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Science, stereotypes and gender: a review of the explanatory frameworks

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Abstract: This article looks into the international literature that explores the unequal gender distribution in Science and Technology (S&T) to review dominant theoretical approaches focused on the role of gender stereotypes in the election of professional and educational paths. Taking into account the limitations of the biological approach, from both an empirical and conceptual point of view, the perspectives focused on psychosocial and socio-cultural processes and the culture of science insist on the persistence of stereotypes and on their fragility and permeability as well. The article highlights that programs to reduce the gender gap are marked by the dominant theoretical perspectives, as well as the appropriateness of adopting global and innovative actions to promote an S&T system based on equality, excellence and competitiveness.
Key words: science, gender, stereotypes, explanatory frameworks.
Resumen: A partir de la literatura internacional que aborda la desigual distribución de género en Ciencia y Tecnología (CyT), este artículo presenta una revisión de los enfoques teóricos dominantes centrada en el papel de los estereotipos de género en la elección de itinerarios formativos y profesionales. Frente a las grandes limitaciones del enfoque biologicista, desde el punto de vista empírico y conceptual, las perspectivas organizadas en torno a procesos psicosociales y socioculturales y la cultura de la ciencia insisten tanto en la persistencia de los estereotipos como en su fragilidad y permeabilidad. El artículo evidencia que los programas para reducir la brecha de género están marcados por las perspectivas teóricas dominantes, así como la necesidad de adoptar estrategias globales e innovadoras con objeto de impulsar un sistema de CyT marcado por la igualdad, excelencia y competitividad.
Palabras clave: ciencia, género, estereotipos, marcos explicativos.

Introduction[1]

Ever since Rossi (1965) approached the issue of absence of women in scientific careers in his already classic study Women in science: why so few?, the interest in the science-gender relation. Historically, women have changed from exclusion to segregation in science (Osborn *et al.*, 2000: 21), in addition to being concentrated in the so called "velvet ghettoes" (Guillaume and Pochic, 2009: 19), nowadays women are still a minority in learning and professional trajectories in scientific-technical spheres (Eurostat, 2014: 5).[2]

This tendency is especially worrying because, in spite of the efforts and initiatives adopted, we face a phenomenon with a "persisting" character (over time), "progressive" (it worsen in higher education) (Cronin and Roger, 1999: 4) and rooted at international level (Sjøberg, 2002; Valenduc *et al.*, 2004: 24). Growing sensibility and concern on the gender gap in S&T, which acquires visibility as of the 1990's decade, is justified from the principles of equity and social justice, argumentations which have been joined by others related to the unmet demand for professionals, economic growth and competiveness, advantageous use of talent, innovation and diversity (EC, 2007: 6; EC, 2010: 103-106; Unesco, 2010: 2; Bøe, 2012: 1).

The purpose of this article is to review studies that have been carried out so far and that explore the relation between gender stereotypes and the minority representation of women in S&T. to do this, we examine researches in this field of knowledge almost exclusively in European countries and the United States, for in addition to be there where the most of this kind of studies concentrates, on occasions this bibliography is not easily accessible for the Spanish-speaking readers.[3] This approach will allow us to identify large explanatory frameworks

1 This article is framed in the research project Meta-analysis of gender and science research [RTD-PP-L4-2007-1] funded by the European Commission via the 7th Macro Program. I am grateful for the comments of the anonymous reviewers of the journal as well as the suggestions of the editorial board itself. However, only the author is responsible for the content of the present article.

2 Year after year the diminution of young people who opt for learning trajectories in S&T is verified. Recent data reassure the tendency which the European Council of Lisbon called to attention to in 2000: in spite of the increase in the absolute number of students of science and technology and similar disciplines, the relative participation among student population has been decreasing both in secondary and tertiary education (OECD, 2008: 33; EVERIS, 2013: 8). Moreover, it is important to point out that even if the number of female university students has grown faster than that of males, the former barely amount to 12.4% of graduates of UE-27 in sciences, mathematics and technology, against 37,4% of men (CAWMSET, 2000: 13-14; OECD, 2008: 42; Van den Berghe and de Martelaere, 2012: 20; INE, 2014: 3).

3 However, some Spanish-language works are included as it is considered that they can enrich the texts, for example: Vázquez-Cupeiro (2013, 2011), Caprile (2012), Pacheco *et al.* (2011, 2010), Castaño (2008), Díaz (2008), Pérez-Sedeño and Gómez (2008), Pérez-Sedeño (2007, 2006), Sáinz (2007), Blazquez Graf and Flores (2005), Bonder (2004), García de León and García de Cortázar (2002), González and Pérez-Sedeño (2002) and Morgade and Bonder (1996).

proposed over recent decades in international literature in relation to the unequal gender distribution in S&T, and it will also be useful to stress the limitations and challenges of research on this topic.

Reviewing the studies that approach the unequal gender distribution in S&T is relevant because of various reasons. In the first place, some of the examined works make a brief review of the international literature on this issue, mainly because of space limitations, they do not have the longitudinal and updated character of the bibliography presented here. Secondly, even if we face a complex phenomenon attributed to the interaction of factors of diverse nature,[4] in recent years scientific research has challenged some traditional explanations, identifying besides stereotypes as a potentially relevant factors when it comes to explain gender segregation in S&T: "work schedule, stereotypes, election of learning paths, and undercover barriers and biases in organizational practices, including collective negotiations procedures" (Bettio and Verashchagina, 2009: 45).

Therefore, it is of our interest to present a review that allows not only to move away from parochial approaches, but also account for continuity and change patterns in the debates, approaches and dominant strategies stated at international level. Last but not least, such review will be useful for underscoring the challenges faced by research devoted to this issue, in addition to orient the political action in developing global actions in views of fostering a S&T system marked by equality, excellence and competitiveness.

From a methodological standpoint, we have tried to review studies of updated longitudinal character in the most systematic manner possible. The works included have been published from the early 1970's up to now. To do so, we have performed a bibliographic search using, in addition to consultation with experts on the topic, the online Gender and Science Database, which hosts more than 4500 scientific publication in this issue.[5]

The categorization of the theoretical approaches that allow explaining the lesser presence of women in the science system has not an easy task. Inspired by the works of Cronin and Roger (1999), Glover (2001) and Schiebinger (2008), which analyze the international evolution of the initiatives aimed at closing the gender gap in S&T, we have opted to organize the extensive multidisciplinary literature according to chronologic and thematic criteria. Up to the 1980's decade most of the

4 Without being exhaustive, see Cronin and Rogers (1999), EC (2004), Valenduc et al. (2004), Blickenstaff (2005), Suter (2006), Xie (2006a), NAS (2007), OECD (2008) and Hill et al. (2010).

5 This database has been created in the framework of the European project Meta-analysis of gender and science research, which comprises more than 50 experts in gender and science of all the EU country members and countries associated to the 7th Macro Program. For further information, visit: http://meta-analysisofgenderandscienceresearch.org/web/index.php [November 13th, 2014].

research focused on issues related to the access of women to the science system. The interest is to find out why women do not choose sciences and why they choose sciences to a lesser extent than their male counterparts (horizontal segregation).

Even if the research tends to present women as "the problem", stressing individual characteristics, some researches also refer to sociocultural issues. The explanations can be thus classified around the biological, psychosocial and sociocultural approach. As of the 1990's the research fundamentally focuses on issues related to permanence and promotion of women in the science and technology system. The literature tries to explain the persistent horizontal and, especially, vertical, and for this the theoretical models focus in structural, cultural and organizational aspects (external to women). This supposes, as Harding and McGregor (1995: 16) point out, substituting the model upon which the explanatory framework is based: from the "deficit of women" to the "deficit of science". The new statements are organized on the culture of science, specifically, on the institutional and epistemological approach.

The article structures as follows. After identifying the dominant theoretical approaches in relation to the unequal gender distribution in S&T, we present the debate related to the role of gender stereotypes, their persistence, fragility and permeability in the election of learning and professional trajectories. Later on, we analyze the nature of the initiatives set into motion in views of reducing the gender gap in S&T. finally, we include some conclusions that stress the challenges of research and the strategies to foster a S&T system marked by excellence and equality.

The deficits of women: the biological approach

The biological perspective suggest that women choose learning and professional trajectories in sciences less often because of the deficits in mathematical learning in school. This approach has its inception early in the 1970's, when abundant laboratory experiments documented the gap between the capabilities of men and women, it continues over the 1980's and 1990's decades through researches that explain, from mathematical performance, spatial dexterities and speaking and writing abilities (Shepard and Metzler, 1971: 701; Halpern, 1989: 1156-1158; Geary, 1996: 229), that differences in learning and career election have a biological origin.

In addition to resort to neurobiological techniques and meta-analysis, it is frequent to carry out studies from standardized tests and controlled laboratory experiments to approach the cerebral structure and functioning, hormonal influence on cognitive performance, the psychological development in childhood and evolutionary psychology (NAS, 2007: 37); all of this to also suggest the biological origin of the different educational results in boys and girls.

The issue of gender gap in the innate cognitive capabilities and abilities is a debate retaken periodically.[6] From the methodological standpoint the Hyde's (2006) critique on the petty statistical differences between boys and girls is challenged to state that in reality, the accumulation of petty differences becomes a large gender gap (Halpern, 2006: 22). In like manner, the debate is inspired by the "critical filter hypothesis" according to which participation and accomplishment in disciplines akin to science mark, if not determine, the posterior election of scientific-technical studies and careers (Sells, 1980: 340-341). This way, it is widely known the polemic generated after the controversial declarations of former Harvard President, as he stated that the lesser academic success of women's scientific and academic trajectories lies, in addition to maternity and discrimination, on their lower innate capabilities for mathematics than their male counterparts (Summers, 2005).

However, in spite of there might be the gender differences in relation to scientific capabilities and mathematical aptitudes, the explanatory and methodological limitations of biological approaches have been widely documented (Spelke, 2005: 956; Sagebiel and Vázquez-Cupeiro, 2010: 17). The gender breach is narrow, it has been shortening as of the 1960's and systematic and/or biological difference have not been proved in most cognitive functions (Hyde, 2006: 11; NAS, 2007: 49). Moreover, the biological postulations overlooks both the similitude between boys and girls and the cases of superior feminine performance (Epstein *et al.*, 1998; Gallagher and Kaufman, 2005: 316; Else-Quest *et al.*, 2010: 125).

The international study Culture, Gender and Math, which analyzes gender differences according to PISA data in forty countries, concludes that: 1) even if girls obtain a mean inferior to boys in mathematics, they have better results in reading; and, 2) there is a positive correlation between inequality and gender gap in mathematics, as for the latter tends to disappear in more egalitarian societies (Guiso *et al.*, 2008: 1164-1165). Moreover, as pointed out by Alaluf *et al.* (2003), cognitive differences do not indicate that aptitudes cannot change or that, if the election of studies of young women tends to be more diverse, the differential performance in mathematics can adequately explain the gender gap. As summarized by Xie and Shauman (2003: 208), gender differences in educational and professional trajectories cannot be explained on the basis of academic performance in mathematics or natural sciences because:

6 For the most recent developments, see Geary *et al.* (2000), Gallagher *et al.* (2002), Weiss *et al.* (2003), Gallagher and Kaufman (2005), Hyde (2006), Halpern (2006), NAS(2007) and Geary (2011).

> Gender gap in the average performance in mathematics is narrow and has been decreasing, despite boys being more likely than girls to reach a high-competence level. Gender differences nor in mean nor in the high performance in mathematics can explain the greater specialization of young men in science and engineering areas in comparison with young women.

The psychosocial and sociocultural approach: identity, stereotypes and socialization

Far from gender differences based on differences of cognitive, neurological or biological character, evidence pinpoints at the influence of accumulative factors (Etzkowitz *et al.*, 1992: 163; Li, 2007), and particularly, at the interaction of psychosocial and sociocultural factors. As of the 1970's and 1980's decades a number of researches focus on the construction of identity and gender roles from three theoretical approaches: human capital, role modeling and stereotype construction (Sagebiel and Vázquez-Cupeiro, 2010: 5).

From the perspective of human capital, men and women do not give the same value to the same tasks, therefore they choose different learnings and professions. While men tend to give priority to their professional development; most young women usually show a greater interest in studies and occupations that allow conciliating personal, family and professional life (Ibid.: 32-33).

Studies with the perspective of role modeling suggest that individual, learning and labor decisions are marked by familial background and in particular by the availability of feminine role models from which to learn and to identify with (Suter, 2006: 99). Since it is frequent that girls who choose studies in sciences have at least one parent with professional experience in such field, a good part of the literature, as we will see further in the text, defends the need to increase the possibility of increasing the availability of feminine role models, and in some case masculine as well (Hansen and Mulholland, 2005: 130), in order to change traditional gender stereotypes and, ultimately to compensate the gender gap in learning and professional trajectories.

The third approach, more complex and with greater explanatory power than the previous ones (Xie, 2006b: 42), assumes that gender stereotypes assign characteristics and roles, define the reference schemas, influence on the expectations and behaviors of men and women, and ultimately, reinforce the continuity of learning and occupational segregation (Acker, 1992: 57; Valenduc *et al.*, 2004: 40; Suter, 2006: 98). Before the masculine stereotype, which underpins the belief that boys are interested in technical and analytical subjects, and are oriented toward objectivity and rationality, the feminine one assumes women are affective, empathic, intuitive and passive (Eagly and Steffen, 1984: 735; Etzkowitz *et al.*, 1994: 43-44).

This dichotomy makes room for binary categorizations, specialist and reductionist, which recreate traditional gender stereotypes among students, educators, families and the media (Mendick, 2005: 203), and ultimately, they contribute to explain the gender gap in S&T. the election of the learning paths is marked by the abilities, interests, personality, opportunities and knowledge of career options (Halpern, 2006: 21), demonstrating the connection between the approach focused on individual influences and the sociocultural approach (familial and social influences). According to the psychosocial perspective, the individual characteristics that can influence on the various results in S&T would include both affective and cognitive characteristics such as individual behaviors (participation and academic results) (Xie and Shauman, 2003: 40). Therefore, some studies orient to the attitudes regarding science and mathematics, interests and success expectations, self-esteem and self-perception, etc.[7] According to the report by American Association of University Women Educational Foundation, two are the prevailing stereotypes: girls are not as good as boys in mathematics, and scientific work suits men better (Hill *et al.*, 2010: 38). However, gender stereotypes do not only assign characteristics, but as they define the reference schemas and influence expectations and behaviors, they also have a prescriptive character (Valenduc *et al.*, 2004: 88).

According to the achievement-related choices model, there would be a propensity, marked by gender roles and sociocultural pressures, to opt for disciplines that we believe we can command and those which we assign great value (Eccles *et al.*, 1983: 82; Eccles *et al.*, 1999: 169). At the same time, negative stereotypes on intellectual potential and abilities for science and similar disciplines can become a stereotype threat and drive them away from the world of science, making girls and women act in such manner that the stereotypes are verified in terms of results and aspirations (Hill *et al.*, 2010: 38-39).

The socialization agents are decisive as well in the construction of gender roles and in the transmission and perpetuation of traditional gender stereotypes that influence the election of learning and professional trajectories (Campbell *et al.*, 2004: 4; Vázquez-Cupeiro, 2013: 30). Parents have expectations marked by gender, girls will stand out in language and boys in mathematics, and often as they grow boys with innate abilities for mathematics underrate the mathematical intelligence of girls (Sadker and Sadker, 1994). Family and particularly parents tend to foster gender differences, not only because they assess their characteristics differently, but also because they treat boys and girls in a differentiated manner.[8] Often they

7 See the researches by Sadker and Sadker (1994), Eccles *et al.* (1999), Li (2007), Sáinz (2007) and Bøe (2012).
8 As for the role of parents, interesting are the contributions of Xie and Shauman (2003), Simpkins *et al.* (2005), Suter (2006) and NAS (2007).

use differential language, cognitively less demanding with girls (Tenenbaum and Leaper, 2003: 44), in addition to devote more time to explain science subjects to boys and buy fewer materials related to S&T (computers, books, games, etc.) for girls (Crowley *et al.*, 2001: 258; Simpkins *et al.*, 2005: 27). Consequentially, the persistence of negative gender stereotypes in the family sphere, in addition not to motivate the girls to take up a science-related career (Xie and Shauman, 2003: 46). Might contribute to girls and young women end up underrating their capabilities.

The literature also identifies a number of channels by means of which the school exerts influence on learning elections: characteristics of the peer group, expectations of the teachers and sort of orientation, sort of course and extra-school activities, etc.[9] together with the fact that technical and science subjects are usually associated with masculinity, a high degree of difficulty and great effort (Sjøberg, 2002), the election of the learning trajectory is usually made according to traditional gender roles in order to facilitate continuity in the group.

This way, the peer group is a key socialization agent in terms of role modeling and achievement perception. In the case of young women, who are usually more sensitive to the perception of social acceptance in the group and the need to belong to it, this can induce them to "camouflage their talent" in the attempt to attain better acceptance (Kerr, 1994; Kerr, 2000: 649; Campbell *et al.*, 2004: 3). Some studies conclude that in addition to the scarcity of feminine role models in science subjects, the teachers also participate in the consolidation of gender stereotypes, often interacting in a biased manner from the gender standpoint; this definitely contributes to activate the "self- fulfilled prophecies" (Sadker and Sadker, 1994; Bauer, 1999: 22; Sáinz, 2007: 39).

Finally, a part of the literature focuses on the connection between cultural representations and gender gap in science. The representations of people devoted to science that appear in the media influence the attitudes, behavior and learning decisions, reinforce traditional conceptions on femininity and masculinity, and reproduce stereotyped contents, which especially in adolescence, might limit the vision of the possible I's and in the end, mark the learning and professional trajectories.[10]

9 Some studies that approach the influence of school are: Håpnes and Rasmussen (2000), Valenduc *et al.* (2004) and EC (2007).

10 On science and cultural representations, see: Ruvolo and Markus (1992), Barman (1997), Steinke (2005), OECD (2008) and Unesco (2010).

The culture of science: institutional and epistemological aspects

As of the second half of the 1990's decade, a large part of the research challenges the dominant approaches prior to the assumption that the inside of scientific organizations is not neutral to gender. Thus the center of attention changes, from psychosocial and sociocultural aspects to organizational issues centered on the epistemology of science (Sagebiel and Vázquez-Cupeiro, 2010: 54-55; Caprile *et al.*, 2012: 16). The premise, initially accepting the neutral character of science, is that the problem to access, retention and promotion of women in the scientific-academic sphere lies in the interior of the institutions. There are gendered organizations (Acker, 1990: 139), marked by gender differences in terms of (formal or informal) labor division. There is research on organizational norms and practices, hidden discrimination mechanisms in the selection and promotion processes, informal power networks (male networks), cooptation processes, excellence criteria, etc.[11]

Among the most relevant conclusions we can point out sexism and nepotisms tests in peer evaluation (Wenneras and Wold, 1997: 342), wage gap and respect to the available resources among scientists with the same category (MIT, 1999: 6) or the need to identify discrimination mechanisms (rather subtle) in institutions, in addition to design fair and transparent procedures of selection and promotion (Osborn *et al.*, 2000: 28).

Researches inspired in feminism deal with the culture of science and the nature of scientific knowledge to challenge their neutral character and the need to produce new contents and methodologies; issues related to the neutrality of institutional norms and the hegemonic position of masculinity in the science system are approached, in addition to reflect on the social construction of science and the nature of scientific knowledge.[12] Many are the studies that show how science produces, reproduces and legitimizes gender stereotypes and biases in terms of contents, methodologies and practices.[13] Some researches reflect on the masculine nature of science, power relations and labor division in the world of science. The culture of science and occidental science have fostered a homosocial and misogynistic culture, as not only women have been "marginalized, but also

11 From this perspective, see: Etzkowitz *et al.* (1992), Bagilhole (1993), Benokraititis (1998), Morley (1999), Husu (2001), Bagilhole and Goode (2001), García de León and García de Cortázar (2002), Deem (2003), Knight and Richards (2003) and Vázquez-Cupeiro and Elston (2006).

12 For further details see: Haraway (1988), Longino (1990), Rose (1994), Morgade and Bonder (1996), Faulkner (2001), Blazquez Graf and Flores (2005), Pérez-Sedeño (2006, 2007), Pérez-Sedeño and Gómez (2008), Schiebinger (2008), Díaz (2008), Hearn and Husu (2011) and Pacheco *et al.* (2010, 2011).

13 Díaz (2008: 7) distinguishes four large frameworks that explain the slow professional progress of women in science: the perception of science as masculine; science as a source of power; the model of the scientific laborer based on the patterns corresponding to a society based upon the male breadwinner and the female housewife; and the gender bias in the proper content of science.

stigmatized"; supposedly, they face not only discrimination, but also mistrust based on clericalism and fear that the power of women might "soil" sciences" (Noble, 1992: xiv). In addition to suggest a binary statement that associates masculine attributions to science, Wajcman (1991) states that the image of hegemonic masculinity in science is transferred via polarized gender stereotypes that connect initiative, strength, rationality and autonomy with men, at the time that they build women as inferior.[14]

By ignoring creative and personal aspects, science reinforces gender stereotypes (emotive women and not objective, with holistic visions leaning toward soft sciences). The masculine bias of the social definition of science implies not only excluding and devaluating the feminine, as it is not identified with the socially attributed prestige of science, and in like manner profiles men who differ from the hegemonic way of masculinity, but also that the similar subjects and professions are not the first option of women (Steinke, 2005: 52).

Scientific disciplines are not neutral constructions (Knights and Richards, 2003: 222), they shape and influence the behavior (Townley, 1994) and organize around various gender regimes (Connell, 1995: 20; Vázquez-Cupeiro and Leontowitsch, 2007: 285). The more power concentrates in a field, less favorable it is for women (Kanter, 1977; Cockburn 1985; Stolte-Heiskanen, 1991), contributing to maintain male domination and segregation (horizontal and vertical) in scientific communities. The strong male domination in science, therefore implies unequal power relations, which often turn into the generalization of negative stereotypes on women and their scientific capabilities (Díaz, 2008: 7).

Other studies point out that, in addition to unequal power relations, male domination in science implies the systematic forgetting of scientific contribution of women (Anderson, 2011). With feminist stances these studies state that conventional research develops on the basis of masculine values and references, and reflect on the gender biases of scientific knowledge, challenging the character, agenda and epistemological content of science, such as the nature of certain theories and methodologies, the excluding language of science, etc.[15] This way, the statement about "gender innovations" defends the need to integrate the gender analysis into research and production of knowledge in views of increasing the participation of women in the system of science and technology (Schiebinger, 2008; Schiebinger and Schraudner, 2011).

14 Connell (1995: 77) states it is a central concept in the construction of gender and reproduction of masculine power in science and which she defines as: "the configuration of the practice of gender that personifies the currently accepted answer to the problem of the legitimacy of patriarchy, which guarantees (or is taken to guarantee) the dominant position of certain men and the subordination of women".

15 Some especially interesting works are: Acker (1992), Rossiter (1993), Fox-Keller (1996), Husu (2001), González and Pérez-Sedeño (2002), Klinge and Newman (2010) and Wajcman (2010).

Gender stereotypes: perpetuation or permeability?

Xie (2006b: 107) states that gender differences in the election of studies are not fixed, but subject to the influence of social forces. Roles and gender stereotypes, mental models and how women and men should be and behave in different spheres, are social constructions and because of their permeability change over time and in function of the sociocultural context. This way, a small part of literature focuses on the role of socialization agents that, besides transmitting and reproducing traditional gender roles, are instruments too powerful to overcome them (Unesco, 2010: 11).

In spite of the similarities around the stereotyped election of learning and professional trajectories of young men and women, there are differences by countries, associated to the nature of the educational system and labor market, traditions and social perspectives (for instance, respect to religious beliefs), sort of school, social class or gender policies.[16] Most of the studies verify that if socialization takes place in contexts in which the independence and flexibility of role models is promoted, interest increases, results in sciences and similar disciplines improve and as there is not heavy pressure, learning elections tend to be less stereotyped (Eccles and Jacobs, 1986: 367; Eccles *et al.*, 2000: 330; Paechter, 2003: 129; Hyde, 2006: 13).

The educational level and interest in science and mathematics of the parents (Xie y Shauman, 2003: 46), as well as the presence and/or absence of feminine models in the world of science in the familial sphere (Suter, 2006: 99; Hill *et al.*, 2010: 41-42; Vázquez-Cupeiro, 2011: 276) are crucial to explain the divergent changes that young men and women experience. Several researches also suggest a relation between transmission of gender role and family type. At households with better gender equality, the classification of occupations tends to be less stereotyped and girls opt for less conventional studies, moreover they express greater interest and obtain better results in mathematics and sciences; aware of the lower expectations associated to girls, in this sort of families, parents will adjust their daughters' attitudes, aspirations and behaviors. In more conventional families, on the contrary, gender conceptions are usually stereotyped, consequently they foster and expect better performance and perseverance from boys.[17]

16 As instances, see: Williams and Best (1990), Arnot *et al.* (1999), Van Langen and Dekkers (2005), Vázquez-Cupeiro and Leontowitsch (2007), OECD (2008), Guiso *et al.* (2008) and Van den Berghe and de Martelaere (2012).
17 From this perspective, relevant are the studies by Weisner and Wilson-Mitchell (1990), Jacobs and Eccles (1992), Xie and Shauman (2003), Xie (2006a) and NAS (2007).

Areas such as engineering and technology are still masculine territory (Cockburn, 1985; Wajcman, 1991; Faulkner, 2001; Castaño, 2008), but in recent decades not only the representation of women in some areas traditionally dominated by men has increased, but changed (Kilminster *et al.*, 2007: 39), this has also taken place for men in areas in which women prevailed.[18] Besides the connection between gender roles and status in terms of power, hierarchy and authority, these changes allow illustrating the fragility of the stereotypes traditionally associated to men and women. This way, not only has the need to raise awareness on the effects of negative gender stereotypes been pointed out, but also the need to commit on equality promotion from inside out (Vázquez-Cupeiro, 2013: 39).

Strategies to reduce gender gap

The problem is far from being solved, nevertheless; because of this, an important part of the literature reflects on the nature of the initiatives set into motion to produce interest and reduce the gender gap in S&T. There is a parallelism between the various explanatory models and the strategies that have been started (Caprile *et al.*, 2012: 60). This way, the initiatives can be classified in as those that intend to attract women, those focused on supporting women already in science, and finally, those oriented to change science an make it more inclusive from the gender standpoint (Cronin and Rogers, 1999: 11).

Following this categorization, Schiebinger (2008) identifies three interrelated approaches. In the first place, programs aimed at women in views of increasing their participation and equate their representation with that of men (fix the numbers). The minority presence of women in science and technology is explained from the metaphor of a "leaking tube", which is interpreted in terms of preferences and decisions of women themselves (less ambitious, their priority is family, etc.). Before this situation, as of the 1980's decade the need to attract young women is stated. However, the initiative centered on women "deficits" have not been particularly efficacious as they are punctual and independent measures, which seek an "adjustment" and ignore institutional and epistemological aspects, thereby, with limited capability to transform the cultural context.[19]

Secondly, reforms in scientific organizations to eliminate structural/cultural barriers and thus increase the participation of women (fix the institutions). As of the 1990's, the initiatives try to reform the institutional culture, organizational practices and gender relationships to transform them into more inclusive environments.

18 In relation to this question, see: Hayes (1989), Chusmir (1990), Williams (1992), Neighbours (1999), Burton and Misener (2007) and Loughrey (2007).

19 On this critical perspective, for further details see: Etzkowitz *et al.* (1992), Osborn *et al.* (2000), Faulkner (2001) and Schiebinger and Schraudner (2011).

The neutrality of scientific and academic institutions is contested and reforms are promoted to detect subtle discrimination, avoid biases in the selection and promotion processes, foster practices to facilitate conciliation, etc.

But these measures tending to transform institutions usually assume research and the nature of scientific knowledge is neutral from the gender standpoint. This way, in the third place, it will not be until the early XXI century when the measures are oriented to change the epistemological and methodological bases of science as well as the hegemonic position go masculinity in science. In views of not limiting creativity and excellence in scientific knowledge, there are strategies that facilitate the incorporation of gender perspective in research design and reduce the biases in knowledge construction (fix the knowledge) (Schiebinger, 2008: 369).

A change that supposes a new way to understand science is promoted (EC, 2004: 15). However, even if most of OECD countries have undertaken structural educational reforms and have set a wide range of policies and programs to approach this issue into motion,[20] a multi-level approach becomes necessary (OCDE, 2008: 112). As pointed out by Van den Berghe y de Martelaere (2012: 11), many initiatives do not only lack adequate long-term perspective, but additionally, in order to be effective, they require a sustainable supporting structure that includes:

> An integrated approach, strategic long-term plan coherent actions from the nursery school to higher education, measures related to labor market, sensitization activities, a coordinating organ, binding commitments between the interested parts and sufficient financial funds to be able to reach critical mass.

As a conclusion

The legislation and political initiatives on equality, as well as the expansion of opportunities and socioeconomic changes have contributed to increase the number of women in the professional and academic spheres. Against the elitism, exclusion and inequalities that have characterized the educational systems of the past, nowadays there is talk on plurality and equality. However, the persistent gender gap, in countries with diverse sociocultural and geopolitical contexts, in addition to undermine the capability of innovation and competiveness of the S&T system, supposes condemning women to remain on the "fringe of science" (Jones *et al.*, 2000: 191).

The review and analysis carried out underscore a number of issues. In the first place. The explanatory frameworks that help us understand the gender gap in S&T and, in short, why young women do not study sciences are presented

20 On the reforms and political actions, see the works by Sjøberg (2002), Bonder (2004), EC (2007), Unesco (2010) and Kearny (2011).

chronologically. However, it cannot be said that some substitute the others but overlap, complement and are interdependent, facilitating a better comprehension of the problem. In the second place, even if we face a complex multi-causal phenomenon, not all the explanations are equally valid or effective to understand both the election of learning trajectories and the scarce representation of women in science and technology in S&T. Leaving aside the controversial biological approach, as it was demonstrated that gender gap not only is not significant, but it has decreased, the perspectives centered on the construction of stereotypes, socialization and the social construction of science have a greater explanatory power. Thirdly, it is necessary to reflect on the persistence and reproduction of gender stereotypes, as well as the dynamics that allow overcoming. To so do, it would be necessary to design innovative studies, from the conceptual and empirical points of view, that favored the deconstruction of dualist discourses (for example, exploring patterns of continuity and change in areas, traditionally and recently feminized and/or masculinized or researching the gap in the election of studies and professions paying attention to the different election of men and women).

Finally, in addition to demonstrate the relation between theoretical perspectives an initiatives designed to reduce the gender gap, it is vital to orient research and political action to the development of innovating strategies. As pointed out by Morley (2013: 126) "we need new rules for a very different game". The scant participation of women in science, base of social welfare in developed countries, supposes to waste large part of social and individual investment in human capital and go against the formulation of new innovative quality scientific perspectives. Therefore, promoting diversity by means of equitable participation of men and women is not only an issue of social justice but also of advantageous use of talent, socioeconomic development and competiveness. To do so, it is necessary to design and set into motion global intervention strategies, stable and long-lasting, aimed at boosting a S&T system marked by equality and excellence.

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