[25] https://www.mdpi.com/2076-0760/7/1/11/htm

*PARE Objective 53: "Discourage and prevent continuation of abuse based on gender."

*PARE Objective 54: "Ensure that the protection of family, maternity and parenthood is effectively implemented with its legal basis as a minimum."

*PARE Objective 55: "Give equal recognition of achievements regardless of gender, taking into account the circumstances."

*PARE Objective 56: "See the differences between the genders as an opportunity for a symbiosis of distinct talents that furthers smooth progress."

*PARE Objective 57: "Increase the participation of women in aeronautics in the most effective way."

*PARE Objective 58: "Recognise the historic achievements of women, including in aeronautics, in biased or unfavourable circumstances."

As the traditional masculine beliefs and values have been rooted in the aviation industry for a long period, despite several efforts made, the percentage of women pursuing a career in the field remains low, particularly in the technical side (section 11.3.1). To oppose this, it is necessary to raise - awareness of all career opportunities in aviation, to offer the guarantees of equal treatment and prevention of abuse (section 11.3.2), to ensure the protection of family, maternity and parenthood (section 11.3.3) and to recognize the achievements of female employees and to compensate for eventual gender differences (section 11.3.4).

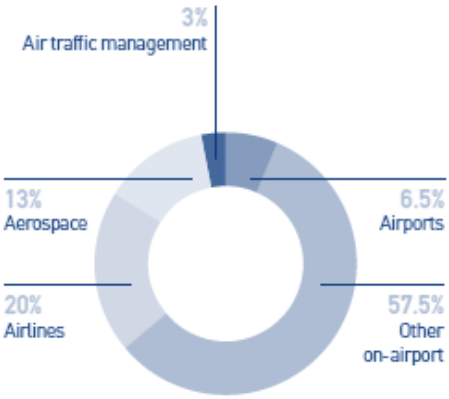
Ultimately, it is also relevant to acknowledge the benefits of complementarity, *i.e.* a greater number of women in aeronautics should be regarded as not just as a numerical enlargement of the workforce but also as a broadening of the talent available, through real-life stories of women that distinguished themselves by their achievements in several sectors despite facing challenges (section 11.3.5).

Gender Imbalance in the aviation sector

According to a global report[26] entitled *Aviation: Benefits beyond Borders* prepared by Oxford Economic for the Air Transport Action Group (ATAG), the aviation sector in Europe directly employed an estimated 2.6 million people in 2016. The aviation sector has five segments (Figure 11.21) and accounts for a variety of employment jobs types (Figure 11.22), being considered direct jobs: airport operators (operations, planning and engineering); other on – airport (retail, car rental, government agencies such as customs and immigration, freight forwarders and some catering); airlines (flight and cabin crews, executives, ground services, check-in, training and maintenance staff); civil aerospace (engineers and designers of civil aircraft, engines and components); and air navigation service providers (air traffic controllers and executives).

In Europe, women make up 41% of aviation employees, but this percentage is deceptive because it reveals little of the skill distribution between the sexes or the extent of female presence in senior roles. For example,

[26] https://aviationbenefits.org/downloads/aviation-benefits-beyond-borders/



even though there is a high share of female cabin crew, it is estimated that only around 4-5% of the world's commercial airline pilots are female[27]. The same goes to technical positions, which require STEM skills, which will likely skew towards men.

Figure 11.21- Direct employment in air transport in Europe in 2016 by segment. (Source: ATAG Report 2018)

In airport operational roles and ground handling, women make up 25.8% of employees, although in the lower age bracket (those under 30) over 32% of staff are women. A sample survey of air navigation services providers conducted in 2017 found that 25% of air traffic controllers were women. In airline's executive roles, the gender gap is as great as in technical positions, with women making up 3% of the top 100 airline chief executive officers; 8% of chief financial officers and 3% of chief operating officers. In human resources, women constitute 32% of HR directors.

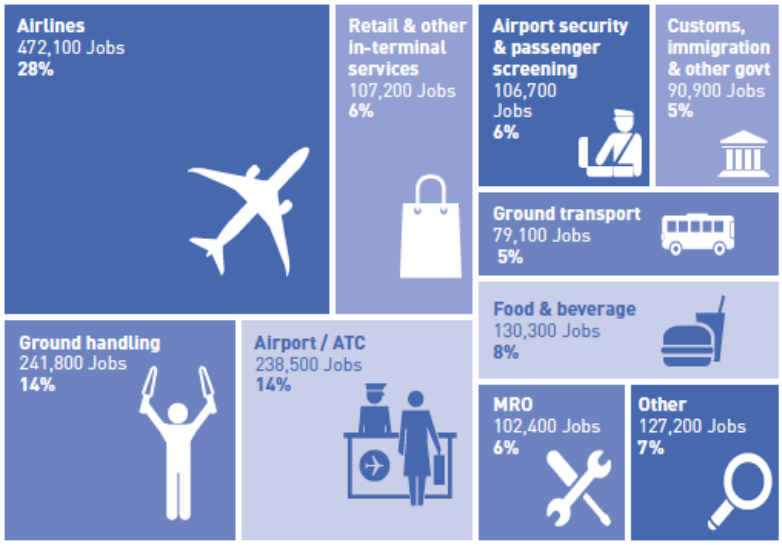


Figure 11.22- Overview of the types of jobs at a typical European airport. (Source: ATAG Report 2018)

Therefore, the aviation sector has both jobs requiring STEM skills as well as not. For instance, to be a cabin crew member there's no necessity to follow STEM education. Some airlines don't even request for a university course and just ask for high school education. Jobs related to ground handling service do not also require STEM education.

[27] https://www.sesarju.eu/sites/default/files/documents/SESAR%20women%20in%20aviation.pdf

Normally when someone refers to a career in aerospace, most people instantly think of technical roles, such as pilots and engineering jobs. However, airlines rely on many individuals to perform their job in order to keep them in business.

Moreover, there is also the possibility to follow an academic career (e.g. as professor in an aerospace engineering degree), which would positively influence girls with interest in pursuing a STEM subject by both representing a female role model and mentor.

Women should be also aware of this in order to also attract them to these jobs, which can be done by using effective communication good practices and strategies (Key – Topic T11.8).

KEY TOPIC T11.8 – COMMUNICATION GOOD PRACTICES AND STRATEGIES IN EMPLOYMENT

Within the Üstra rockt' ('Üstra rocks')' campaign, bus and tram male drivers wore skirts as part of their work uniforms, conveying the idea that "if men can wear skirts, women can be drivers", therefore seeking to break gender stereotypes. This was one of the campaign examples that originated DG MOVE's 6th good practice – *"**Working with Men to engage Women**".*

Regarding DG MOVE's 4th good practice – *"**Providing opportunities to experience the job**",* the initiative '#Nolimitsforwomen' - provided by Lufthansa in Germany allowed women to apply for a career day with the company. The winner could choose from a wide range of professions mostly in operational areas that are typically male- dominated, such as logistics, aircraft, maintenance or the air – traffic control centre. In addition, the company provided travel to Lufthansa headquarters as well as accommodation in Frankfurt for the lucky winner.

Both following examples (DG MOVE's 2nd best practice – *"**Taking a strategic approach (a long-term plan with specific targets**"*) counted their success in terms of the increase in the number of applications and subsequent recruits from the target groups:

- Air France – currently, 32.2 % of the company's senior executives and 48% of managers are women and it aims at increasing the share of women in management by 5 percentage points by 2020;
- 'Üstra rockt' ('Üstra rocks')' – implemented in 2015 by the German bus operator Üstra with the goal of increasing the number of women employees from 16% to 22%, including in driving and technical jobs. The number of female applications for all positions (drivers, management and service) increased threefold in 2 years and their proportion went from 20% to 60%. Also, interviewees felt that the campaign managed to set a dialogue on the topic of gender equality in the workplace.

A number of companies in the aviation sector have or are currently implementing initiatives to enhance female participation in the aerospace, being them:

- Airbus: is striving to promote diversity by inviting female high school students to visit its facilities and meet its female employees to discuss their experiences via the *Elles du Futur* and similar initiatives. Also, women's networks and mentoring programs at Airbus are actively promoting a more balanced leadership within the company. At present, the chief technology officer (CTO) at Airbus is a women: Grazia Vittadini;

- National Air Traffic Services (NATS): hosted a "Bring Your Daughter to Work Day", where sixty 13 to 18-year-olds met with engineers. This initiative is part of NATS' Early Careers recruitment scheme, aimed at motivating the next generation of female controllers, engineers and technicians by raising awareness of STEM (Science, Technology, Engineering & Mathematics) related career paths in aviation;

- Thales: encourages internships and apprenticeships allowing female candidates to gain hands-on experience. The company partnered, in 2011, with Elles Bougent, the association which provides networking opportunities for young women and promotes careers in science and technology. Under this partnership, over 150 Thales women were Elles Bougent mentors in 2018, acting as mentors and share their passion for engineering. Additionally, Thales is actively involved in the annual *Réseaux et Carrières au Féminin* forum, the *Journée des Sciences de l'Ingénieur au Féminin* event and various other initiatives promoting careers in science and technology to female pupils, students and graduates.

In aerospace academic careers, women are also still a minority and even though they perform as well or better than men, there are too few candidates. A real-life example of a job position for Assistant Professor had 56 applications from all over the world, being only 3 of them from female applicants. From the chosen 3 candidates to the position, two were male and gave up for various reasons (geographical, family and economic), and the third was a young women. When offered the position she had applied for, she was very reluctant to accept, because she thought her family situation (divorced with a young daughter) would make it impossible to meet the high academic standards of the university: assistant professors face a very demanding reporting and vote after 5 years that decides between dismissal and tenure. She had to be persuaded to accept the job and her doubts started to vane as soon as she found a very favorable and friendly professional atmosphere. She performed very well from the beginning and all along and is very likely to have tenure at the 5 years completion. This example shows that men have a role to play in gender equality at work and should mentor against self-efficacy doubts in women that often are not justified.

Guaranteeing equal treatment and preventing abuse

All aspects of the job recruitment, from the announcements to the interview, to the benefits (including salary) must be gender equal and if there are eventual gender differences, these should be compensated. Another key aspect refers to gender-abuse, which should be taken as seriously as gross incompetence or major financial misconduct regarding the consequences and should leave no doubts on anyone's mind about this policy in order to discourage and prevent the continuation of abuse based on gender.

JOB RECRUITMENT AND RETAINMENT

Even though aviation employers have a good reputation for encouraging young women to enter the industry, the number of women in technical roles remains low, therefore, careers information and supporting activities need to be more appealing and effective for girls too. According to the book entitled *Women Scientists and Engineers Employed in Industry: Why so few?*[28], effective recruitment approaches are centred on six elements:

1. The recruiters are engineers, scientists, and managers of engineers and scientists, not the Human Resources Division representatives;
2. Employees chosen as corporate recruiters are those who exhibit strong interpersonal skills, who "care and go the extra mile";
3. Recruitment occurs at a targeted group of universities. Additional linkages with universities have been developed by many companies to identify prospective employees;
4. The company maintains a corporate presence on each campus, interacting with faculty, students, and staff;

[28] https://www.nap.edu/read/2264/chapter/1#viii

5. Entry-level recruits rotate through a series of technical and management assignments to learn about program opportunities.
6. Co-op programs enable the company to evaluate potential employees while they pursue projects that support the work of the company laboratories.

Additionally, it has been noted that support for women needs should also exist at the organizational level. Leadership should make efforts through the creation of a positive work environment where mentoring and networking has been also indicated to be helpful. Even if leadership simply connects corresponding individuals or even assigns mentors or role models to provide encouragement for female employees, these efforts can greatly improve job satisfaction and, as a result, retention. Human resource personnel should also be trained to be considerate of the recruitment and retention of minorities. Ideally, formal practices are put into place to create an inclusive work environment and recruitment process.

GENDER PAY GAP

According to the Deloitte UK report, women are disproportionately more likely to go into jobs in industries or sectors where pay levels are lower. Considering all employment, based on provisional figures from the Office for National Statistics (ONS) in 2015, the average gender gap for UK full-time workers *(i.e.* the difference between median hourly wages for men and women, expressed as a percentage of the male median wage) was 9.4%.

However, the gender gap in starting salary between men and women who have STEM qualifications and go on to take jobs in those spheres is smaller than in any other subjects studies. If more women were to pursue careers in these areas, not only would it give them a more balanced portfolio of skills, but it would also narrow the gender pay gap for those in the early years of their working lives.

The gender pay gap has various causes and therefore, no single measure will be sufficient to eradicate it. It is partly related to the fact that many women take time out from work for family reasons and may only take on a part-time job when they eventually return to work, which in general is paid less per hour than full-time work. To find a suitable balance between family and working life, combined with lower pay for part-time working contributes significantly to the pay gap.

Also, the age of workers is also a cause of the gender pay gap, in the fact that it is wider between men and women at an older age. Part-time work is not equally spread between women and men, since in the EU in 2017, 32% of women in employment worked part-time, compared with 9% of men. The EIGE *Study and work in the EU* report also considers that gender segregation in STEM is a major cause of the gender pay gap.

Deloitte UK report defends that solving the gender pay gap over the long term means tackling an ingrained difference in the skills that women gain and choose to develop during their academic studies and, therefore, in the jobs they go on to take. If more women are encouraged to study STEM subjects during their education and are taught in a way that recognises their cognitive preferences, they are not only being prepared for a more dynamic world of work but it simultaneously starts to bridge the gap in pay.

Tackling the gender pay gap and its root causes depends upon strengthening the engagement that already exists between businesses, educators and policymakers. In particular, businesses have to take a greater role in helping to reduce the engrained differences in the skills that women gain and develop. Recommendations for business include: providing educators and policymakers with practical careers insight; providing more support for women returning to work, and publishing detailed information on the gender pay gap.

GENDER ABUSES

Women feel more supported in environments which recognize their range of skills they have, provide opportunities for progression and take a firm line on sexist behaviour.

Companies usually take seriously, up to and including grounds for dismissal, two types of inappropriate action, and they should add a third. An employed that proves to be professionally incompetent and causes a disservice to customers or harms the reputation of the company can be rightly dismissed. Similarly, an employee that misuses company resources or fails to carry out important duties may face consequences. Using the workplace an opportunity for gender abuse, whichever way should have a similar sanction to incompetence or dishonesty, because all three are improper forms of conduct.

Additionally, in most institutions, including large ones, individual rights are not equally applied. A successful top executive may have much more reward than all others that contributed to the result; a failed worker may be dismissed whereas a failed top executive may have a generous retirement offer that cannot be refused. Countering gender abuse may face similar difficulties, especially if the culprit is up and the victim down the hierarchical ladder; this should be countered by putting more responsibility on those who have more power and should be more ethical in its use.

The issues of women on-the-job treatment need to be considered very seriously in order to have access to this major half of the workforce (Key Topic T11.9).

KEY TOPIC T11.9 – INTEGRATION OF WOMEN IN THE AEROSPACE SECTOR

Concerning on-the-job treatment and preventing abuse, there are three main factors to take into consideration:

1. **Women mentoring programs:** women mentors can support in efforts to make the industry and job functions more transparent, giving entrants a realistic depiction of how the industry works and what it is really like in the work environment

   Additionally, female mentors can provide individuals entering aviation or those early in their careers with assistance dealing with issues affecting women that are not applicable to men, e.g. balancing the desire to have a family with professional aspirations.

   Evidence shows that the assistance of a mentor is important for women at all stages in their careers (Ehrich, 2008; Singh et al., 2002; Vinnicombe and Singh, 2002; 2003), but especially in terms of career advancement (Durbin and Tomlinson, 2010; 2014; Lineham and Walsh, 1999; Ragins, 1999). Mentoring also acts as a channel for the exchange of tacit knowledge and information that is often linked with promotion opportunities (Durbin, 2010; Swap et al., 2001). Mentoring is of particular significance for women as it may help them to break through the 'glass ceiling' (Lineham and Walsh, 1999; Ragins, 1999). Mentoring also increases women's visibility within organisations (Hersby et al., 2009) and contributes to raising aspirations and levels of self-confidence (Institute of Leadership and Management, 2011). However, mentors are harder to come by for women, especially in male-dominated industries (Durbin, 2010; Durbin and Tomlinson, 2014).

   Alta is an Economic and Social Research Council (ESRC) co-funded project to design a mentoring scheme for women in the aviation and aerospace industry. The project was based on a knowledge-exchange partnership between the University of West of England, the Royal Aeronautical Society (RaeS), the Royal Air Force (RAF) and Airbus. These partner organisations recognised the critical role that women play in their industry and through a formal mentoring programme, wanted to support their female professionals and encourage more into leadership roles. Aligned with the project Alta is

a mentoring scheme, providing one-to-one mentoring from successful women, and a network that's dedicated to ensuring that talented women reach their full career potential, for the benefit not only of individuals but also our industry as a whole.

2. **Women job satisfaction determinants:** on-the-job treatment should also consider women's determinants for job satisfaction (Table 11.3) and design their jobs ensuring these factors

Women
Independence in my work
Part of a larger team; supervisor values my contribution; flex time
Job stability

Source: Aviation Week 2015 Workforce Study

Table 11.3 - Some determinants for job satisfaction of women.

For instance, in 2015, independence on work, be part of a larger team, valorisation of work by the supervisor, flex time and job stability were pointed as crucial to women workforce in aviation.

3. **Women networking:** establishing networks of women to share experiences and promote opportunities are perceived to be an important element of improving working conditions

There are several organizations aiming to help women through networking opportunities:

- Women in Aviation International - a non-profit organization dedicated to the encouragement and advancement of women in all aviation career fields and interests. Women in Aviation International provides: education resources, scholarships, outreach programs, an annual conference and job fair, Girls In Aviation Day (girls ages 8-17) and girl Scout Aviation Patch;

- Women in Aerospace (WIA) – is dedicated to expanding women's opportunities for leadership and increasing their visibility in the aerospace community. Networking is one of the many significant benefits of joining WIA. Comprised of individuals from an array of disciplines and technical experiences, WIA members are given a number of opportunities to meet equally driven colleagues at events held throughout the year;

- Women in Aerospace Europe (WIA – E) - encourages female employees to form networks, dedicated specifically to " the promotion of women to senior positions within the European aviation and aerospace industries";
- The Royal Aeronautical Society's Women in Aviation & Aerospace Committee (WAAC) - was established in 2009 to encourage more young women to consider aviation and aerospace as a worthwhile and exciting career. It also exists to provide support for women already working in all sectors of aviation and aerospace;

- The International Aviation Women Association (IAWA) – a non-profit international organization providing a worldwide network dedicated to promoting the advancement of women in the

aviation and aerospace industries at all levels across the globe. Founded in 1988, IAWA brings together women of achievement and promotes their advancement throughout the world. Women are assuming greater and more visible roles within the industry. Through annual global conferences, regional receptions and connects, IAWA provides a forum to share views on matters of importance to the industry, as well as to women in general. Women should have five years' leadership experience in aviation or aerospace to apply for IAWA membership. However, IAWA conference is open to all women in our industry. IAWA also sponsors informative meetings, hosts receptions and connects, publishes newsletters, and keeps its members updated on the latest industry developments.

Protection of the Family, Maternity and Parenthood

The protection of the family and children is a fundamental value of society that the law tries to ensure in all situations including employment. However, there are still cases of dismissal using collateral arguments that cannot be accepted for their consequences and are equivalent to a disguised violation of the prevailing law.

How the parenthood allowance is shared between the parents is a family matter that should not be interfered with. Special circumstances have also to be allowed for. In some cases, a change of type of work or a different assignment can make more compatible company priorities and family needs, by adjusting schedules or timetables.

Although many in modern times advocate complete mobility, there is nothing wrong with children becoming fond of the employer of their parents, whom they grow to see as a reliable part of their life, perhaps wishing to follow a similar career, continuing their parents work for another generation.

The following companies in the aviation sector have or are currently implementing initiatives to ensure the protection of their employees regarding their family, maternity and parenthood:

- NATS: provides a supportive and encouraging environment for women to pursue a fulfilling career whilst bringing up children by allowing work-time flexibility;

- ENAIRE: for the company, seeking the talent of women is embedded in corporate recruitment policy. The company has a "strategic plan, the Flight Plan 2020," which "establishes various actions aimed at achieving equality between men and women via programmes that reconcile work and family life". Also, ENAIRE has "women leading key areas of sustainability in their business, such as the environment, social action and contracting areas";

- German Aerospace Center (DLR): the company believes that work-life balance is about providing flexible working methods and that "cutting-edge research requires excellent minds – particularly more females – at all levels". "Equal opportunities and a range of support measures for a better work – life balance have therefore long been the central pillars of DLR's HR policy". The company wants "to reach much fairer participation of women in the scientific-technical area in particular, also in leadership positions" – which it intends to achieve by setting "target quotas that should be reached in the next few years". On a practical level, DLR provides "flexible work-time models, the possibilities of alternating teleworking and mobile working, consulting and intermediary services in matters of child support care and dependent relatives". And when women have taken a break to raise children, it offers a "structured career re-entry process after a period of family-related absence." DLR also joined the Women in Aerospace Europe (WIA – E) network in 2009;

- Frequentis: as a family-owned company group, it maintains "a special focus on work-life balance and the compatibility of family and career", offering "a range of parental leave possibilities and childcare programmes".

Recognizing achievements and compensating eventual gender differences

The recognition of professional achievements must, of course, be objective and fair, using the same criteria applied in the same way, regardless of gender, age or belief. However, fairness also means equal opportunities, and while applying the same final criteria, all should have the same opportunities to attain those objectives.

The recognition of job achievements should also include a reasonable allowance for special circumstances. The adjustment of working conditions or schedules or responsibilities to account for special individual circumstances of women or other groups is not a favour, but rather having an even playing field inside the company as the company would like to have in the market versus its competitors, promoting a loyal division of tasks within the organization.

It also should be considered, not only the need to avoid direct and reverse discrimination or bias by judging and rewarding achievements in an even, transparent and fair way but the need of assigning positions and tasks using the best talents and skills available in both genders, thus promoting creativity and efficiency.

Reverse discrimination may not be the best way to correct gender inequalities nor forced statistical equality: women do not need favours they only need equal opportunities and fair treatment, and this applies not only to gender issues but also to other potential forms of discrimination that could creep into the workplace.

Women have had remarkable successes in aviation (Key Topic 11.10) in spite of modest recognition, suggesting they could achieve even more in more favourable circumstances.

KEY TOPIC 11.10 – ACHIEVEMENTS OF WOMEN IN AVIATION

Women were present in aviation activities since the first flights. However, until the 70s their presence was, with rare exceptions, mainly as passengers or flight attendants on-board of male-piloted vehicles. Prejudices formed in the general social life were exacerbated in aviation. Claude Grahame-White (1879-1959), a British pioneer of flight (he is credited with the first night flight) is quoted saying that "women are not temperamentally suited to fly an aeroplane".

This biased opinion persisted over decades, determining a large delay in pioneer women penetrating in male-dominated aviation professions. The notable exceptions were the effect of a combination of factors:

1. Outstanding qualities (Hanna Reich);
2. The encouragement of a political system using women images for propaganda objectives (Valentina Teleshkova, the first woman in space, Lydia Litvyak and Yekaterina Budanova – the only women among the combat flying aces in World War II);
3. Powerful support from families (*e.g.* Jacqueline Cohcran's husband was one of the richest men on the planet; Jacqueline Auriol was the daughter-in-law of the French president; Amelia Earhart's exploits were financed by her husband, a press magnate, Marga von Etzdorf who was the first woman to fly for an airline when she began co-piloting for Lufthansa in 1927 was presented her first aircraft by her grandfather for her birthday); and
4. Luck.

Only in 1929, a Canadian was the first woman to earn a master's degree in aeronautical engineering. One year later, Ellen Church, a pilot and nurse, who was unable to secure work flying proposed to airline executives that women be allowed to act as hostesses on planes. She was hired on a three-month trial basis by Boeing Air Transport and selected the first seven flight attendants for airlines, requiring them to be under 115 pounds, nurses and unmarried[29].

In 1937, Sabiha Gökçen of Turkey became the first trained woman combat pilot, participating in search operations and bombing flights during the Dersim Rebellion. While Gökçen was not the first to have participated in military operations, she was the first woman to have been trained as a military pilot, graduating from the Aircraft School[30]. While in Soviet Airforce certain women-only units were used in combat during WWII, other military branches strictly prohibited combat participation of women. Only in 1991, the United States Senate lifted the ban on military women flying in combat and in 1993 women were permitted to fly fighter jets. The UK had done the same two years earlier.

One of the most dramatic forms of prejudices against women was the refusal by NASA to train any woman-astronaut in the early stages of the space flights in the 60s. The US did not send a woman in space until 1983, 20 years after Russia' Valentina Teleshkova orbital flight. And although this first US woman-astronaut, Dr Sally Ride, was arguably one of the best and the brightest NASA had to offer, she was a Mission Specialist and not a Pilot or Mission Commander. And it was another 12 years (February 3, 1995) until NASA had a female PILOT (Col. Eileen Collins). And then, 4 years after that, Col. Collins became the first Mission Commander[31].

Back in early 60s, Jacqueline Cochran and another outstanding woman pilot, Jerrie Cobb, (a professional pilot who owned 4 FAI altitude record and was a test pilot for North American Aviation) took the initiative to engage a total of 13 women including Cobb (so-called "Mercury 13" by analogy with "Mercury 7", the first group of astronauts recruited by NASA) to participate, at a private clinic, in the very same physical and psychological tests that were used to select the original astronaut applicants. All 13 passed the tests. However, NASA was unimpressed.

On the 17th and 18th July 1962, Representative Victor Anfuso convened public hearings before a special Subcommittee of the House Committee on Science and Astronautics to determine whether or not the exclusion of women from the astronaut program was discriminatory, during which John Glenn and Scott Carpenter testified against admitting women to the astronaut program. Glenn stated at the hearing "men go off and fight the wars and fly the airplanes," and "the fact that women are not in this field is a fact of our social order"[32].

None of the women who had passed the tests were military jet test pilots, nor did they have engineering degrees, which were the two basic experiential qualifications for potential astronauts. Women were not allowed to be military jet test pilots at that time. On average, however, "Mercury 13 girls" had more flight experience than the male astronauts. "NASA required all astronauts to be graduates of military jet test piloting programs and have engineering degrees. In 1962, no women could meet these requirements." This

[29] Bednarek, Janet R. D. & Bednarek, Michael H., 2003, Dreams of Flight: General Aviation in the United States, College Station, Texas: Texas A&M University Press

[30] Altınay, A. G., 2001, Dünyanın İlk Kadın Savaş Pilotu: Gökçen [World's First Women's War Pilot: Gökçen] (in Turkish), BİA Haber Merkezi, Istanbul, Turkey

[31] http://www.mercury13.com/

[32] https://web.archive.org/web/20151211072933/http://nasa.lu/static/qualifications_for_astronauts_hearing_1962.pdf

ended the Mercury 13 programme. The American space programme did not open the ranks of its astronaut corps to women until 1978.

The discrimination was not limited to space flight. The airline industry was also a biased field. The United States Commerce Department regulations required pilots to have flown a large number of hours before being licensed for commercial airline flights. Only in the military, they could acquire sufficient flight hours, and since the U.S. services barred women from flying (before 1970), they were routinely denied work in commercial piloting. Women eventually began to enter U.S. major commercial aviation in the 1970s and 1980s, with 1973 seeing the first female pilot at a major U.S. airline, American Airlines. American also promoted the first female captain of a major U.S. airline in 1986 and the following year had the first all-woman flight crew. However, even today, a strong imbalance is still observed both in the pilot professions and in the non-pilot aviators.

Enlargement of a workforce with broader talent

Women and men can have different sensibilities, distinct approaches to the same problem and complementary abilities that can be of benefit to the balanced and efficient performance of many tasks. Choosing which skills fit best each task is part of the efficient management of human resources in a company. Gender-based discrimination is not only unfair but also a loss of valuable talent. The combination of different talents in a cooperative and open-minded environment of equality promotes the emergence of new ideas and allows pursuing them to achieve the best results in less time and with reduced effort.

Thus, greater participation of women in aeronautics is not only an enlargement of the workforce in numbers, but it is also an enrichment in quality and talent, which are the foundations of inventiveness and competitiveness, on which depend the continuing European leadership in an ever more competitive world with new challengers.

The current dominance of the world aerospace market by two continents (Europe and US) is increasingly challenged by other countries, like BRIC (Brazil, Russia, China and India) with large populations and resources. It is claimed that there are 200 000 university students in aeronautics in China alone, showing how much importance the regime attaches to this sector.

Europe cannot match the number of people in some of the countries that are its main customers and can only sustain its position with a smaller number of more talented professionals, that continue to lead the way in basic science and its application in engineering and technology to deliver the goods and services that modern society expects. The challenge of STEM means that there are proportionally fewer candidates than for soft skills and services. This makes the STEM able professionals the key actors of the future prosperity of the aerospace sector in Europe, forming a community in which both genders can contribute equally.

The challenges that women have faced in their professional careers are best demonstrated by the real-life stories of those that distinguished themselves by their achievements in several sectors. A pair of examples is given in 4 areas:

1. Humanities and Sciences:
   - Maria Moliner produced the first literacy dictionary of the Spanish language at a time when discrimination was far more severe than today;
   - Marie Curie was also discriminated, was more fortunate to receive help from her husband and due recognition during her lifetime;

2. Daring aviators:
   - Amelia Earhart was the first woman to fly across the Atlantic with a tragic outcome of an attempt to cross the Pacific Ocean;

- Hanna Reich was the only pilot small enough to fit into the V-1 for the first manned flight tests of this first flying bomb, and carrier out many other dangerous missions during the WW2;

3. Women test pilots:
   - Jaqueline Cohcran held FAI speed records flying the Lockheed F-104 Startfighter;
   - Jaqueline Auriol held FAI speed records flying the Dassault Mirage;

4. Women astronauts:
   - Valentina Tereshkova was the first woman astronaut in Soviet times;
   - Dava Newman career spans astronaut, MIT professor and NASA deputy administrator.

The achievements of María Moliner and the challenges she had to overcome (Key Topic T11.11) show the prejudices against women outside the aviation sector. Amelia Earhart daring flights (Key Topics T11.12) contributed to the visibility of women in aviation, consolidated by women astronauts, such as Valentina Tereshkova (Key Topic T11.13) from the Soviet Union and Dana Newman (Key Topic T11.14) from the United States.

KEY TOPIC 11.11 – THE ACHIVEMENTS AND CHALLENGES OF MARÍA MOLINER

María Moliner produced the first literary dictionary of the Spanish language at a time when discrimination was far more severe than today. The novelty and scope of such a huge task provoked both admiration and envy. She followed her great passion for words to compose a "divergent", revolutionary and innovative dictionary, which was unusual for that time, including among them foreign ones, colloquial usage, slang and acronyms not contemplated in the academic dictionary of the Spanish Royal Academy. The "Diccionario de uso del español" represents her enormous task, but it was not her only one.

María Moliner is considered as a pioneering figure in librarianship in Spain only when the democracy has been restored in the country. In her early adulthood she dedicated herself mainly to the reorganization of Spain's system of public libraries and to the boost she gave to such libraries, understanding that this was the way to give a brief of hope in a rural Spain that was largely illiterate.

Her works and goals were to disseminate culture and literacy. During the dark period of the Second Republic, followed to the Civil War, the ideals of democracy and equal opportunities were subject to oppression and ostracism.

María Moliner dedicated herself to the cause of disseminating culture with her outstanding intuition that this would be the right way to mitigate the injustice, irrationality, and misery of a Spain. Moliner alone undertook the enormous task of editing an extremely important book, the famous dictionary that bears her name. This attitude and efforts came from her fascination, passion and interest in linguistic expression and grammar derived from a Spanish cultural historian, philologist and literary critic, Americo Castro, who challenged some of the prevailing notions of Spanish identity.

LIFE

María Moliner was born in Paniza (Zaragoza, Spain) on the 30th of March 1900, within a family composed by the doctor Enrique Moliner Sanz and Matilde Ruiz. Her parents moved to Almazán (Soria) in 1902 and then almost immediately to Madrid. In the capital city, María Moliner studied at the Free Education Institution. In 1912, her father travels to Argentina as a Navy doctor but never returns, a fact that deeply marked María. The family circumstances forced her to collaborate in family maintenance from very young. She continued her baccalaureate studies at the General and Technical Institute of Zaragoza. After that, she graduated from

the faculty of Philosophy and Arts, History section at the University of Zaragoza in 1921 with an outstanding qualification and an extraordinary award.

She belonged to the generation of the first women university graduates in Spain who pursued a profession. In fact, in 1922 she passed the state examination to enter the Association of Faculty Archivists, Librarians and Archaeologists, being the sixth woman entering the Association. She worked as a public sector employee in this association until 1970. In 1923, she obtained her first posting in the Simancas Archive in Valladolid, Spain. After that, she requests the transfer to the National Historical Archive but it was not granted. However, she obtained a post in Murcia, in the Archive of the Treasury Department.

Figure 11.23- María Moliner, the first female teacher at the University of Murcia.

In 1925, she married Fernando Ramón y Fernando, a physics professor, with whom she had four children. At the beginning of the 1930s, the family moved to Valencia: Fernando to the Faculty of Sciences and María transferred there by the Treasury Department. The period in Valencia was a high point in Moliner's life, both personally and professionally. In the professional sphere, she became fully involved in cultural enterprises that reflected the spirit of the Second Republic.

Moliner taught grammar and literature at the Cossío School and was a member of the governing board and secretary of the Friends' Association. She was involved in the organization of popular libraries, public libraries today). She also managed the library at the University of Valencia (1936-37), where her husband was a lecturer, as well as the Office for Book Purchases and International Exchanges. She undertook teaching duties at the Free Education Institution, and during the Second Republic, she introduced a ground-breaking system of rural libraries.

Once war broke out in 1936, she found ways of sending books to soldiers in the front line. After the war was over, she and her husband both suffered reprisals: she has dropped eighteen places on the promotion scale, and he was suspended from his job without pay for three years (they would both be reinstated years later). In 1946, they moved to Madrid with their four children, and she became the head librarian at the capital's Higher Technical School of Industrial Engineers.

Moliner dedicated these years, in which she was not involved in the major decision-making spheres of either politics or culture, to the mammoth task of compiling a dictionary of Spanish usage, which is acknowledged throughout the world as a vital tool for this language. Nevertheless, her candidature to the Spanish Royal Academy in 1972 was rejected. If she had been accepted, she would have been the first woman to join the academy.

It was in her early adulthood that she dedicated herself mainly to the reorganization of Spain' system of public libraries and to the boost she gave to such libraries, understood to be centres of literacy and cultural dissemination in a rural Spain that was largely illiterate.

In 1975, she was diagnosed with cerebral arteriosclerosis and she finally died on January 22, 1981.

In the following points, it is included the achievements that she reached throughout her life as well as the challenges that she had to overcome.

CHALLENGES

- In 1912, her father travels to Argentina as a Navy doctor but never returns, a fact that deeply marked María;
- From very young, she was forced to collaborate in the family maintenance due to the family circumstances;
- María Moliner was part of a generation of pioneers who accessed the University as a result of the 1910 decree and, for that reason, she had to compete in a world of men;
- After the Civil War was over, she and her husband both suffered reprisals: she was not allowed to hold leadership posts, and he was suspended from his job without pay for three years.
- During Franco's dictatorship, she was barred from taking part in Spanish politics and cultural policy, losing her professional category. She did not fully recover it until 1965.

ACHIEVEMENTS

- In 1921, she graduated from the faculty of Philosophy and Arts, History section at the University of Zaragoza with an outstanding qualification and an extraordinary award;
- In 1922, she was the sixth woman who entered in the Association of Faculty Archivists, Librarians and Archaeologists;
- On the one hand, she obtained her first posting in the Simancas Archive in Valladolid in 1923 and, on the other hand, she obtained her second post in the Archive of the Treasury Department in Murcia in 1924;
- In 1931, she ascended to the maximum category of the Faculty Corps and began to manage the Valencia Archive;
- In 1933, she was appointed a member of the Valencian delegation of the education trust, the Patronato de Misiones Pedagógicas. In addition, she was commissioned for the organization of rural libraries;
- In 1935, she participated in the creation and development of the Cossío School and managed the School Library in Valencia;
- In 1936, she was appointed Director of the Valencia University Library and occupied several positions in the Central Board of Archives, Libraries and Art Treasury;
- In 1937, Moliner published the "Instructions for Attending to Small Libraries" and she assumed a new responsibility: the direction of the Office for Book Purchases and International Exchanges;
- In 1946, she moved to Madrid where she incorporates to the Higher Technical School of Industrial Engineers;
- In 1966/67, the first edition of the Dictionary of Spanish usage was published by the Gredos Publishing House in two volumes;
- Numerous libraries in Spain bear María Moliner's name, as does a prestigious award funded by Spain's Ministry of Culture for projects encouraging reading in small local, rural, public libraries.

KEY TOPIC 11.12 - THE DARING FLIGHTS OF AMELIA EARHART

The 20th century marked a positive change for aviation in general and for women in aviation as in another field. In fact, in the 1930s, America women power started to be in more demand and the fledging air transportation industry began to see the advantage of women in aviation and as a passenger to keep the aircraft industry running. Furthermore, women were encouraged to educate themselves for engineering. As an example, Boeing Air Transport hired the industry's first stewardesses. It is worth to mention that a major

breakthrough for women followed in 1934 when Helen Richey was hired as a pilot for Central Airlines. Unfortunately, her employment lasted only a few months because of pressure from male airline pilots.

Looking deeply in the past, although women have flown since 1908, and give a great contribution in aviation and in women consideration only in 1930, nearly all of them were restricted to general aviation such as private planes or support jobs. Thanks to their efforts, leading women pilots also took part in the development of commercial air travel by writing articles and giving speeches on the safety, convenience, and even luxury of air travel. Among those women, Amelia Earhart is the most-known one, even if she was not the pioneer female pilot (before America had a notable number of other memorable female pilots), which gained international attention. Earhart's fame grew immediately after her first achievement. She was the first woman to cross the Atlantic by air as a passenger.

Furthermore, she defined for the decade what women pilots were trying to prove: *Flying is safe, and women make good pilots*. The Hollywood film Amelia, 2009 has increased her notoriety to the vast public.

Her life was dedicated to improving the women's self-confidence, not only in the aviation field but in other fields. Her outstanding experiences and dissemination brought her global fame and charm, persisting still today as an icon to women. In addition to her flying, Earhart served as president of the NinetyNines, vice president of the National Aeronautic Association, assistant general traffic manager of Transcontinental and Western Air, and a member of the Guggenheim Committee for Aeronautical Education in Primary and Secondary Schools. During her life, she wrote best-selling books and popular columns about her experiences, endorsed commercial products, and lectured in the aviation department at Purdue University in 1935. She performed aviation records at a time when there were hardly any female pilots bring the women freedom and capable to perform the same duty and mission, even better than men.

LIFE

Amelia Earhart was born on July 24, 1897, in Kansas. She grew up "here and there" spending her youth moving between Kansas, Iowa and Canada - due to the continuous changing's job of her father. She entered in Chicago High School where she graduated in 1915 and entered college in 1916, attending the Ogontz College in Rydal, Pennsylvania. In 1918, Amelia spent the Christmas time, visiting her sister in Toronto and she was very affected by a "tragic" view; the sight of four wounded soldiers walking on crutches together down the street. Amelia decided not to stay and graduate in Ogontz School, but to move to Toronto and join in the war effort. She became a Voluntary Aid Detachment nurse at the Spadina Military Convalescent hospital in Toronto, caring for wounded World War I soldiers. Many of the patients at the hospital where she worked were pilots. In 1918, she attended her first flying exhibition while serving as a Red Cross nurse's aide in Toronto, Canada.

In early 1919, she enrolled at Colombia University in New York entered in the premedical program. Furthermore, she took her first flight in California in December 1920, with veteran flyer Frank Hawks, and declared, "As soon as I left the ground, I knew I myself had to fly." In 1921, Earhart passed her trials for a National Aeronautic Association license and she participated in exhibition flying at the Pacific Cost Ladies Derby at the Sierra Airdrome in Pasadena and she bought her first airplane, a Kinner Airster.

In 1922 she performed her first aviation record, obtained a women's altitude record of 4,267 meters (14,000 feet), at Rogers Field. Amelia was among the first score of women received the FAI certificates. On May 16, 1923, Amelia was issued certificate number 6017 by the FAI becoming the 16th woman to receive an official Fédération Aéronautique Internationale pilot license. By the end of 1923, Amelia had accumulated almost 300 solo flight hours and became the first woman which had ever fly higher before. In 1928 Amelia received an exciting offer. Captain Hilton H. Railey, asked her if she would like to be the first woman to fly across the Atlantic. Amelia enthusiastically agreed to this adventure.

Amelia did not try to make any money from her flying. She considered it not only a sport, a passion, a dream, but also a way where women can find the freedom which they are seeking. She tried to demonstrate that women could learn to fly as quickly as men, obtaining the same results and progresses in all fields. She was truly an inspiration to women, her attitude toward success and failure outlined in the following quote, "Women must try to do things as men have tried. When they fail, their failure must be but a challenge to others." Earhart's goal was proving that flying is safe and that women make good pilots. She was constantly training, learning, writing, and prone to divulge her experience with a key message for all the women.

Thanks to these outstanding features and her perseverance she realized one of her goals: on 21-22 May 1932, Amelia Earhart pilots this Lockheed Vega 5B (Figure 11.24) in a solo flight across the Atlantic from Newfoundland to Ireland, and nonstop across the United States, both first for a woman. This flight made her the first person to fly across the Atlantic twice. Because her flight was five years to the day after Lindbergh's and because there was a perceived physical resemblance between them, Amelia's nickname was "Lady Lindy".

Figure 11.24 - Amelia Earhart's Lockheed Vega 5B.
(Source: https://airandspace.si.edu/collection-objects/lockheed-vega-5b-amelia-earhart)

During her aviation career, Earhart wrote books and articles endorsing automobiles and other products, driving women to encourage their husbands to fly instead of driving or taking a train on business trips, and suggesting that flying was the best method of travel for a family vacation. By this way she helping airlines promote travel to female passengers and improvement in the industry. Furthermore, she is designing women's clothing and luggage, launched a fashion house to manufacture and market clothing designed by her, opening her first shop in New York.

In 1935 Amelia became the first person to fly solo across the Pacific Ocean from Hawaii to California. This was also the first flight in which a civilian aircraft carried a two-way radio. In the same year, she became the first person to fly solo from Los Angeles to Mexico City. Amelia testified before the U.S Senate regarding plans to place aviation under control of the Interstate Commerce Commission.

During 1936 and 1937, Earhart formed a close alliance with Purdue University and became a visiting professor stared as a part-time career consultant in the Counsellor in Careers for Women which represented the culmination of her career, where she could share her philosophies with young women. She continued her job at Purdue, serving as a part-time career counsellor for women and an advisor in aeronautics.

In 1936, Amelia was honoured by women geographers and she illustrated before a Senate sub-committee on air safety. That same year she acquired a Lockheed Electra 10E airplane, financed by Purdue University.

With her new airplane, she started planning for a flight around the world at the equator. Earhart used the aircraft, which had a ceiling of 27,500 feet, to test and observe the human reaction to flights at high altitudes. In fact, in 1937, Earhart began her round – the – world flight at the equator in Oakland, California and set a new record for fastest east to west (Oakland to Honolulu) travel in 15 hours and 47 minutes in March. A second round-the-world attempt started, departing from Miami, and travelling from west to east. After completing 22,000 miles of the flight, Amelia route to tiny Howland Island, losing radio contact with the US. Her disappearance on July 2, 1937, while trying to land on tiny Howland Island in the Pacific Ocean, came as she attempted to set a spectacular new record—a circumnavigation flight near the equator. Amelia Earhart was declared legally dead in superior court in Los Angeles, CA on January 1939.

In Figure 11.25 is depicted Earhart in the cockpit of her Electra plane in 1937, not long before her disappearance at the age of 39 on an attempted circumnavigation flight.

Figure 11.25-Earhart in the cockpit of her Electra plane in 1937.
(Source: Amy Sue Bix, 2010. Courtesy George Palmer Putnam Collection of Amelia Earhart Papers, Purdue University Libraries)

Nowadays, women have gained full access to military and commercial cockpits, Space Shuttle and aerospace technology as well. The website[33] of the Smithsonian's National Air and Space Museum is dedicated to review the history of female pilots and highlight the growing contributions of women in that sector.

ACHIEVEMENTS

Amelia Earhart succeeded well in her dual goals—the air transportation industry and women pilots. A summary of the major records set by Amelia Earhart is presented below[34]:

- In 1922 — feminine altitude record of 4.267 meters;
- In 1928 — first woman to fly across the Atlantic as a passenger in the Fokker F.VII Friendship;
- In 1929 — feminine speed record;
- In 1930 — feminine speed record;
- In 1931 — first woman to fly an autogiro;

[33] https://airandspace.si.edu/

[34] https://airandspace.si.edu/explore-and-learn/topics/women-in-aviation/earhart.cfm

- In 1931 — autogiro altitude record of 5.612 meters;
- In 1932 — first woman (and only the second person) to fly solo and nonstop across the Atlantic. Also, the first person to cross the Atlantic twice by air;
- In 1932 — the first woman to fly solo and nonstop across the United States;
- In 1933 — reset her transcontinental record;
- In 1935 — the first person to fly solo from Honolulu, Hawaii, to the U.S. mainland (Oakland, California);
- In 1935 — speed record between Mexico City and Washington, D.C.;
- In 1935 — first person to fly solo from Mexico City to Newark, New Jersey.

KEY TOPIC 11.13 - VALENTINA TERESHKOVA

Valentina Vladimirovna Tereshkova (Figure 11.26) was the first woman to go into space. She is the only woman in the world who made a space flight alone. In 1963, she spent almost three days in space and orbited Earth 48 times in her space capsule, 'Vostok 6'. That was her only trip into space. Tereshkova later toured the world to promote Soviet science and became involved in Soviet politics.

Figure 11.26 - Valentina Tereshkova as astronaut.
(Source: https://www.space.com/21571-valentina-tereshkova.html)

LIFE

Valentina Vladimirovna "Valya" Tereshkova was born on March 6, 1937, in Maslennikovo, a village near the Volga River about 277 kilometres northeast of Moscow. Her parents worked on a collective farm, and her father was killed during World War II. Valentina left school when she was 16 and worked at a textile factory, but continued her education through correspondence courses, according to the Smithsonian Air and Space Museum. Tereshkova joined the factory's Young Communist League (Komsomol) and soon advanced to the Communist Party. She became interested in parachute jumping after joining the Yaroslavl Air Sports Club.

After Yuri Gagarin became the first man in space in 1961, Tereshkova volunteered for the Soviet space program. Although she did not have any experience as a pilot, she was accepted into the program because of her 126 parachute jumps. At the time, cosmonauts had to parachute from their capsules seconds before they hit the ground on returning to Earth.

Along with four other women, Tereshkova received 18 months of training, which included tests to determine how she would react to long periods of time being alone, to extreme gravity conditions and to zero-gravity conditions. Of the five women, only Tereshkova went into space.

In choosing Tereshkova for the role of the first woman-cosmonaut, in addition to the successful completion of training, the ability of the candidate to conduct active social activities was also taken into account, to appear in public on numerous trips around the country and the world. Valentina Tereshkova easily communicated with journalists and other people, gave laconic and natural answers to questions.

ACHIEVEMENTS

- In 1968-1987, Valentina Tereshkova headed the Committee of Soviet Women;
- In 1969, Vice-President of the International Democratic Women's Federation, a member of the World Peace Council;
- In 1987-1992, she was a Chairman of the Presidium of the Union of Soviet Societies of Friendship and Cultural Relations with Foreign Countries;
- In 1989-1992, she was a People's Deputy of the USSR from the Union of Soviet Societies of Friendship and Cultural Relations with Foreign Countries and the 'Rodina' Society;
- In 1992, the Chairman of the Presidium of the Russian Association for International Cooperation;
- In 1992-1995, First Deputy Chairman of the Russian Agency for International Cooperation and Development;
- In 1994-2004, the Head of the Russian Centre for International Scientific and Cultural Cooperation;
- In 1983, a commemorative coin with the image of Valentina Tereshkova was produced - she became the only Soviet citizen whose portrait was in life placed on Soviet coins;
- Tereshkova remains active in the space community, and her legacy is widely celebrated in everything from books to museums to stage productions;
- In 2017, London's Science Museum opened a temporary exhibit called "Valentina Tereshkova: First Woman in Space," which celebrated her contributions through artefacts as well as photographs (Figures 11.27 and 11.28);
- In 2020, as member of the Russian Parliament (also known as State Duma), she proposed a constitutional amendment allowing Vladimir Putin to stay in power until 2030's (as long as Josef Stalin) "in the interest of stability".

After her flight, Valentina Tereshkova no longer flew into space. She became an instructor-cosmonaut, worked in the Cosmonaut Training Centre as a senior research fellow, even graduated from the Zhukovsky Air Force Engineering Academy, becoming a candidate of technical sciences, professor and writing over five dozen scientific papers. In 2016 during the parliamentary elections, Tereshkova was elected a deputy of the State Duma of the Russian Federation.

Figure 11.27 - Valentina Tereshkova with decoration.

On the 6th of March 2018, Tereshkova celebrated 81 years. She is a now a retired Major General, spends a lot of time with her family, and also continues to pursue a political career. The first woman cosmonaut is very fond of her native region, strives to help Yaroslavl orphanage, native school, to improve the city and help to open new educational, production and infrastructure facilities in it.

Figure 11.28 - Valentina Tereshkova now.

KEY TOPIC 11.14 – DANA NEWMAN

Dana Newman was born in 1964. She is a former Deputy Administrator of NASA. She is also the Apollo Program Professor of Aeronautics and Astronautics and Engineering Systems at the Massachusetts Institute of Technology and a Harvard–MIT Health, Sciences, and Technology faculty member in Cambridge, MA. She is a MacVicar Faculty Fellow (awarded for contributions to undergraduate education), former Director of the Technology and Policy Program at MIT (2003–2015), and former Director of the MIT–Portugal Program (2011–2015).

Figure 11.29 - Dana Newman now.

As the Director of MIT's Technology and Policy Program (TPP), she led the Institute's largest multidisciplinary graduate research program. She has been a faculty member in her home department of Aeronautics and Astronautics and MIT's School of Engineering since 1993. In the following points, it is included the achievements that she reached throughout her life as well as the challenges that she had to overcome.

ACHIEVEMENTS

- Investigating human performance in varying gravity environments;
- She was the principal investigator on four spaceflight missions;
- She was a Co-Investigator on the Mental Workload and Performance Experiment (MWPE) that flew on STS-42 to measure astronaut mental workload and fine motor control in microgravity;
- She also developed the MICRO-G space flight experiment to provide a sensor suite and study human adaptation in extreme environments;
- She was the MIT Principal Investigator on the Gravity Loading Countermeasure Suit, or Skinsuit, which flew the International Space Station as an ESA technology demonstration from 2015 to 2017;

- She is the author of Interactive Aerospace Engineering and Design, an introductory engineering textbook, has published more than 300 papers in journals and refereed conferences, and holds numerous compression technology patents;

CHALLENGES

- Promoting the development of space activity suits, namely the BioSuit;
- Sending American astronauts to Mars in the 2030s;
- NASA teams are doing some of the most impressive work anywhere on Earth to support exploration, discovery, and technology off of it;
- Reach for new heights, and work to expand humanity's presence in the solar system while strengthening America's leadership here on Earth;
- On the ground, astronauts will be expected to explore extreme environments like the Olympus Mons, a volcano the size of Arizona that's nearly three times the height of Mount Everest;
- They also developed a custom robot that can simulate a full range of human movement and withstand the uncomfortable prodding required to ensure a proper fit.

Figure 11.30 - Female astronaut spacesuit designed by Dana Newman.

Suits will need to be easier to don and doff, provide greater freedom of movement, and be comfortable for long haul journeys. Newman's solution is called the BioSuit and looks a bit like a superhero's costume, but it's actually just a form-fitting math problem.

In order to survive in the vacuum of space, human bodies require pressure. EMUs[35] solve this problem by creating a pressurized vessel, sort of like a mini airplane cabin. By contrast, the BioSuit employs semi-rigid ribs traced across the body to provide mechanical counter pressure while letting the wearer retain a full range of movement.

[35] The Extravehicular Mobility Unit (EMU) is an independent anthropomorphic spacesuit that provides environmental protection, mobility, life support, and communications for astronauts performing extra-vehicular activity (EVA) in Earth orbit.

Gold fibres are woven through the outfit and paired with biometric sensors to collect data that helps mission control keep tabs on the crew. The snug units protect astronauts, provide greater freedom of movement and more physically taxing experiments.

Beyond its good looks, the BioSuit will also be safer. If a micrometeorite or piece of space junk pierced an EMU, the suit would rapidly depressurize, leaving the astronaut out of luck in outer space, but the BioSuit could be patched with next-gen duct tape.

Conclusions and Future Considerations

In conclusion, women are underrepresented in some areas of work, notably those where some knowledge of STEM subjects is required. More women typically work in jobs where the importance of soft skills is high but where technical skills are not as important, and on the other hand, men typically work in occupations where there is a more even blend of cognitive, social and technical skills. This clear divide in skills between genders needs to be addressed so that all students – whether male or female and at all stages of their education – are provided with an equal foundation upon which they can build the career of their choice. To do so, it is important to encourage more women in STEM fields and careers, to increase the diversity of ideas in the related workplaces, thus reducing the gender gap in these fields and encouraging teamwork among women and men.

This will require greater equality in the nature of the support provided to students, improved recognition that the way males and females are taught may need to be different, and greater encouragement and breadth of careers advice from schools and parents. Only then will women be able to male better-informed choices about the potential of their future careers. In sum, some strategies and changes suggested are:

Remove existing barriers and impediments: it is important to identify characteristics that are impeding the progress and remove both real and perceived barriers, thus making the gender equality a reality in the field of aviation. This also includes examining potential mechanisms to improve work-life balance

Increase visibility and outreach to younger girls through the existence of role models: young girls did not consider or even imagine becoming a pilot because they rarely if ever, saw a woman piloting a plane. People need to have role models and to see people who look like them for it to occur to them to strive for a career in such an area

Provide support for women while they are students, trainees, and employees: social support is an important part of confidence-building and sense of belonging which provides women the assurance they may need to pursue STEM fields education and therefore aerospace sector careers

Address retention in addition to recruitment: further analysis is needed to perceive why women's numbers are dropping after training. While recruitment efforts can be improved by increasing awareness and role models, on the other hand, retention seems to be an issue that also needs to be addressed (e.g. difficult schedule and lifestyle)

Reinforce leadership and organizational support: ensuring the existence of role models, including a mentoring system, as well as promoting diversity training which addresses attitudes, practices, and approaches to working with people who are different than yourself

Change cultural perceptions: if a culture has been traditionally male-oriented, it will be difficult for diversity to take hold. Cultural attitudes need to change in order to open up more paths for career development of previously underrepresented occupations

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