Chapter 9
Gender Perspective in STEM Disciplines in Spain Universities

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Abstract In this paper we present different initiatives carried out by Spanish universities for the incorporation of the gender perspective in STEM disciplines. One of these initiatives is the collection of guides of the Vives University Network for university teaching. These guides cover the sections of objectives, contents, evaluation, learning environment, organizational modalities, teaching methods, and didactic resources with the aim of making women scientists visible in the discipline and eliminating the androcentric vision that predominates in science and engineering. In particular, we analyze the fields of engineering, mathematics, and physics. With the aim of being more than just a review of different initiatives, the paper unifies the fundamentals on which these initiatives are based. Thus, the general principles are well defined, and those aspects more related to each university and discipline particular cultures are identified. The comparison between initiatives will allow us to identify both successful strategies and resistances. Sometimes, the confluence of different events allows an action to become relevant or not. As a result, the paper can be used to effectively define the implementation strategy of the incorporation of gender perspective in STEM teaching at university level.

Keywords STEM · Gender equality · Higher education

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9.1 Introduction

Spanish women are majority among university students, but they continue to be a minority in STEM careers (Science, Technology, Engineering, and Mathematics). According to the report *Científicas en Cifras 2021* (Unidad de Mujeres y Ciencia, 2021) the percentage of female students enrolled in undergraduate studies in the area of Health Sciences is 70.8% while in the area of Architecture and Engineering is 25.1%. The intrinsic cause of these gendered preferences or orientations when choosing the studies respond to multiple factors as stated in the work carried out by the GenTIC research group at Universitat Oberta de Catalunya (Sáinz, 2011; Sáinz et al., 2020; González-Pérez et al., 2020). These factors include family and teachers' influence, stereotypes, the perception on maths and ICT abilities, and outstanding personalities in the field, among others. The understanding of such factors can significantly contribute to design efficient approaches to increase girls' engagement to engineering studies. Even more, it elucidates how gender perspective can be introduced in the engineering curricula.

This gender gap, which is also produced in other Western countries, has negative consequences for society and women and reduces their job opportunities in the labor market especially in some sectors such as technology, where more net employment will be created in the coming years (World Economic Forum, 2016). Women's underrepresentation in STEM careers has serious consequences for how research is conducted and applied (García-Dauder & Pérez-Sedeño, 2017; Schiebinger, 2021) . From the educational field, we can contribute to solve this problem by introducing the gender perspective in teaching so that "students learn to problematise dominant socialisation patterns and develop skills that will enable them to avoid gender blindness in their future careers" (Catalan University Quality Assurance Agency, 2018). Gender equality goals for higher education are found in all national legislations. It should be remembered that we have a normative framework for the introduction of the gender perspective in higher education in force at European and state level (Verge, 2021). However, reality shows us that the level of inclusion of the gender perspective is low (Verge & Cabruja, 2017) because as Verge exposes "absence of instructions and lack of supervision of the implementation of the gender mandates by evaluation agencies have allowed universities to ignore and even actively resist the call for curricular reform" (Verge, 2021). Fortunately, the policy innovations recently introduced by the Catalan University Quality Assurance Agency (AQU Catalunya) can be a model to Spanish quality assurance agency (ANECA), thus contributing to integrate the gender perspective in the functioning of higher education institutions and in the design and implementation of their programs (Verge, 2021).

This article examines the similarities and differences in the culture of physics, engineering, and mathematics, showing initiatives that can help bridge the gender gap in these disciplines. Among them, the guides for the introduction of the gender perspective in Physics, Mathematics, and Industrial Engineering that are part of the collection *Guies per a una docència universitària amb perspectiva de gènere* published by the Vives University Network. A pioneering resource in the European

Higher Education Area recognized by the European Institute for Gender Equality (EIGE) is an example of good practice in its Toolkit for Gender Equality in Academia and Research (GEAR).

9.1.1 Common Aspects of STEM Disciplines

A significant proportion of faculty and students believes that inequalities are overcome, and many young women say they have never experienced, or have seen, any discrimination. As a logical result of their identification with the elitism and rationality of the fields, they understand meritocracy as neutral. Van den Brink and Stobbe (2014) describes understanding meritocracy as neutral in terms of the following fallacy: the informal practices that help men in their careers are so normalized in the professional culture as to be invisible, while the formal policies established to help women overcome these disadvantages are conspicuous; thus, what is done openly to encourage women to advance professionally is understood as being unfair by most men but also by an important number of women, especially those women who have built an identity as part of the elite (and whom the system harms as well). As Sara Ahmed tells us (Ahmed, 2017), doing equality work means crashing into walls. Walls that were previously concealed and are painfully revealed through the crashing act itself.

Women in academia in Spain have different workload from their male peers, according to the sample analyzed in the article by Cabero and Epifanio (2021). There is a gender gap about the time spent on quality of teaching and caring tasks. Nevertheless, teaching quality is not nearly taking into account in the national system of evaluation for promoting. The big difference is on the number of hours devoted to care of people and domestic work. During the range from 35 to 40 years, the most frequent period of parenting, the difference between women and men is on average 30 h per week for care.

All these things should be taken into account in equality policies. A recent paper critically reviews the implementation of gender perspective in the regulation of scientific and technological research in Spain (Barrios et al., 2021), based on the document "Stop Discriminación" (https://mym.rsme.es/images/docs/mym/stop.pdf).

Concerning the introduction of gender perspective in curricula, a deep analysis of the work carried out at GenTIC research group at Universitat Oberta de Catalunya (Sáinz, 2011; Sáinz et al., 2020; González-Pérez et al., 2020) yields to the identification of three key aspects and the corresponding needs. First, it is observed that female STEM students show a lower self-confidence than their counterpart what might partially be caused by the perception of a lesser ability in maths and ICT during their high school studies. Such perceptions persist during their university studies. Thus, the empowerment of female students is a need. Second, there are still gendered stereotypes in our society and, specifically, concerning STEM occupations. Thus, stereotypes need to be revised and awareness must be raised regarding the consequences of gender biased stereotypes. Third, the lack of female outstanding

personalities in STEM field prevents female students to be engaged. Thus, female referents within the STEM field need to be included. The gender perspective in engineering disciplines implies meeting these needs.

In the following lines, the main issues and most interesting strategies identified all along a pilot project at the UPC (Peña et al., 2021) are summarized, following the four pillars classification according to Catalan University Quality Assurance Agency (2018) (i.e., methodology, learning environment, contents, and assessment).

Introducing gender perspective in the methodology is intrinsically related to co-education. This implies active methodologies such as project base learning (PBL), cooperative activities, and debates among others. However, including such methodologies does not guarantee that gender perspective is considered, but it depends on its implementation. Nevertheless, active methodologies can be an efficient framework where gender activities can be easily included, the idea is to reduce competition and emphasize collaboration, and all this is combined with increasing confidence in one's own abilities and reducing the threat of stereotype, as well as improving the sense of belonging. In the frame of the European Higher Education Area, active methodologies have been gradually introduced in the Spanish STEM curricula. Despite this, in the majority of physics, engineering or maths subjects, gender perspective has not been integrated nor made explicit. Moreover, the usage of non-sexist nor androcentric language is still missing. An interesting approach to co-education and its characteristics can be found in Gónzalez-González et al. (2019).

All of these active methodologies involve peers' interaction what corresponds to the second pillar of the curricula, the learning environment management. Here, deep work is being performed by gender-sensitive teachers when dealing with teamwork. The explicit analysis in the classroom related to gender distribution among groups and the roles and their gender biases, the rotative nature of such roles and special focus on leadership are feasible activities for STEM subjects.

The learning environment management pillar also includes students' interaction with the teaching staff both inside and outside the classroom. Also, it has been observed that female students feel significantly less comfortable than male students participating in the classroom, whereas out-of-the classroom the differences persist but are less significant (Alsina et al., 2019). In order to guarantee that female students equally participate to the learning process, actions promoting their participation by empowering them and increasing self-confidence are slowly being implemented.

The third pillar, contents, is the one that represents the main obstacle for most of the teachers that start introducing the gender perspective in their STEM subjects. Identifying specific subject contents related to gender is not straightforward in most of the cases. However, each STEM subject provides a good opportunity to visualize female engineers and scientists. Indeed, in the analysis of the questionnaire answered by students at UPC during 2018–2019, it is observed that there is a lack of female referents, especially those internationally recognized in engineering fields (Alsina et al., 2019). This scenario is of major concern since the female referents can strongly condition the professional expectations of our female students (Botella et al., 2019). There are some initiatives among STEM universities in Spain designed to increase

the number of female referents, and an interesting example is to propose to students the creation of a female biographical profile on Wikipedia (Calvo-Iglesias, 2020).

The remaining fourth pillar of curricula is the assessment. Gender biased peer-assessment and teachers' assessment have been widely reported (Rasooli et al., 2018; Hofer, 2015). Also, several studies can be found related the lower qualifications obtained by female students in multiple choice tests (Birenbaum & Feldman, 1998; Pekkarinen, 2015; Riener & Wagner, 2017), highlighting the fact that not only the methodology but also the instruments are to be deeply revised. However, major concern is focused on how the assessment of the new gender-related actions has to be defined and described in the teacher guide. Indeed, teacher guides in STEM studies are starting to include some of the above mentioned aspects, especially in those universities where a gender dedicated transversal competence exists and hence, not only the competence but also the learning results have to be explicitly introduced.

9.1.2 Main Differences Among STEM Disciplines

The objective of study of physics is what happens in the material world, what we can observe experimentally, formalize in abstract ways, and from these abstractions, make predictions about future experimental observations. Following the ideas of Barad (2007), we understand that in experiments, in measurements, a reality materializes that did not exist before (because it was not known). Although the answer given by nature is impossible to deduce a priori and cannot be built from any discourse, the question asked, how the experiment is designed, what phenomenon is considered important to study, this contains the whole discursive burden of the society that produces that knowledge. Furthermore, this response is also articulated in a discursive way, with metaphors and interpretations that respond to a contingent cultural intelligibility.

Physics has traditionally been done by men, with genealogies of men and stereotypically masculine values. In this sense, Keller (1985) tells us that insofar as physics is defined by those who have practiced before it and practice it now, anyone who wants to enter this community must adapt to existing codes; anyone who does physics without being a man, therefore, has, at the same time, more difficulties but also more potential to subvert them.

The formalism and abstraction of physics can make us lose sight of the fact that when we do physics, we are doing gender. In fact, scientific production, because of its system of rewards through funding, publications, citing practices, etc., is embedded by a patriarchal logic. In addition, science is communicated, also in class, through androcentric coded discursive practices.

Another very prevalent belief, according to Sainz et al. (2017), is that people who engage in physics are "geeks" and have few social skills, but instead are very intelligent. This profile does not align with the gender roles traditionally assigned to women, as they are expected to like (and be competent in) social interaction. In addition, gender stereotypes lead to significant biases among teaching staff (Carlone,

2004). Active teaching methodologies do not appear to have a positive gender impact either (Brewe et al., 2010). Research indicates that even those women who choose to study physics find it difficult to reconcile their being women with a legitimate identity as scientists (Danielsson, 2012; Gonsalves, 2014). It is no wonder women continue to be underrepresented in physics at all levels (Sistema Integrado de Información Universitaria (SIIU), 2019; Figures, 2019), despite decades of interventions of various kinds (Archer et al., 2020).

Physics is taught as an authoritative, unquestionable set of knowledge that is transmitted in such a way that it can maintain a high level of difficulty and status (Hughes, 2001). Students arriving at the faculty must negotiate these dimensions of elitism and difficulty by confronting them first of all with their own coordinates of gender, class, parents educational level, ethnicity, and so on, and how they relate to stereotyped ideas of what kind of person is brilliant in this field. Then, the pace and level of abstraction of the studies themselves, despite being a wonderful way to access a world of ideas and information that can be extraordinarily enjoyable (when the student finish their studies, they usually miss learning so many interesting things in such a short time), is also a constant threat (and in many cases an erosion) to theirself-image as people capable of doing physics. In this sense, the feeling of belonging is reinforced by codes of behavior and expression, very close to the "geek" culture, which are also very much gendered.

In particular, the jokes and memes that form the backbone of this membership, and which are shared by both teachers and students, have the apparent goal of making people laugh, but actually serve to establish or strengthen ties within the community, while excluding those who do not belong, that do not understand the joke or do not find it funny (Johansson & Berge, 2020). And here, in this grouping and excluding, the hidden gender curriculum is incorporated in a particularly insidious way, as it is very difficult to look critically at the sexism implicit in a social practice, these jokes, where adherence or not to enthusiasm and laughing is a kind of shibboleth, a password, which indicates whether or not a given individual is part of the group.

Contrary to Physics stereotypes, the Engineering field has been generally associated with a rich labor market, social recognition, and success (Ariño et al., 2019; Sáinz et al., 2020). Paradoxically, despite such positions require a high degree of communication skills and teamwork, the stereotypical profile of an engineer is someone with a high level of individualism and with a preference on the object oriented work. As an example, the key attractions for engineering students have traditionally been cars, motorbikes and space rockets, among others. Many projects and competitions exist related to these technologies among engineering universities. This scenario prevents girls to be engaged in engineering studies. Moreover, it significantly reduces the sense of belonging to the already engaged girls. Indeed, the social utility value was the main motivation of already engaged STEM girls (Sáinz et al., 2020), being such utility concept mostly related to health and environmental problems solving. It is now the time to change the focus of the engineering interest to problems related with the 17 Sustainable Development Goals, not only in order to increase girls' engagement, but to change the goals and stereotypes of all, male and female, engineering students and to, gradually, contribute to a change in our society.

It is worth to mention that the revision of the stereotypes related to the engineer (i.e., aggressive leadership, high self-concept, business oriented, …) and the reorientation of the engineering objectives toward social utility values also allow male students to find to define their gender identity, out of the traditional roles and limitations.

In math, we can find now both stereotypes. One the one hand, we find the "geek archetype" of solitary persons who are proud of being very abstract and not seeing any application to what they are doing nowadays. On the other hand, mathematicians are now in high demand in business due to the big data and artificial intelligence applications, which fits the "technological archetype". None of them fits the stereotypical female role.

9.2 Key Actions

The equality committee of the Physics Faculty of Universitat de Barcelona has carried out several initiatives to generate an understanding of the very fact that when we do physics, we do gender. If we are not aware of this, if we carry on with business as usual, we are doing gender in a patriarchal way. We do not advocate to include gender in physics (it is there), we do not attempt to teach feminism (feminism cannot be taught). We want to give the tools, to our students and colleagues, to reach an "aha" moment and start seeing the patterns of exclusion in the codes we have to learn and internalize to become physicists.

We have not been alone in this, a summer school on physics and gender was designed and implemented in the context of the European project Diversity in the culture of physics (Erlemann et al., 2019), and now the project is over will be continued as a Catalan summer school co-organized with Universitat Autònoma de Barcelona, Universitat Politècnica de Catalunya, AMIT-Cat, and SCF. This summer school is offered to women finishing their degrees so that students can network with each other, learn about which research fields are open for them to carry out a Ph.D., how a career in physics looks like, gender as relevant to physics, and available resources for equality advancement.

Besides the summer school, the equality committee of the Physics Faculty of Universitat de Barcelona also carries out activities for the students to understand the matrix of privileges or lack thereof in which they navigate or to critically review the metaphors used by famous physicists. In addition, actions are carried out to try to reverse the epistemic injustice and to recover genealogies of female physicists of the past for the canon. Seminars are offered that help incorporate gender perspective into research, entrepreneurship, and dissemination, especially for doctoral students, and we also offer seminars to teaching staff, where the importance of the discourse is emphasized, not just in terms of inclusive language, but also with regard to the examples or situations described in the problems, and the jokes which are made in class.

In order to spread how to include the gender perspective to math not only to university teachers but also to teachers of all educational levels, a virtual asynchronous math coeducation course (http://www.coeducamates.uji.es/) was carried out in November 2020 at Jaume I University. Being free, recognized by educational authorities as official training, virtual and asynchronous made that participation was very high: more than six hundred people from all over Spain took part. Being asynchronous was key because it favors conciliation. The course was formed by short videos of more than 8 h of duration in total, and written material. There were (written) forums for each area and debates where very profitable, with thousands of comments. In the aim to assess that participant met the course learning requirements, a multiple-choice test was arranged at the end. The resources of the course are available by free for everybody, even not being participant. More details about the usefulness and assessment of this course by participants can be found in Epifanio et al. (2021).

Two complementary strategies can be adopted to include a gender perspective in curricula. The first consists of including specific subjects, for example, the subject *Gender Relations, Science, Technology and Society* offered by the University of Valencia in the degrees in Science and Engineering and Architecture, and in the degree in Pharmacy or the subject *Gender and Science* in the new degree in Science, Technology and Humanities taught jointly by the Carlos III University, Autonomous University of Madrid and the Autonomous University of Barcelona. The second strategy is the introduction of gender perspective in curricula through a cross-sectional approach. In this approach, gender dimension can be included in all subjects through the four pillars of curricula (methodology, learning environment, contents and assessment) described above. It implies a cultural change not only in the institution policies but also in each one of the members of the teaching staff. To this aim, training courses on gender in teaching are being conducted all along the Spanish universities including the strongly masculinized engineering ones. However, since several resistances might be found during this cultural change, as identified in a recent article (Linkova & Mergaert, 2021), more proactive actions must be defined. An interesting example is the pioneer pilot project held at the Universitat Politècnica de Catalunya (UPC) during the course 2018–2019 (Peña et al., 2021). It was a volunteer project where 35 teachers (40% men, belonging to 8 Bachelor and Master Degrees) reviewed the state of the art on gender in teaching, discussed strategies, experiences, and points of view and defined new activities to be implemented during the project. The final outcome of the project was the UPC guide, designed as a checklist, with the aim of becoming an easy and practical tool for the whole UPC teaching community. In the definition of this pilot project there was the clear intention to provide a new learning experience, with less gender biases, to the UPC students all along their studies. To this aim, each of the 8 participating degrees was represented by a team of at least 3 teachers, with subjects at different courses to provide this feeling of coherence all along the studies.

Similar innovative projects are being currently performed in other Spanish universities. For instance, a pilot plan designed for the Electronic Engineering Degree of Universitat de Barcelona from 2018 and funded through a PEVG-2019 project (Estradé, 2021) contemplates gender mainstreaming in all courses, with a strong

focus on teaching staff training. Also, specific gender content is introduced in some subjects (Laboratory Fundamentals, Economy, and Projects), and an optative course on Science, Technology and Gender is offered as well.

9.3 Guides for Mainstreaming Gender in University Teaching

Guides for mainstreaming gender in university teaching are a set of guides covering various disciplines that provide recommendations for regendering course goals and contents, references, and teaching and assessment methods. The goal "is to erode the professoriate's resistance to gendering courses, compensating for its lack of gender training, and combating the belief that gender is not applicable to certain fields with practical examples on how to do so" (Verge, 2021).

9.3.1 Physics

"The subject of all physics is affected by the background of the researcher, teacher, and student, and it follows that a gender perspective is needed" (Brage, 2019). And to do this, it is key to publicize the good practices that have been carried out in this subject (or others in the same field) in both Spanish and foreign universities. This is what is intended in the physics guide (Calvo-Iglesias, 2021) that covers all aspects (competences, methodology) showing how the gender perspective can be introduced in physics.

This guide, which is available in four languages, has been presented at various training courses for university teachers organized by the Universities of Alicante, Valencia, Girona, and Extremadura. It has also been part of the webinars organized by the Specialised Group of Women in Physics on the occasion of the 11th February (http://www.gemf-rsef.es/11-de-febrero-2021/) and has also been presented at other conferences.

9.3.2 Mathematics

In the mathematical guide (Epifanio, 2020), a lot of emphasis is placed on the humanization of problems, not only for social justice but also for breaking with the stereotype that math is not useful for real life.

In basic statistics we can use real data to introduce gender biases, such as the Jennifer-John effect (Moss-Racusin et al., 2012) or the importance of sex and gender

analysis in science and engineering (Tannenbaum et al., 2019), but social justice problems can be introduced in other math subjects (Buell & Shulman, 2019).

Math guide also highlights the importance of inclusiveness of minoritised groups. It shows that LGBTQ content can be included in math problems (StoneWall, 2017) and it provides resources for the visibility of LGBTQ people, people with functional diversity or other people who do not fit the archetype of mathematician.

9.3.3 Engineering

The concepts and strategies included in the Industrial (or Mechanical) Engineering guide (Mas de les Valls & Peña, 2020) can be easily extended to other engineering studies. In the guide, a detailed revision of the four pillars is provided. However, the main contribution of the guide is the presentation of a strategy to include gender in the contents of an engineering subject. It is based on the classification of all the engineering subjects in three clusters: (1) scientific foundations, (2) technologies, and (3) management subjects. Within the scientific foundation cluster, the contextualization of problems and exercises (also for the assessment) is crucial. New contexts could be related to health and environmental. Even the data gathered in matrices in Algebra or Statistics could be gender segregated data and provide an interesting framework for a debate. An interesting example in this direction is written by Alsina, on the integration of gender dimension in STEM degrees (Alsina, 2019). The 17 Sustainable Development Goals, adopted as part of the 2030 Agenda for Sustainable Development, conform an interesting framework for the technologies cluster of subjects. Indeed, aspects such as perception of risk, ergonomics, environmental impact, consumption patterns, and others can be included as design parameters and, therefore, present gender differences can be analyzed and discussed. Also, service learning activities are a good strategy to increase female motivation and deal with communication skills and teamwork. An example of it can be found in reference (Calvo-Iglesias, 2016), where female engineering students prepared workshops to be hold in schools. In this direction, some research show that these role model interventions addressed at girls from and above 12-year-old are a way of reducing stereotypes and increasing girls' engagement with STEM fields (González-Pérez et al., 2020). Finally, in the management subjects' cluster the aspects that are gender-related are interpersonal skills, leadership, recruitment, and labor market. Concerning leadership, it relies on a more opened and cooperative point of view not only for women but also allowing a space for men to develop their own styles and a diversity of voices (López-Belloso et al., 2021).

9.4 Discussion

As we have seen in this article, STEM disciplines have similarities and differences. We have a problem of female vocations that is common to all of them and that we should address from an early age. However, at university level we can definitely contribute to promote equality among our students through the introduction of gender perspective in our STEM disciplines. By doing so, we can contribute to the reduction of the stereotypes, we can increase our students' awareness on the gender issues already occurring in STEM professions and we can enable them to become gender bias free citizens.

Being highly masculinized disciplines, we need to mainstream the gender perspective and comply with European and state regulations that demand it, but we also need to introduce specific subjects that train students in gender, at least while the level of mainstreaming is low. It is important to point out that we currently have guides for the introduction of the gender perspective that cover many of the STEM disciplines and, thanks to the equality units, numerous courses have been given to train university professors. However, to attract faculty to these courses we need incentive. We should not forget that in general, the academic career values research more, so it should be included as a merit in the accreditations to professors, for example. For all this we need to introduce changes in the evaluation agencies that promote changes in universities and allow us to overcome possible resistance to the introduction of the gender perspective in STEM degrees.

Other alternatives may be some of those discussed above, for example, being able to provide real-life application examples, or an education oriented to the fulfillment of the SDGs in engineering. We also consider very important activities such as the ones carried out in the framework of the European project *Diversity in the culture of physics* (Erlemann et al., 2019) or the creation of a virtual itinerary of training in gender, with courses like those of the UJI (Epifanio et al., 2021). The online activities also facilitate the reconciliation of work and personal life and could be a first step toward obtaining a certificate in equality.

9.5 Conclusions

In this communication we have shown the similarities and differences in relation to gender in Physics, Engineering, and Mathematics, as well as some strategies to integrate the gender perspective in these disciplines: a summer school on physics and gender, an asynchronous virtual course on mathematical coeducation or pilot projects carried out at the Universitat Politècnica de Catalunya (UPC) and Universitat de Barcelona (UB). Also, the guides for the incorporation of gender in university teaching, which show us how to integrate this perspective in the objectives and contents of the courses, the references and the teaching and evaluation methods.

Although awareness initiatives and a strong commitment from individual professors can be a good starting point, we cannot underestimate the power structures opposing real change in university settings. In fact, it is when trying to challenge these power structures that we realize how deeply entrenched they are.

A decided political action from institutions is needed, as we see for instance in the Catalan context, where the requirement of the assessing agency of University quality (AQU) of gender mainstreaming in all studies has led to a new concern for gender issues among faculties. How superficial this concern is going to be in the near future remains an open question.

In this sense, it is imperative to network, collaborate, and engage in debate among the different agents committed to making and teaching better science and technology for everyone.

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