Guides to
mainstreaming gender
in university teaching

Industrial Engineering

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SUMARY

PRESENTATION

What is the gender perspective and what relevance does it have in teaching undergraduate and graduate programmes? When applied to a university setting, the gender perspective or gender mainstreaming is a comprehensive policy to promote gender equality and diversity in research, teaching and university management—all areas affected by different gender biases. As a cross-cutting strategy, it involves all policies taking into account the characteristics, needs and interests of both women and men, and distinguishing biological aspects (sex) from culturally and historically constructed social representations (norms, roles, stereotypes) of femininity and masculinity (gender) based on sexual difference.

The Xarxa Vives d'Universitats (XVU) (Vives Network of Universities) encourages a cohesive university community and reinforces the projection and the impact of academe in society by promoting the definition of common strategies, especially in the gender perspective scope of action. It should be highlighted that policies that do not take into account these different roles and diverse needs and are, therefore, gender-blind do not help to transform the unequal structure of gender relations. This also applies to university teaching, where we offer students a compendium of knowledge to understand the world and intervene in their future professional practice, providing sources of reference and academic authority and seeking to promote critical thinking.

Knowledge transfer in the classroom that is sensitive to sex and gender offers different benefits, both for teachers and for students. On the one hand, deepening the understanding of the needs and behaviours of the population as a whole avoids partial or biased interpretations—both theoretically and empirically—that occur when using man as a universal reference or when not taking into account the diversity of the female or male subject. In this way, incorporating gender perspective improves teaching quality and the social relevance of (re)produced knowledge, technologies and innovations.

On the other, providing students with new tools to identify stereotypes, social norms and gender roles helps to develop their critical thinking and skill acquisition that will enable them to avoid gender blindness in their future professional practice. Furthermore, the gender perspective allows teachers to pay attention to gender dynamics that occur in the learning environment and to adopt measures that ensure that the diversity of their students is addressed.

The document you are holding is the result of the work plan of the XVU Gender Equality Working Group, focused on gender perspective in university teaching and research. The report entitled *La perspectiva de gènere en docència i recerca a les universitats de la Xarxa Vives: Situació actual i reptes de futur (2017) [Gender Perspective in Teaching and Research at Universities in the Vives Network: Current Status and Future Challenges]*, coordinated by Tània Verge Mestre (Pompeu Fabra University) and Teresa Cabruja Ubach (University of Girona), found that the effective incorporation of gender perspective in university teaching remained a pending challenge, despite the regulatory framework in force at European, national and regional levels of the XVU.

One of the main challenges identified in this report in order to overcome the lack of gender sensitivity in curricula on undergraduate and postgraduate programmes was the need to train teachers in this skill. In this vein, it pointed out the need for educational resources that help teachers provide gender-sensitive learning.

Consequently, XVU Gender Equality Working Group agreed to develop these guidelines for university teaching with a gender perspective, under the coordination of Teresa Cabruja Ubach (University of Girona), M. José Rodríguez Jaume (University of Alicante) and Tània Verge Mestre (Pompeu Fabra University) in a first stage and M. José Rodríguez and Maria Olivella in a second one.

Altogether, 17 guides have been developed so far, eleven in the first phase and six in the second by expert lecturers and professors from different universities in applying a gender perspective in their disciplines:

ARTS AND HUMANITIES:

ANTHROPOLOGY: Jordi Roca Girona (Universitat Rovira i Virgili)

HISTORY: Mónica Moreno Seco (Universitat d'Alacant)

HISTORY OF ART: M. Lluïsa Faxedas Brujats (Universitat de Girona)

PHILOLOGY AND LINGUISTICS: Montserrat Ribas Bisbal (Universitat Pompeu Fabra)

PHILOSOPHY: Sonia Reverter-Bañón (Universitat Jaume I)

SOCIAL AND LEGAL SCIENCES:

Communication: Maria Forga Martel (Universitat de Vic – Universitat Central de Catalunya)

Law and Criminology: M. Concepción Torres Díaz (Universitat d'Alacant)

Sociology, Economics and Political Science: Rosa M. Ortiz Monera and Anna M. Morero Beltrán (Universitat de Barcelona)

Education and Pedagogy: Montserrat Rifà Valls (Universitat Autònoma de Barcelona)

SCIENCES:

Mathematics: Irene Epifanio López (Universitat Jaume I)

Physics: Encina Calvo Iglesias (Universidade de Santiago de Compostela)

LIFE SCIENCES:

Nursery: M. Assumpta Rigol Cuadra and Dolors Rodríguez Martín (Universitat de Barcelona)

Medicine: M. Teresa Ruiz Cantero (Universitat d'Alacant)

Psychology: Esperanza Bosch Fiol and Salud Mantero Heredia (Universitat de les Illes Balears)

ENGINEERING:

Architecture: María Elia Gutiérrez-Mozo, Ana Gilsanz-Díaz, Carlos Barberá-Pastor and José Parra-Martínez (Universitat d'Alacant)

Computer Science: Paloma Moreda Pozo (Universitat d'Alacant).

Industrial Engineering: Elisabet Mas de les Valls Ortiz and Marta Peña Carrera (Universitat Politècnica de Catalunya)

Learning to incorporate the gender perspective in subjects merely implies a reflection on the different elements that constitute the teaching-learning process based on sex and gender as key analytical variables. In order to review your subjects from this perspective, the guidelines for university teaching with a gender perspective provide recommendations and instructions that cover all the following elements: objectives; learning outcomes; content; examples and language used; selected sources; teaching methods and evaluation, and management of the learning environment. After all, incorporating the principle of gender equality is not just a matter of social justice but also teaching quality.

M. José Rodríguez Jaume and Maria Olivella, coordinators

01. INTRODUCTION

The guide drawn up by Elisabet Mas de les Valls Ortiz (Universitat Politècnica de Catalunya) and Marta Peña Carrera (Universitat Politècnica de Catalunya) explores how the gender perspective can be included in the teaching and research of industrial engineering, a discipline that comes under STEM, an area of knowledge that is well known (especially in the West) for having a low percentage of female students. Although industrial engineering is not the most male-dominated STEM discipline, there are few handbooks and studies that address the specific gender problems in this area of knowledge and how they can be addressed. This guide opens the way to continue deepening knowledge of gender bias in industrial engineering. It is a vital tool for people who teach and research in this field with a critical spirit.

The guide starts with background information about how the low proportion of female students in industrial engineering affects the generation of industrial technology. It reflects on male predominance in the professional and academic culture of this discipline. Then, it addresses how to incorporate the gender perspective into the teaching of technical disciplines, with a focus on the case study of the Gender in Teaching project at the Universitat Politècnica de Catalunya (UPC). The next section presents a proposal to revise the course plan for industrial engineering by incorporating cross-disciplinary competencies and adapting the teaching contents and assessment. The authors propose different types of action on teaching contents and assessment by dividing the subjects into a) scientific principles, b) technologies and c) professional track subjects. This section is complemented by a set of recommendations for teaching in which the authors provide advice on the use of gender-sensitive language and unbiased visual resources and on themes to include in course contents so that they are more inclusive. Next, the guide provides a series of recommendations for adopting a gender perspective in research, with a focus on the types of projects that are carried out in bachelor's and master's theses and in some cases doctoral theses. Finally, the guide suggests a series of bibliographic and multimedia resources to continue to explore this subject area. It is highlighted that industrial engineering needs to generate research and good practices for gender mainstreaming adapted to the specific needs of the discipline.

02. GENDER BLINDNESS AND ITS IMPLICATIONS

In the Vives region, women make up the majority of university students but continue to be a minority in scientific and technical degrees, also known as STEM (science, technology, engineering and mathematics) subjects. In engineering degrees, the distribution of female students follows gender stereotypes (Brawner *et al.*, 2012). In fact, if we look at the figures for male and female bachelor's degree students at the UPC in the 2017-2018 academic year (Figure 1), a clear correlation can be seen between the distribution and gender stereotypes.
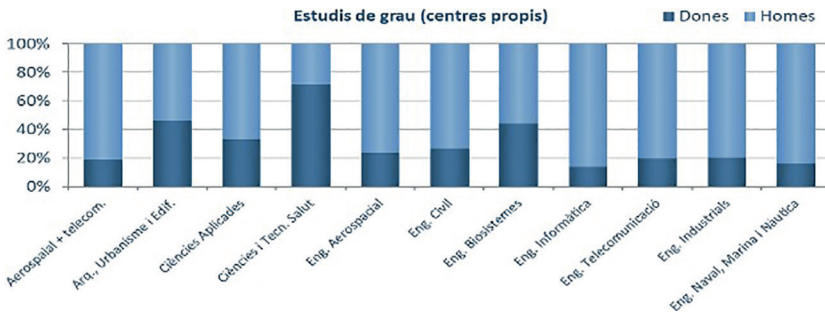
Figure 1: Distribution by sex in UPC bachelor's degrees, 2017-2018 academic year (UPC Observatory)

Numerous studies have shown that people's behaviour is determined by implicit or unintentional biases due to repeated exposure to widespread cultural stereotypes (Reuben, Sapienza and Zingales, 2014). These studies describe women as less competitive but also show their warmth and friendliness compared to men, according to stereotypes associated with femininity (Moss-Racusin *et al.*, 2012). Assuming that girls are better at language and boys are better at science and mathematics 'by nature' reinforces sexist stereotypes that limit equal opportunities and the free development of talent. Although sexism has diminished in recent decades, these subtle gender biases still exist, even among those who state that they are more egalitarian. Such biases can be found in men and women (Carlana, 2018).

In Spain, the percentage of women enrolled in the 2015-2016 academic year in bachelor's and first- and second-cycle degrees was 54.5%. Of these, only 25.5% were enrolled in degrees in the area of engineering and architecture, the lowest rate of women in all the areas that were compared (INE, 2017: 15). A similar pattern is found in postgraduate studies, in which there are few female doctoral

students in the area of engineering and a lower rate of completion of third-cycle degrees among women (Llibre Blanc, 2011: 24). This situation can also be found in research careers. In 2006, the number of women taking a postdoctorate in engineering and technologies was only 33.1%, the lowest percentage in all areas (Llibre Blanc, 2011: 110).

The lack of women in the STEM area (Sáinz, 2017) does not only reduce their opportunities to work and participate in the advances and decisions of the technological future but affects the results of research and innovation and therefore has an impact on all society. In recent decades, considerable efforts have been made to try to increase the presence of women in the teaching of technology and engineering. This renewal is necessary at all levels but essentially in the curriculum and classroom teaching. It must be accepted that neither courses nor teaching methodology are gender neutral and the needs of women and men must be ensured in the definition and presentation of course contents and in classroom management, teaching methodology and assessment. In addition, inclusion of gender in a cross-cutting way in subjects and degrees should result in an improvement in the culture and climate experienced in our schools and faculties and, as a result, in our students' degree of satisfaction.

03. GENERAL PROPOSALS FOR INCORPORATING THE GENDER PERSPECTIVE INTO TEACHING

The Universitat Politècnica de Catalunya · BarcelonaTech (UPC, www.upc. edu) has been working for many years (since the end of the 1990s with the TECNO-IA project and from 1997 with the creation of the Programa Dona) to include the gender perspective in its state-regulated degrees. Through the 2016-2020 Third Gender Equality Plan, this university promotes actions aimed at ensuring non-discrimination and actions required within the area of gender policy, such as T'STEAM (Olmedo, Peña *et al.*, 2018), +NoiesTIC, M2m, timetable reorganisation and the Glass Ceiling, among other programmes (UPC, 2019). In addition, the UPC is a member of the European H2020 project (GEECCO, 2017-2021) that includes the development of gender equality plans in research institutions (such as universities) and gender mainstreaming in teaching as one of its main areas.

The Gender and Teaching (GiD, 2019) project is one of these actions. The first phase of the Gender and Teaching project arose as a pilot project that was developed at the UPC in the 2018-2019 academic year. As an example of a proposal for mainstreaming gender in teaching for this guide, this first phase of the project is described in detail below (objectives, period, pillars, tools generated and impact).

3.1 Objectives

The main aim of Gender and Teaching was to start to train academic staff to redefine subjects by incorporating the gender perspective and, in the mid- to long term, to introduce the gender perspective in a general way in all UPC curricula. In addition, the aim was to draw up a guide of recommendations that could subsequently be used by all teaching staff at the University. In this context, in December 2018, the Catalan University Quality Assurance Agency (AQU Catalunya), in collaboration with the Women and Science Committee of the Interuniversity Council of Catalonia (CIC), published a framework document establishing guidelines and recommendations for facilitating the effective incorporation of the gender perspective into teaching in all areas of knowledge (AQU, 2018). The aspects that this project covered included the social and gender relevance of the subjects, inclusive methodology, classroom management and assessment. Care was taken to define indicators so that the project could be assessed properly on completion.

The length of the project coincided with the spring semester of 2019, which allowed the proposed strategies to be implemented over the course of the academic year. The project is expected to be continued in subsequent academic years.

3.2 Pillars

The aim is to give teaching teams the tools they need to introduce the gender perspective into these subjects. To achieve this, four main pillars were defined: the contents taught in each subject, the teaching methodology used, classroom management and the student assessment process. Each one of these pillars was divided into three sections: self-concept, strengthening capacities and interdisciplinarity. In each one of these 12 subsections, questions were set on very specific aspects, for example, introducing into the subject talks by female role models, and more subtle aspects such as explanations prior to the talk on the relevance of the speaker or an analysis after the talk.

3.3 Tools generated

A self-assessment tool was created for teaching staff that, once revised and documented, could be made available to the entire community to detect potential improvements in gender mainstreaming in subjects. A questionnaire was created to analyse the degree of students' gender awareness. Once revised, this questionnaire could be used in the first and last year of degrees as an indicator in the analysis of cross-disciplinary gender mainstreaming in UPC degrees. In addition, a network of contacts was forged between teachers for future collaborations, and the UPC staff's knowledge was substantially expanded on how to introduce the gender perspective into STEM teaching.

In general, the teaching staff in the team were sensitive to gender aspects in the classroom, which matched their willingness to participate in the project. However, it was found that the relevance of this issue is not explained in the classroom, which reveals that there is still a social taboo against talking about gender inequalities.

Regarding the questionnaire to analyse students' perceptions, 76,4% of bachelor's and master's degree student responses were from men and 23.6% were from women. The questions refer to aspects relating essentially to knowledge of role models in the profession (men and women), communication and language (whether sexist language or gender stereotypes have been

detected in the subject material or in the oral presentation), treatment received from teaching staff and classmates (whether differences were detected in the treatment of one gender or the other, including in assessment), how comfortable and secure students feel to participate in the classroom or seek advice, the conception of differences between women's and men's capabilities to complete their studies, and gender differences in the roles adopted in group projects.

It was found that, in general, there are few role models in STEM professions. This lack is more notable for female role models: 54% of students knew of a male role model in their profession, compared to 24% who stated that they knew of a female role model. In addition, it was found that many of the role models were friends, relatives or teachers. Therefore, it is important to increase the visibility of STEM careers in the most suitable way, with an emphasis on female role models.

3.4 Impact

In this project, 41 teachers from 8 STEM degrees participated voluntarily.

In the student questionnaire, 44% of the women considered that to a greater or lesser extent lecturers treated men and women differently, compared to 20% of men. When we asked how classmates treated men and women, the percentages were similar but different people answered affirmatively, as 60% of women and 34% of men detected different treatment by classmates. Therefore, there is a certain perception of difference in the treatment of men and women, and women were more likely to have this perception.

Half of the women identified the use of sexist language by teaching staff or the use of images with gender stereotypes in the course material, compared to a quarter of men. This leads us to conclude that there really is sexism in the language and images and that, as gender bias tends to have a negative impact on women, it is women who detect it more frequently.

All of the above partly explains why less than half of women feel comfortable participating in class, compared to almost 70% of men. The results indicate that more attention should be paid to the treatment that is given to women and men.

It is crucial to focus on the gender perspective in course contents and how they are transmitted and take action to improve women's self-esteem and feeling of security so that they can participate in the classroom under the same conditions as their male classmates.

04. PROPOSALS FOR INTRODUCING THE GENDER PERSPECTIVE INTO TEACHING INDUSTRIAL ENGINEERING

Industrial engineering is strongly multidisciplinary and comprehensive within the area of engineering. It covers all subareas, from the more technological to the more business-related. Therefore, one of the main results expected from industrial engineering degrees is for students to gain the capacity to adapt to a wide range of situations and sectors, including technological, economic and management sectors. In addition, industrial engineering professionals often have to lead multidisciplinary teams. To meet all these needs, projects and business management are often included as core subjects in the current industrial engineering curriculum. However, most of the compulsory training is composed of subjects that introduce scientific principles and subjects in which industrial technology are studied. Therefore, the more social and humanistic dimensions of industrial engineering are often not clearly set out in the curriculum. Consequently, gender mainstreaming in the teaching of industrial engineering depends almost exclusively on teaching staff's awareness of the issue and how they manage to express this in the subjects they teach. Below, we present good practices to introduce the gender perspective into the teaching of industrial engineering.

4.1 Objectives of the subject/cross-disciplinary competencies

As there are no specific subjects on gender, cross-disciplinary competences are the only current aspect of degrees that enables gender-aware lecturers to introduce the gender perspective into teaching. For this purpose, lecturers often resort to the competence of teamwork and leadership and competencies that include ethical and human rights aspects. One example is the competence in respect for the environment at the Technical University of Madrid (UPM), which includes four dimensions: the environment, sustainability, ethical values and human rights. At the Universitat Politècnica de València (UPV), we find the ethical, environmental and professional responsibility competence defined using two dimensions: ethical and professional responsibility and environmental responsibility. The UPC goes a step further and clearly specifies gender in the cross-disciplinary sustainability and social commitment competence, which covers fives areas: sustainability, ethical values, gender equality, cooperation and

universal accessibility. This explanation of gender relevance is vital to promote gender mainstreaming in teaching.

However, indicating in the course guide that a cross-disciplinary competence is addressed is not sufficient for students and the university community to note that the gender perspective is being incorporated in teaching. The degree of implementation of these cross-disciplinary competencies should be specified and the relationship between gender and all sections of the course guide should be described: the objectives, contents, methodology, assessment and references. Indeed, to increase the visibility of women in the industrial engineering field, one good practice is to include publications by female authors in the subject's reading lists and to ensure that their full names are given, not just their initials.

As Lina Nilsson stated in an article in the The New York Times (Nilsson, 2015), women are more attracted by engineering if we give it social meaning. This statement is supported by the similar numbers of men and women enrolled for recently created humanitarian engineering degree in the United States (Bixler *et al.*, 2014). Without radically changing the current curricula for industrial engineering, the proposal we make to facilitate gender mainstreaming in teaching is to focus the contents and design of subjects more on the usefulness of the subject of study, how it benefits society and the environmental consequences. The aim is to humanise industrial engineering. Therefore, an additional effect of considering gender equity in teaching is the training of industrial engineering professionals who are better qualified to be more useful to society.

Currently, the word gender is very unlikely to be found in course guides, although some references to more social concepts may be included. For example, the subject Machine and Mechanism Theory on the bachelor's degree in Industrial Technology Engineering in Barcelona (GETI, UPC), coordinated by Lluïsa Jordi Nebot, includes the following points in its general objectives:

- "To integrate the theory of machines and mechanisms in engineering studies using prior knowledge taught in previous subjects, working on the capabilities of engineering and making it attractive and useful for students, willing or not to opt for a mechanical profile."

- "To raise students' awareness of the relationship between technology and society by analysing the role of machines in this binomial and the sustainability of the current model of human activity."

In these objectives, the relationship between technology and society is clear; a relationship that should be present in most of the subjects in the industrial engineering curriculum. Ideally, the words "gender" and "people" should be included repeatedly in course guides.

4.2 Contents of the subjects/cross-disciplinary competencies

The extent to which the gender perspective is introduced in contents depends on the type of subject. Considering the current curriculum for industrial engineering (including bachelor's degrees and master's degrees) we can define three main blocks of subjects, which are described below.

4.2.1 First block of subjects: scientific principles

The subjects that we classify in the first block are those that introduce scientific principles. These are more typical of bachelor's degrees than master's degrees. The following could be included in this block of subjects: Calculus, Chemistry, Mechanics, Geometry, Differential Equations, Electromagnetism, Statistics, Materials, Thermodynamics and Fluid Mechanics. Due to the apparent gender neutrality of the contents of these subjects, gender mainstreaming is often limited to introducing female role models, ensuring that the language used is neither sexist nor androcentric and managing the classroom. All of these are relevant aspects that will be addressed later. However, the statements of exercises and their contextualisation could include gender aspects or avoid perpetuating gender stereotypes.

One interesting example is the subject Statistics, in which the methods that form part of the contents of the subject can be put into practice with assignments in small groups and real data to analyse. These data can be taken from real surveys with a certain social content, for example, the results of PISA tests, the frequency and nature of journeys within the city or the staff contracted by some of the leading companies in the sector. It is vital to separate by sex the data that are analysed. In addition, the students themselves should decide on the subject of the data to be analysed. This will provide a wide range of subject areas to analyse in the classroom, even if the methodology that is used is the same. The most relevant aspect in terms of the gender perspective would be the final reflection on the results. This reflection/debate, led by students who have carried out the study, should be shared in the classroom. It is the lecturer's responsibility to focus part of the reflection on how gender still affects people's behaviour or opportunities. This proposal introduces the gender perspective in the contents without altering

the depth of the scientific concepts that are to be transmitted. In addition, as it is a proposal for a contextualised exercise, it enables other aspects that are often overlooked to be addressed, such as the validity of the initial data, the quality of the questionnaire that is the source of these data (in terms of the way questions are set out and the format of responses) and the many interpretations of the questions in the survey and the results, depending on aspects such as gender, nationality and social class, etc. To sum up, we can make a subject that appears gender neutral more human and useful by contextualising it. At the same time, students gain cross-disciplinary competencies for their life and professional career.

4.2.2 Second block of subjects: technologies

The second block of subjects is composed of those in which a technology is explained. In the subjects in this block, the concept of the use of technology and its impact on society comes into play. Gender can form an explicit part of the concepts when aspects of safety, the environment, ergonomics and types of consumption are analysed.

At the bachelor's degree level, this block would include subjects such as Machine Theory, Environmental Technology, Thermal Technology, Electric Machinery and Manufacturing Systems. As these subjects are part of bachelor's degrees, factors relating to the final design of the product are still not very evident and the final user of the product could be relegated to second place. However, environmental and safety aspects are relevant. For example, in Thermal Technology, insulation tends to be designed for thermal components to avoid heat loss to the outside and the risk of burns to operators. Therefore, thermal losses can be related to environmental aspects and criteria established by safety regulations can be discussed. This last point is important, as it should be reviewed how safety criteria are obtained, on what type of person they have been based and whether diversity should be considered. The same analysis could be applied in Nuclear Technology with the maximum radiation dosage. A special case is that of the subject Environmental Technology and Sustainability, as the content includes an analysis of the system of life in our society and sustainable consumption alternatives. Therefore, the social relevance of the subject is evident and enables reflection from different perspectives on gender, cultural habits and roles in society.

At the master's degree level, this block of subjects includes Thermal Machinery, Constructions and Industrial Architecture, Technological Innovation and Transport, among others. At this level, the social significance of technology is

more evident and should be explained. For example, atmospheric pollution by combustion gases is an unavoidable topic in the subject Thermal Machinery, and preferences when choosing a car or another product could be related to variations in environmental sensitivity due to gender. Another example are contents relating to urbanism in the subject Construction and Industrial Architecture. In these contents, gender aspects are relevant as they relate habits that are currently differentiated by gender with a population's urban development needs (Bondi and Rose, 2003; Fenster, 2005). The same thing occurs in the analysis of passenger transport in the subject Transport. Indeed, it is precisely in the different ways of consuming a product (transport, a component or a source of energy) that we can find behaviour differentiated by gender, nationality or purchasing power, among other factors. The subject Technological Innovation also enables the gender perspective to be incorporated into the phase of identifying new products and their design.

4.2.3 Third block of subjects: professional track

The third and last block of subjects is composed of subjects that are directly related to working life, such as Projects, Organisation and Management, and Economics and Business. In these subjects, the gender perspective can be integrated into the contents to a considerable extent. The previous recommendations on the contextualisation of statements or the analysis of the use of technology and its impact on society are perfectly applicable to subjects in this third block. What is more, interpersonal relations are relevant in the contents and to explain gender aspects directly. For example, in the subject Project Management on the bachelor's degree in Industrial Technologies at the UPC, gender aspects are unavoidable in the area of human factors in projects, in relation to human resources and project management. The gender biases that still exist in hiring new staff (van den Brink, Benschop and Jansen, 2010; Fox and Lawless, 2010; Koch, D'Mello and Sackett, 2015) must be described. In addition, gender stereotypes on the characteristics and attributes of those who manage projects should be eradicated. When a woman is the leader of a project, this should be made clear (by using the feminine form of the noun in Spanish or Catalan). It is vital to talk about very positive characteristics that are typically attributed to women such as less competitiveness among members of a team and more participatory, democratic leadership (Holly Buttner, 2001). Other attributes of female leadership are collaborative work, the feeling of responsibility and the empowerment of the entire team, among others.

At the master's degree level and within this third block of subjects we can include Business and Organisation Administration, Industrial Scheduling and Human Resources. Gender aspects and biases are a key point to address in the subject Human Resources. However, other subjects include contents of social and gender relevance. Business and Organisation Administration could include gender aspects in contents on strategic management and corporate social responsibility. Aspects of work-life balance can be included in contents on the organisation of working time in the subject Industrial Scheduling.

Finally, we would like to include some thoughts on bachelor's and master's theses. Industrial engineering projects tend to include a section on economic analysis and a section on environmental impact. However, these aspects are rarely analysed from a social perspective, in which results are related to the real context of the project: the zone, the social habits, the needs, in short, the people who live there. To incorporate the gender perspective in final theses, the analysis of this social context of the subject under study should be included in the written report and the oral defence.

4.3 Assessment of subjects

Given the nature of industrial engineering, the assessment of subjects is highly varied. Among the assessment instruments that are most widely used are open exercises, multiple-choice tests, projects and oral presentations. According to the European Higher Education Area (EHEA) guidelines, assessment is summative and includes mid-semester tests. As an example, the UPC establishes at least one mid-term assessment in all subjects halfway through the semester, usually in the form of a multiple-choice test. In addition, the coordinator of each subject defines the frequency and type of other assessed activities during the semester. Although the summative nature of assessment is strongly established, there is no official guideline on how to avoid gender biases in the entire assessment process.

According to the EHEA, assessment must be formative. That is, assessment must enable students to determine the extent to which they have attained the learning objectives so that they can redirect their learning throughout the course. This is assessment for learning (Rasooli, Zandi and DeLuca, 2018), that is, it is a dynamic process with teachers, students and the curriculum as agents. To carry out this assessment, suitable feedback must be given. In their feedback, students can perceive the fairness of the assessment process. If they do not think it is fair, they will be unlikely to adapt their learning. According to the classification of Murillo

and Hidalgo (2017), students have two conceptions of a fair assessment: one associated with equality and the other with equity. According to this classification, the egalitarian approach that aims to achieve legal equality in examinations and their conditions, with prior information about what the assessment will be like, the assessment criteria, the number of tests, the dates, duration and weight, must be balanced with the equitable approach that aims to achieve social justice by ensuring that students participate in the learning process (when, how and why). Indeed, as Rasooli *et al.* 2018 indicated, students' perception of fairness in terms of the lecturer's use of power (in assessment, feedback comments and their consequences) contribute to empowerment. This empowerment of girls is a key factor in the introduction of the gender perspective in teaching.

4.3.1 Assessment instruments with a gender perspective

Assessment instruments used in industrial engineering can have gender biases in the content (statement of a problem, topic of study in a project, etc.) and in the form. In general terms, it is not considered how these biases impact the grades obtained by students, the stereotypes transmitted or students' motivation.

For assessment instruments to incorporate gender in their contents, the statements of problems should humanise science. Following the recommendations of Cantero Riveros (2016), ethical (who does it benefit) and pragmatic (why) aspects should be included in assessment instruments. This point is easy to apply to subjects in the third block, those related to working life, and it should also be possible to apply it to the second block of subjects, those that are more technological. In addition, to assess relevant learning and consider all genders, all assessment instruments should incorporate contextualised statements, at least partially. In fact, Rasooli *et al.* (2018), showed that men have better results than women in decontextualised examinations. In contrast, women have better results in contextualised examinations with qualitative answers.

To introduce the gender perspective in the form of assessment instruments, it should be considered that men have better results on multiple-choice tests than women (Rasooli *et al.*, 2018). Indeed, various studies at the university level (Birenbaum and Feldman, 2011; Pekkarinen, 2015) have shown that women leave more answers blank in multiple-choice tests, and therefore obtain a worse mark than men. So much so that Riener and Wagner (2017) recommended avoiding penalisation for incorrect answers and only considering correct answers. The reasons for this difference in behaviour are still not clear, but everything seems to indicate that it is due to a low perception of self-efficacy and management of

actual risk in women (Pekkarinen, 2015). However, these results are not directly applicable in the STEM environment, as the studies were carried out in subjects in the social or humanistic fields. Therefore, the studies should be repeated in STEM subjects and the conclusions confirmed, if applicable.

In the university environment, it is not unusual for subjects to be assessed just with multiple-choice tests to reduce the cost of correction and optimise lecturers' always limited time. Considering the results of the aforementioned studies, these practices should be reduced, although multiple-choice tests could still be used occasionally in the assessment process. The range of assessment instruments should be expanded with open questions in written examinations, group and individual assignments, oral presentations, laboratory practicals, short individual oral examinations, etc. This wide range of instruments is easy to attain in all subjects regardless of which block they belong to.

4.3.2 Types of assessment with the gender perspective

Given that industrial engineering is strongly multidisciplinary, the high number of students taking the subjects makes it hard to thoroughly monitor students and provide suitable feedback. As a result, the formative nature of assessment is at risk.

To achieve quality formative assessment, the types of assessment that are used need to be reconsidered, and this must be done from a gender perspective. Types of formative assessment include self-assessment and peer assessment. In self-assessment, the tool must provide a summary with strengths and weaknesses and the student must be able to make an overall final assessment. However, it should be considered that good students have a tendency to undervalue themselves (Dochy, Segers and Sluijsmans, 1999). The main advantage of this type of assessment is its use in working life, which is precisely one of the factors that should be incorporated when the gender perspective is introduced. In peer assessment, it is important to consider that students of one gender tend to give better marks to students of the same gender (Rasooli *et al.*, 2018).

Within the kinds of summative assessment, we find external assessment (all the kinds of examinations that have already been mentioned) and co-assessment, which is assessment between peers in which the teacher has the last word. According to Dochy *et al.* (1999), co-assessment improves student-teacher communication, motivation and confidence in the student's development, that is, it is a very useful tool to improve women's perception of self-efficacy.

It is important to consider the often unconscious bias of lecturers when they assess students (Carlana, 2018; Moss-Racusin *et al.*, 2012). Consequently, systematised monitoring should be carried out at the end of the course to measure the distribution of grades by sex and detect potential biases.

4.4 Classroom management

Women are underrepresented in industrial engineering classrooms. They tend to comprise 30% of all students. Therefore, the classroom is the perfect environment to empower these women, increase their perception of self-efficacy and eliminate gender stereotypes between students. In fact, classroom management is one of the points in which gender stereotypes of teachers and students are most evident. In the classroom, we can identify three key aspects on which to work: (1) inclusive language, (2) participation and (3) roles in group assignments.

There are many forms of classroom communication, including oral communication by the teacher, teaching material (notes, digital presentations, problem statements, etc.), student contributions and reports, assignments and exercises submitted by students. It is important to use inclusive language in all these forms of communication. In fact, in industrial engineering classrooms, it is still very common to hear engineers and other professionals in the STEM area referred to as men. In addition, images of professionals in the STEM area often follow gender stereotypes. One of the tasks of teaching staff is to indicate that students should use inclusive verbal and visual language to avoid the perpetuation of gender stereotypes in the roles assigned to professionals. STEM teachers should review the basic norms of inclusive language (Xarxa Vives d'Universitats, 2019).

Time pressure to complete the syllabus often forces lecturers to ask for brief, immediate participation of students in the classroom. Currently, on average, men meet this need with a faster response and show less shyness and a more participatory attitude (Orenstein, 1995). In addition, when a woman who is speaking in class hesitates, a (disruptive) man often appears who does not wait and responds impulsively for her. Therefore, as gender-sensitive lecturers, we must protect all students, and especially women, from these disruptive interruptions and promote balanced participation of men and women. In industrial engineering, women are in a minority compared to men. Consequently, women's participation in the classroom must be encouraged and their interventions boosted to empower them.

In group assignments, whether they are laboratory practicals or projects, roles with gender stereotypes are evident. It is vital that the team itself identifies these roles, ensures that they are held in rotation and explains this to the lecturer (Cantero Riveros, 2016; Fabra, n.d.). In addition, the teacher should specify the distribution of students by sex in the various work groups, without forcing an equal distribution by sex and allowing gender separation. In fact, when there is separation by sex in groups, women can more easily take on roles that are typically attributed to men.

An interesting example is an experience introduced in the optional subject Human Resources at the master's degree level at the UPC (Gallardo-Gallardo, 2016), through a NASA exercise in which students must complete a challenge individually and then in a mixed group. It ends with reflection/discussion on the advantages of group work. Therefore, it is a complete experience as it focuses on participation and roles within a group.

4.5 Teaching methodology

The need to combine participatory lectures with other teaching methods is fully accepted today. A good summary applied to the European Higher Education Area is that of Miguel Díaz (2005). In addition, an increasing proportion of university students have completed secondary school education using the problem-based learning/project-based learning (PBL) methodology, due to improvements in motivation and achievements (Méndez Coca, 2015). Therefore, it seems reasonable to make use of this student experience and refocus it on technological applications with social relevance to introduce the gender dimension (Du and Kolmos, 2009).

According to studies by Hughes, Nzekwe and Molyneaux (2013), the interest of women and their self-efficacy in relation to STEM increases when they are exposed to female STEM role models. Consequently, one of the priorities is to provide female role models in the classroom. This could be carried out by female lecturers, who could explain their work as researchers or engineers. In addition, female speakers could be invited to the classroom, and female role models could be added to the historical introduction to new concepts or phenomena. To provide female role models for students, a short biography of a prestigious female scientist or engineer can be included in the introduction to each topic (Calvo Iglesias, 2017). This resource is already used in teaching mathematics (Verdejo, 2013).

To really see the relevance of all activities undertaken with students to introduce female role models, the following should be carried out: (1) they must be properly introduced, with clear objectives and explicit gender relevance, (2) spaces for discussion in the class must be promoted to analyse the results, especially to debate gender stereotypes, and (3) they must be properly assessed and have a certain weight in the final grade.

For the lecturer to be able to note any increased awareness of students or change in stereotypes or self-efficacy in aspects of STEM, a pre-test and a post-test should be defined (García Holgado, 2017). This means defining indicators corresponding to the classroom activity. For example, if the aim is to analyse the contribution of women's talent to electromagnetism (to continue with the previous example), in the pre-test the teacher should ask whether the students know of any female role models, the names of these people and their contribution, and the same question should be asked about male role models. At the end of the activity, the same question should be asked and the students' evolution assessed. More open questions such as the identification of potential reasons for the lack of visibility of women could be interesting, particularly if the activity includes a classroom debate at some point.

05. SPECIFIC RESOURCES FOR GENDER MAINSTREAMING

5.1 How to use gender-sensitive language

The following linguistic criteria and strategies should be used to address gender in oral and written communication in Spanish and Catalan.

References to specific people:

- Always use the corresponding masculine or feminine gender when you refer to a specific person (for example, in Catalan: *enginyer* - engineer MASCULINE or *enginyera* - engineer FEMININE).

- Consider some specific cases to apply gender criteria to a text.

References to undetermined people:

- Avoid the use of the generic masculine in references to undetermined people.

- Pay attention to implicit and explicit discrimination of people.

- Use common sense to avoid excessive use of the gender marker.

- Generic forms are the first option to consider. The use of generic forms should be considered as the first option to avoid the generic masculine, because they are the resources that most favour readability.
  - Use the word **persona** (person) or other invariable words to avoid the masculine.
  - Choose collective nouns and classes for plurals: *el professorat* (teaching staff) is better than *els professors* (teachers-MASCULINE).
  - Use the name of bodies and units instead of the job position.
  - Use the name of studies instead of the qualifications.

- Split forms are the last option and only in some types of texts:
  - Split forms include both the masculine and the feminine gender. They can be written out in full or abbreviated. Their use should be limited because they reduce readability. They are only suitable for documents in which we want to stress the reference to women, for example in regulatory texts and in some administrative documents. There are

two types of split forms: full ones, which can be coordinated with a conjunction or separated with a slash; and abbreviated forms that are always separated by a slash. In the same document, one of these options should be selected and the coherence maintained throughout the text.

- Other options before using split forms:
  - If split forms are used, preferably select full split forms.
  - Only use abbreviated split forms if there are space limitations.
  - Repeat nouns and adjectives in compound nouns.
  - For simplification, it is not necessary to duplicate articles and other determiners.
  - Neither is it necessary to repeat prepositions.
  - Use the masculine forms of adjectives and other elements.
  - Put the verb of the split form in the singular.

Changes in writing are a good solution to make it easier to read the text: they can be used not only to avoid the use of the generic masculine, but also to limit the use of split forms that tend to make it hard to read the text.

- Avoid split forms in headers with the identifiers of the section.
- Alter the phrase to avoid using the generic masculine and make it easier to read the text.
- Use an adjective instead of the masculine noun.
- Eliminate articles and other determiners of invariable words.
- Eliminate unnecessary references to people.
- Use *vós* as a form of address in administrative texts.

5.2 How to make contents relating to gender equality into themes and how to work on them in the classroom

Another teaching resource for gender mainstreaming is illustrating the applications of industrial engineering in disciplines that tend to be more attractive for women. In general, students have a high degree of social activism, but they see industrial engineering as an abstract thing that does not have applications in real life. Statements of problems can also be contextualised, to make them more attractive to women.

In addition, the number of female role models that are introduced should be increased and the contributions of women to the area of industrial engineering made more visible. Female role models do not have to be women from the past. Other figures for analysis could be current research groups, the percentage of female authors of papers in a certain scientific or technical area, female principal investigators in research projects and female directors of companies that are leaders in a certain sector.

Many efforts have been made to increase the visibility of female role models in engineering. A good example is the travelling exhibition "L'enginy (in)visible. Dones i tecnologia: passat, present i futur" (The (in)visible talent. Women and technology: past, present and future), which was promoted by members of the UPC, the University of Vic - Central University of Catalonia, the Catalan Technology Society and HP. The exhibition is based on a study carried out by researchers at the UPC promoted by Núria Salán, a lecturer at the Terrassa School of Industrial, Aerospace and Audiovisual Engineering of the UPC and the president of the Catalan Technology Society. Recently, Salgueiriño and Rivas Murias (2019) presented a list of the most notable advances in the electromagnetic field made by women.

> To provide female role models for students, a small biography of a prestigious female scientist or engineer can be included in the introduction to each subject. This resource is already used in teaching mathematics (Verdejo, 2013).

Encina Calvo, from the University of Santiago de Compostela (USC), is also continuously increasing the visibility of female talent, but through activities in the physics and mathematics classroom at the bachelor's degree level. The activities carried out with bachelor's degree students include creating biographies in wiki format (Calvo Iglesias, 2017) and recovering information about relevant physicists in cinema and novels (Iglesias and Rodríguez, 2017).

In addition, reading lists should include the full names of authors, not just the initials, to increase the visibility of women's contribution to scientific knowledge. Women who have contributed to these disciplines can also be highlighted.

5.3 How to select gender-sensitive visual materials

In terms of visual communication, it is very important to include images in which both women and men appear, to highlight the presence of both sexes in functions and tasks, etc. It is vital to avoid the perpetuation of gender stereotypes in all images.

06. TEACHING HOW TO CARRY OUT GENDER-SENSITIVE RESEARCH

To contribute to equality in the field of industrial engineering, corrective measures need to be introduced, such as courses on gender bias for teaching and research staff (Gvozdanović and Maes, 2018), positive action measures relating to maternity, equality in careers, etc. In the past, the production of knowledge and the vision of the sciences has been associated with men. In general, gender blindness is defined as not considering the different roles and responsibilities ascribed to individuals according to gender norms in the development of projects, public policies or programmes.

This lack of attention to aspects of gender contributes to maintaining the status quo, inequalities and the resulting biases. Scientific research in fields ranging from biomedical sciences to engineering or social sciences has been found to be surprising blind, not only to aspects of gender but also to aspects as basic as differences. Future generations of researchers should be trained on gender aspects in their disciplines and on gender-sensitive research.

All of this indicates that training in gender is required to supervise or prepare a bachelor's, master's or doctoral thesis. In the same way that courses are provided to improve writing, courses should be offered on integrating the gender perspective into these projects. In line with this, the UPC is promoting courses such as "Writing projects and class materials using inclusive, non-androcentric language," "Application of the gender perspective in research," etc. These courses are aimed at teaching staff and administrative and service staff, and some have been running for more than a year. Final theses (bachelor's thesis/master's thesis/ doctoral thesis) should be written in non-sexist language and the references should include the full names of the authors, not just the initials, to increase the visibility of women's contribution to scientific knowledge. Women who have contributed to these disciplines can also be highlighted.

One way to include gender in a systematic, cross-disciplinary way in these studies would be to include a new section on gender or a more general section on sustainability that includes gender aspects as far as possible. Equity should also be analysed in members of the examination committee and in assessment criteria.

In terms of subject area, the more social and humanistic aspects of industrial engineering should be made clear in the research. Sustainability, ethical values,

gender equality, cooperation and universal accessibility; this clear statement of the relevance of gender is vital to promote gender mainstreaming in research. To achieve this, the contents and design of project proposals (bachelor's, master's and doctoral theses) should be more focused on the usefulness of the subject under study, its benefits to society and the environmental consequences, instead of just focusing on its design and analysis. In short, the aim is to humanise industrial engineering.

In addition to increasing the social relevance of industrial engineering, part of gender mainstreaming in research could be done by analysing STEM from the gender perspective, in other words, doing research on gender topics. Some studies address this area of research, but the range of possibilities is wide. If we highlight the gender differences that exist (collection of gender-sensitive data broken down by sex), we will become more aware of the problem (slowing down of progression in women's careers compared to those of men, the tendency for women to leave STEM careers, the smaller likelihood of professional promotion for women than for male colleagues, etc.) and we will have more tools to be able to change this trend.

The horizontal segregation that affects the fields of study, the essentially male role models that are found in various areas, the reproduction of gender stereotypes through the use of certain examples or the division of tasks according to traditional gender patterns result in contexts of interaction that sometimes have a gender bias. Some ways to reduce these biases are to question the role models in the discipline, promote balanced participation of students and their self-esteem, and involve them in selecting modes of interaction.

STEM disciplines are sometimes seen as gender neutral, but we must ask ourselves:

- Who defines the agenda of the discipline/research area?

- Whose needs and interests are addressed in the discipline?

- Who are the final users of the knowledge that is produced and transferred through the research?

- Who benefits from the research and the application of the knowledge that is transferred?

The contents of a study can be associated with gender biases, for example:

- If non-inclusive language is used.

- If gender stereotypes are reproduced in terms of examples or iconography.

- If references to female authors are not included.

- If gender aspects that are directly relevant to the subject are not addressed.

- If the impact of gender patterns on aspects such as health, mobility and safety are not considered in discussions of potential users.

07. EDUCATIONAL RESOURCES

7.1 Websites

- GEAR (Gender Equality in Academia and Research) is an online tool for institutional change that includes references to various instruments to mainstream gender in teaching and research: https:// eige.europa.eu/ gender-mainstreaming/toolkits/gear

- "Guidelines on gender fair curriculum development" (2010, Austria) is an assessment tool that includes a checklist of aspects to consider to develop a gender-sensitive curriculum: https://www.wus-austria.org/files/docs/ Publications/guidelines_gender_fair_curriculum_develop- ment.pdf

- "One size fits all? Enhancing gender awareness in teaching" is a publication of the European project TWIST: https://eige.europa.eu/sites/default/ files/ twist-onze_size_fits_all.pdf

- "Gender Bias Learning Project" offers a typology of gender biases in research and teaching and strategies to reduce them: https://genderbiasbingo.com/

- The publications of the ATGENDER network "Teaching with Gender" gather articles on various teaching practices in relation to gender: https:// atgender.eu/category/publications/volumes/

08. IN DEPTH

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8.2 Guides on the gender perspective

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8.3 Links to resources on female role models

- https://igualtat.upc.edu/ca/recursos/exposicio-en-prestec-201cl2019en-giny-invisible201d

- https://mujeresconciencia.com/

- https://mnactec.cat/blog/la-dona-al-mon-industrial/vuit-dones-pione-res-en-disciplines-stem/

- https://recursos.citcea.upc.edu/dones/

Industrial Engineering is part of STEM, a highly masculinized field of knowledge where there is little research and guides that deal with gender-specific issues.

The *Guide of Industrial Engineering to mainstreaming gender in university teaching* offers proposals, examples of good practice, teaching resources and consultation tools to contribute to greater equality between women and men and to bring attention to female models to promote women's access to university studies.

Check out the guides from other disciplines at vives.org

Xarxa Vives d'universitats