New Feminist Perspectives to Understand Gender Gaps in Stem Education: A Case of Study in Mexico

Nuevas perspectivas feministas para entender las brechas de género en educación CTIM: un estudio de caso en México

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Abstract

This paper addresses questions related to gender inequalities, such as gender biases and stereotypes, in the fields of Science, Technology, Engineering, and Mathematics (STEM). This article analyzes, from a gender perspective, some of the gender inequalities present in STEM higher education in Mexico. It also examines briefly some biologicist narratives of gender gaps from the perspectives of gender, philosophy, the history of natural sciences, and biology itself

(Guerrero Mc Manus, 2022). The main questions to be answered in this article are focused on providing a possible response to the gender gaps in STEM areas at Univdersidad Nacional Autónoma de México (UNAM), as well as exploring possible ways of including women in these areas, from a critical perspective. In this article, we propose how some gender biases have negatively impacted Mexican public education policies and hindered the presence of Mexican women in scientific fields. Our position is grounded in philosophical and gender studies perspectives on science and technology, as well as feminist epistemologies, primarily those of authors such as Schiebinger (2004), Maffia (2007), and hooks (2021), who recognize that these gender gaps stem from processes of exclusion in classrooms from communities that are predominantly masculinized and hegemonic. Finally, we present some of the situations that have had to be dismantled to understand inequalities and gender gaps in STEM fields, with the aim of highlighting some of the gender biases and vulnerabilities to historically marginalized communities, such as women that have been exposed in STEM fields in Mexico.

Keywords: Gender bias STEM, gender gaps STEM, stereotypes gender STEM, gender roles at STEM, division of work STEM at Higher Education Institutions

Resumen

El presente trabajo responde a las interrogantes relacionadas con las desigualdades de género, como los sesgos y estereotipos de género

presentes en las áreas de Ciencia, Tecnología, Ingeniería y Matemáticas (CTIM). Este artículo analiza desde una perspectiva de género algunas de las desigualdades de género presentes en la educación a nivel superior CTIM en México. Esta propuesta analiza algunas de las explicaciones biologicistas de las brechas de género desde la perspectiva de género, de la filosofía y la historia de las ciencias naturales, como desde la perspectiva de la propia biología (Guerrero Mc Manus, 2022). Las preguntas principales a resolver en este artículo están centradas en dar una posible respuesta a las brechas de género en áreas CTIM en la UNAM, así como el explorar las posibles vías de inclusión de mujeres relacionadas en dichas áreas, desde una perspectiva crítica. En este artículo, proponemos que algunos de los sesgos y estereotipos de género han estado presentes en los discursos educativos, científicos e institucionales del contexto mexicano, contribuyendo a naturalizar y justificar la exclusión de las mujeres de ciertos espacios científicos. Nuestra postura se sustenta en perspectivas filosóficas y de estudios de género sobre ciencia y tecnología, así como en epistemologías feministas, principalmente de autoras como Schiebinger (2004), Maffia (2007) y hooks (2021), las cuales reconocen que tales brechas de género se deben a procesos de exclusión en las aulas de comunidades, ya que son estas comunidades principalmente masculinizadas y hegemónicas. Finalmente, se exponen algunas de las situaciones que se han tenido que ir desmantelando para la comprensión de las desigualdades y las brechas de género en las áreas CTIM, con el objetivo de exponer algunas de los sesgos de género, y las vulnerabilidades a las que han

estado expuestas algunas comunidades históricamente vulneradas como las mujeres en áreas CTIM en México.

Palabras clave: Sesgos de género CTIM, brechas de género CTIM, estereotipos de género CTIM, roles de género en CTIM, división del trabajo en CTIM en las Instituciones de Educación Superior

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Introduction

In many societies, patriarchal structures have existed for a long time. In these communities, women were discriminated against being able to have medical care, legal and political rights, education rights, and dignified employment, among others. In particular, since childhood, gender inequalities have been perpetuated, in the form of discrimination and lack of or limited opportunities, which has since generated considerable gender biases for the development of women (Košir & Lakshminarayanan, 2023). It is important to mention that the concept of gender order is related to hegemonic masculinity, which will also dominate over marginalized and subordinate masculinities. Besides, the femininity category is given by the idea of "value", i.e. femininity is strongly related to the notion of compliance with subordination and prioritizing the interests of men.

Nevertheless, there are other types of femininities but these are subversive and threaten the already established relationship between man and woman. For example, lesbian relationships, women's empowerment or authoritarianism (Ledman et al., 2021).

Robertoson et al. (2022) argues that within organizations, gender inequality represents a complex problem, and therefore it is very complicated to provide a unique solution. Inequalities are implicitly integrated into organizational structures and norms, even when the organizations themselves are aware of allowing gender neutrality. "Gender is present in the processes, practices, images and ideologies, and distributions of power", even when it is stated that all that is needed is to have the necessary merits to obtain something in the organization. Gender intersects with organizations, people, and their relationships. One of these gender inequalities is analyzed in the article of Nikunen, and Lempiäinen, (Nikunen & Lempiäinen, 2020) where the authors exposed one of these inequalities in academia, the mobility situation related to women. In other words, it is often stereotyped that women have less mobility than men. There are real troubles combining work and family that impact women more than men. Women present a major facility to change their domiciles during the junior phase of their career, because they have fewer family responsibilities than in other stages of their life, for example when they decide to marry or to have children. "Dual-career relationships, which are more common among academic women than men, complicate participation in academic mobility much more than single-career

relationships" (Nikunen & Lempiäinen, 2020, p. 558). The term "dual-career relationships" refers to relationships found in academic fields where women academics with full-time working couples and children were less likely to take part in international research teamwork than male-academics in analogous circumstances.

One of the most important findings during the research of Nikunen & Lempiäinen (2020) is that some researchers choose in the first place their family, i.e. "put family first" and put aside their academic career. "Their strategy is resistance –a gendered strategy based on family values– and trust (and also hope) that there will be career positions available without their being mobile" (Nikunen & Lempiäinen, 2020, p. 567). Nevertheless, other research mentions that the same strategy works better for men than for women, as a result of their stronger network connections. Furthermore, in the article "Gender inequality in academia from the perspective of the dialogical self: beyond autonomous men and relational women" (Ghaempanah and Khapova, 2023) the authors explore the main idea related to gender inequality, specifically if this gender inequality still plays an opposite role in the professional progression of women in academia and they founded three postulates on gender inequality. The first postulate exposed that the first gender inequality appears from the dialogues between self, organization and society. The second postulate arises through the dialogue between self-theory and attending to the multiplicity of "I positions" afford a deep refined description of this gender inequality, exposing the dichotomy of "autonomous

men" and "relational women". The third postulate is the friction in the dialogical structure of the self, which is related to self-organization and society, and is not related to the individualized psychological characteristics. On the other hand, the World Health Organization asserts that schooling level is an important marker of inequality, economic vulnerability and propensity to violence (ONU Mujeres México, 2020; WHO, 2021a, 2021b). In Mexico, only 17% of the youth population manages to enter higher education (Animal Político, 2017). Although, throughout history, women have gained access to higher education, going from 27% of the student body in 1977 to 52% in 2020 (Morales, 1989), there is a pronounced gender gap among careers that significantly affects their future (García & Torres, 2022). In this way, most of the so-called STEM careers (Science, Technology, Engineering, Mathematics) are masculinized (García & Torres, 2022), and taking into account that on average they have higher incomes than other bachelor's degrees, we can say that this masculinization contributes significantly to the wage gap that is shown in our country by gender (Avedaño et al., 2020). This gender gap in STEM careers is expected to affect the economic future of women (Organización para la Cooperación y el Desarrollo Económicos, 2016).

Due to the last paragraph, a couple of questions have arisen over the past few decades when observing these statistical inequalities: (a) What is the possible reason for the gender gap in STEM areas at UNAM? And (b) how can we address

this inequality and work towards greater inclusion of other groups? These questions constitute the core of this analysis.

Theoretical Framework

Our position is grounded in feminist epistemologies and philosophical studies of science and technology, aiming to dismantle the natural sciences' discourses that argue for a "natural inequality" between the sexes. This theoretical framework proposes that gender gaps in STEM fields are not inevitable biological facts, but rather historically situated phenomena that must be understood through the historization of their construction within the Mexican context. Following authors such as Schiebinger (2004) and Maffia (2007), we analyze how the institutionalization of modern science excluded women by assigning values of objectivity and reason to a masculine ideal, while displacing subjectivity to the realm of the feminine. Furthermore, we incorporate the critiques of Ciccia (2022) and Guerrero Mc Manus (2022) to denounce how biological determinism reduces complex social and political phenomena to mere "effects of nature", ignoring the power dynamics that permeate university education and scientific training. Ultimately, this framework seeks to visualize how gender biases and stereotypes circulated within institutional discourses in Mexico, justifying exclusion and naturalizing inequality in access to scientific culture.

Methodology

To operationalize this perspective, the methodology is structured in two analytical dimensions. First, it examines contemporary and historical scientific discourses from the biologicist natural sciences to identify the purported differences in capacities required for scientific practice, which lead these discourses to interpret gender gaps as a direct product of natural inequalities. Second, this section initiates a dialogue between these biologicist explanations and historical-social analysis. By examining specific instances where such narratives permeated decision-making spaces in university education and scientific training, we aim to historize the construction of gender gaps in STEM in Mexico. We argue that it is essential to "look back at history" to understand that these gaps are not inevitable biological facts, while also analyzing how biologicist explanations were constructed within the natural sciences themselves.

Gender gaps in the context of Mexico's HEIs: case UNAM

In recent years, Mexico has gone through a major crisis of gender violence that has had various manifestations on different scales. The most striking indicator is the number of femicides. Mexico ranks second in Latin America in absolute numbers and ninth in relative numbers, i.e. 1.4 per 100,000 women (one hundred and thousand). The social sciences have argued that the very high incidence of this crime is part of the reinfor-

cement of the social message that public space is not for women (Pich 2003, as cited in López 2020). This allows the perpetuation of social orders, roles and stigmas based on gender.

Gender-based violence (GBV) is increasingly being recognized as a problem in schools, colleges and Higher Education Institutions (HEIs) worldwide (Anitha et al., 2024). According to WHO (2020, 2021a, 2021b) reports, young women and LGBTQ+ students between the ages of 15 and 24 are the most at risk of suffering GBV globally. Data such as these are of utmost importance for the present work, since our university community in school education is mostly within this age range. The most documented types of GBV experienced in this age range are sexual aggressions that may or may not be perpetrated by their intimate partners or husbands. According to these reports, the main risk factors are inequalities, with the highest rates concentrated in low-income countries, which Mexico is part of (WHO, 2021). In addition, there are other indicators of violence against women and vulnerable groups based on their gender, such as low access to paid work and low levels of schooling, among others (WHO, 2021a, 2021b). Taking into account the recognition given by WHO to the level of schooling as an important marker of inequality, economic vulnerability and propensity to violence (ONU Mujeres México, 2020; WHO, 2021a, 2021b), it is necessary to recognize that in Mexico only 17% of the youth population enter higher education (Animal Político, 2017), that is, there is a systemic manifestation of violence that attacks the right to public education.

In 2020, the number of people who were part of the Human Resources Educated in Science and Technology (RHCyTE) was 14.3 % million, which represents an increase of 12% over the year of 2019. Of this total, 87.58% of people have undergraduate studies, 9.25% have graduate studies and 3.17% have technical studies. At the undergraduate level, there has been an increase in the number of women graduates. This gap has been narrowing from 2014 to 2022 exceeding the percentage of the male population by more than 7% (Universidad Nacional Autónoma de México [UNAM], 2023) (See Table 1).

Table 1. Percentage disaggregated by gender about graduates at the undergraduate level, 2014 to 2022.

Genders	2014	2015	2016	2017	2018	2019	2020	2021	2022
Women	50.1%	50.0%	50.3%	50.7%	51.1%	51.7%	52.6%	53.6%	53.8%
Man	49.9%	50.0%	49.7%	49.3%	48.9%	48.3%	47.4%	46.4%	46.2%

Source: (Table made by the authors with data from UNAM, 2023).

Something similar happens at the master's level where from 2014 to 2022 an increase in the percentage of women who graduated from this educational level is observed (see Table 2).

Table 2. Percentage disaggregated by gender of graduates at the masters level, 2014 to 2022.

Genders	2014	2015	2016	2017	2018	2019	2020	2021	2022
Women	54.2%	54.7%	55.4%	55.2%	55.3%	55.9%	57.2%	57.8%	58.4%
Man	45.8%	45.3%	44.6%	44.8%	44.7%	44.1%	42.8%	42.2%	41.6%

Source: (Table made by the authors with data from UNAM, 2023).

At the Ph.D. level, it is observed that from 2014 to 2022 there are more female graduates than male.

Table 3. Percentage disaggregated by gender of graduates at the doctoral level, 2014 to 2022.

Genders	2014	2015	2016	2017	2018	2019	2020	2021	2022
Women	48.6%	48.4%	48.3%	48.8%	49.7%	49.9%	50.5%	52%	52.3%
Men	51.4%	51.6%	51.7%	51.2%	50.3%	50.1%	49.5%	48.9%	47.7%

Source: (Table made by the authors with data from UNAM, 2023).

Although throughout history women have gained access to university, from 27% of the student body in 1977 to 52% in 2020 (Morales, 1989), there is a marked gender gap in careers that significantly affects their future (García & Torres, 2022). Within the careers offered at UNAM, we can appreciate this phenomenon,

for example, in 2018 of its 166 careers in the school system, in 58 careers, more than 60% of the population matriculated on these careers are trained by women, that is, there is a process of feminization (Centro de Investigaciones y Estudios de Género [CIEG], 2023; Coordinación General de Planeación y Simplificación de la Gestión Administrativa, 2023). This phenomenon is evident in Social Work degree programs, where the percentage of women exceeds 80%; it is also present in Nursing and Obstetrics, where women represent 73%; and in Psychology, where they account for 72% (Coordinación General de Planeación y Simplificación de la Gestión Administrativa, 2023). On the other hand, there are male-dominated careers where less than 47% of the population is represented by women (CIEG, 2023; Coordinación General de Planeación y Simplificación de la Gestión Administrativa-UNAM, 2023). For example, (1) in the Faculty of Engineering, the percentage of women is 25.9% while the percentage of men is 74.1%. (2) In the Faculty of Economics, the percentage of women is 31.5% while the percentage of men is 68.5%, and (3) in Applied Mathematics, the percentage of women is 18% while the percentage of men is 82%. Therefore, we can observe gender biases where such careers are masculinized. Likewise, it should be noted that as the academic career advances and, with it, the possibilities of accessing resources and spaces of power and decision-making, we observe that the process of masculinization continues to operate. In addition, there is always the possibility of dropping out of

school, which may be due to a variety of factors, thus affecting the possibility of entering the labor market in a negative way.

Regarding paid academic work, at the international level, there is a noticeable inequality that accumulates as there is an ascent to decision-making positions and access to resources. There are some researches, such as the work of Crimmins et al. (2023), Frederick et al. (2019), and Villa Lever (2018), that has demonstrated that inequalities in higher education are reinforced by overlapping social factors including race, ethnicity, and socioeconomic status, which create profound structural deprivation in both European and Mexican contexts. While we acknowledge that an intersectional methodology is a framework for addressing these intertwined asymmetries, this study focuses on gender disparities at UNAM as a foundational step.

Within the analysis of Higher Education Institutions (HEIs) in Mexico, particularly at UNAM, progress in the academic career in research is manifested by membership and advancement in the ranks of the National System of Researchers granted by the National Council of Humanities, Sciences and Technologies (CONAHCYT). The SNI levels include: Candidate, Level I, Level II, Level III and Emeritus. In 2020, 4,992 members of the National System of Researchers (SNI) of the UNAM were registered, of which 60% are men and 40% are women. At the Candidate level men represent 54% and women 46%; at Level I men represent 56% and women 44%, and Level II men have a representation of 62% and women 38%, Level III men represent 74% and

women only 26%. Thus, the so-called STEM careers (Science, Technology, Engineering, Mathematics) are masculinized (García & Torres, 2022) and, taking into account that on average they have higher incomes than other degrees, we can say that such masculinization contributes significantly to the wage gap shown in our country by gender (Avedaño et al., 2020). In many studies, there have been countless inequalities related to gender. Although some fields such as Psychology and Biology have had a greater participation of women and have been able to add gender perspective to their academic programs. Nevertheless, there are other areas such as Engineering, Physics and Computer Sciences that have a greater number of men in their academic enrollment. These disparities are even more meaningful when these fields of study intersect with historically vulnerable groups such as the community of LatinAmerica-women and AfroAmerican-descendants' women, who continue to be underrepresented among undergraduate and graduate students (Frederick et al., 2019).

Ottemo et al. (2021) describe in previous research related to gender bias that these gender inequalities have been more evident in areas such as Computer Engineering and Physics. Due to, STEM areas have justified these gender biases based on masculine attributes. This gender gap in STEM careers is expected to affect the economic future of women due to technological changes and automatization that are predicted in the medium term in the labor market (Organización para la Cooperación y el Desarrollo Económicos [OECD], 2018). As mentioned before, the

level of schooling is an important marker of inequality, economic vulnerability and propensity to violence according to the World Health Organization (ONU Mujeres México, 2020; WHO, 2021a, 2021b), where gender as a social organizer plays a fundamental role. Addressing this problem, the gender gap in different spaces, particularly in STEM career training, implies paying attention to access to training spaces, to conditions that challenge inequality, the economic gap and the propensity to gender violence, among other things. We must understand this to work within our context.

Unequal access to resources and academic training spaces are consequences of gender gaps in STEM. Universities must address this problem to build egalitarian spaces. The analysis process is complex, as it involves a historical, political and social context. Science has even served to legitimize such a process. This work focuses on providing a review of biologicism from a feminist perspective. Biologicist discourses explain the gap as the effect of a biological reality placed in sexual differences and operating in different biological *loci*, which materializes in the behavior and cognitive capacities of women, thus naturalizing a supposed sexual dimorphism that goes hand in hand with gender roles (Blazquez, 2008; Blazquez & Chapa, 2018; Ciccia, 2022). To analyze the problem described above, we consider that it is necessary to review the point of view of feminist epistemologies, which is presented in the next pages.

Biologicism and feminist epistemologies in STEM

Biologicist positions

There are numerous historical analyses that address the ways in which the modern institutionalization of science attempted to explain differentiated faculties by a dichotomous ideal of sex as a starting point for the exclusion of women and non-hegemonic subjectivities from formal scientific education and practice (Schiebinger, 2004; Maffia, 2007; Ciccia, 2022).

For reasons of space, and delimiting some examples within Biology, we observe in works ranging from the most important of Darwin (1968, 1981) to contemporary works, biological explanations that support the above. With Darwin, starting in the 19th century, biology began a particular way of approaching questions about sex, sexuality and the socio-affective behavior of human beings. This inaugurates an explanatory pattern that seeks to elaborate and answer the questions of sex and sexuality from the biological point of view where, in particular, it will seek to prioritize the role that natural selection and sexual selection had in shaping alleged behavioral and intellectual sexual differences between men and women (Cervantes, 2015; Guerrero, 2015).

One of the most widespread claims regarding the alleged differences between men and women and the underrepresentation and distribution of the latter in the sciences is the myth of male mathematical-rational and female verbal-emotional natures. Biological discourses have constantly emerged from

biology that serve a process of naturalization of inequality expressed in gender gaps; that is, they constrain complex, social, political, historical and disputed phenomena to mere effects of nature, and, in this case, of biology. They explain gender gaps as the effects of biological realities placed on the basis of sexual differences. According to this explanation, women are biologically less suited to the sciences, particularly the STEM sciences. Some of the claims about these alleged cognitive differences and intellectual abilities are summarized in the following Table 4.

Table 4. Summary of the alleged cognitive differences and intellectual abilities presented in different bibliographies consulted.

Author(s)	Publication's name	Men posture	Women posture
Darwin (1981)	The Descent of Man.	Higher mental faculties. Strong passions such as courage, bellicosity, increased energy, ambition, selfishness. like bravery, bellicosity, greater energy, ambition.	Lower mental faculties. Tender beings, unselfish, maternal, intuitive, with rapid perception and imitation capacity.

Benbow and Stanley (1983) Benbow (1988)	Sex differences in mathematical reasoning ability: More facts. (1983) Sex differences in mathematical reasoning ability in intellectually talented preadolescents: Their nature, effects, and possible causes. (1988)	Greater variability in intrinsic mathematical talent.	Less variability in intrinsic mathematical talent.

Gaulin (1992) Tiwari M. et al. (2023)	Evolution of sex difference in spatial ability. Wayfinding Strategies and Sense of Direction in Local Environment: Exploring Gender Differences.	Greater spatial orientation in men. Males use route and orientation strategies better than females depending upon context.	Verbal intelligence in girls.
Kimura (1996, 2002)	Sex, sexual orientation and sex hormones influence human cognitive function. Sex hormones influence human cognitive patterns.	When examining language spatial abilities and visual and tactile perceptual tasks, boys do better than girls in most cases. The cognitive systems of effective reasoning in mathematics are dominated by men.	Verbal memory, quick perception.

Szadvari & Jaroslava (2022)	Sex differences matter: males and females are equal but not the same.	The average male brain is designed to better connect sensory perception with motor activity.	The female brain is predisposed to link analytical and intuitive processing.

From the perspective of biologicism, biological causality, posited as a supposed human nature, has been thought of as mechanisms that operate from different biological loci (genetic, chromosomal, gonadal, hormonal and cerebral) that materialize in sexual differences at the behavioral level and in cognitive capacities between men and women.

In this work, we propose that in the case of Mexico at UNAM that some biologicist narratives and deterministics explanations circulated within discourses and public arguments through which the exclusion of women from certain public, educational and scientific institutions was justified and naturalized. We argue that the process of excluding women from scientific education must be addressed as a complex process dating back to the 19th and early 20th centuries, which includes the use of gender stereotypes and the construction of supposed sexual differences in arguments articulated with moral considerations, social expectations about gender and biologically deterministic explanations.

Given the studies such as González (2006), we know that scientific arguments were offered by the educational authorities to limit the study of science (González, 2006) to women, at a

time when science was being institutionalized in modern universities and, specifically, in Mexican institutions. The questions and debates among Mexican politicians revolved around the level of education that was deemed appropriate for women. These discussions were often resolved based on moral considerations, societal expectations regarding gender roles, and purported intellectual disparities between men and women. This was grounded in a sexual dichotomy that reinforced corresponding social distinctions.

Motherhood played an important role in justifying the role of women in society, which made it impossible for them to receive training in science. Thus, we can appreciate debates about decision-making in Mexican educational models during the 19th century as it follows: "I believe that if we reflect on the fact that these girls must later become mothers, whose mission is very delicate because they have to educate their children" (Debates del Congreso Nacional, 1889, pp. 227-228; as cited in González, 2006, p. 781).

In the same way, educational authorities such as Palavicini (1910), official of the Secretariat of Public Instruction and Fine Arts, argued in *Problemas de la Educación* that women had a biology that made scientific thinking impossible, "their lower intellectual capacity was due to the fact that their brains weighed less than men's" (Palavacini, 1910; as cited in González, 2006, p. 784).

In early twentieth-century education magazines it was recommended that women should not receive scientific training, because "the excess of scientific intuition attacks women's organism [...] anemia and neurosis take hold of them and the

children they have are weak and puny" (El Magisterio Nacional, 1905, pp 142-143). The above examples illustrate the use of positivist scientific narratives with sexist undertones in Mexico in the early 20th century, particularly in the realm of political decision-making. During that time, the idea that women lacked the biological capacity to participate in politics or assume leadership roles due to alleged innate differences between men and women was widespread. These beliefs, supported by positivist scientific approaches, had a significant impact on policies and decisions that restricted women's access to positions of power and participation in the public sphere. The situation started to change with the international feminist resistance and mobilizations, particularly the Mexican ones, by organizations, for example, the "Sociedad Protectora de la Mujer". Activists such as the teacher, writer, poet and defender of women's rights, Correa (1853-1924), strongly questioned that "nature" determined the conditions and capacity of women, "women have been confined to a position of inferiority and dependence on men, by social, not natural laws" (México Intelectual, 1903, p. 247, as cited in González, 2006). In the same way, Correa wrote during a critical moment of discussion regarding women's education in Mexico:

> Do not let yourselves be influenced by the traditional idea that science is harmful to women. Do not believe either that there is a single branch of science that is impossible to learn, as long as you want to study it, nor that it is possible

> to teach. (La Enseñanza Normal, 1905, p. 288, as cited in González, 2006)

Until the last decade of the 19th century, women in Mexico and Latin America managed to obtain their first university degrees. However, during the Mexican Porfiriato, these achievements were exceptional, as the State had barely implemented technical education programs aimed at lower-class women, with the goal of integrating them into the industry. The only other educational option available was training as teachers. The strong sexism of the time influenced the lack of social acceptance for women to choose liberal careers such as Law or Medicine; and, on less frequent occasions, they were allowed to study to become midwives (Mata, 2017).

Although Mexican women in the 20th century managed to access spaces of knowledge production, it is crucial to note that explanations alluding to a supposed feminine nature were never excluded from scientific discourse, just as political interests and context were never omitted from scientific narratives. While the context explaining the exclusion of women from universities is complex and requires a detailed analysis in each country, it is essential in this work to bring into view the circulation of sexist scientific narratives in the Mexican context. Addressing this aspect could provide additional elements for understanding current gaps in STEM fields in Mexico from a historically situated feminist perspective.

Interdisciplinary counterpositions with feminist epistemologies

Thanks to feminist analysis, biological deterministic explanations are now recognized as untenable from both the philosophy and history of natural sciences, as well as from biology itself (Guerrero Mc Manus, 2022). In this work, we argue that such explanations are insufficient for explaining gender gaps in STEM fields, particularly when these gaps are approached as historically situated phenomena. What are the elements of reflection that we propose from a feminist perspective for disassembling biological determinism in understanding gender inequalities and gaps in STEM areas within the Mexican context?

Maffía (2007) invites us to think that this type of explanation played a process that prevented the participation of subalternate communities, among them women, by impeding their participation in epistemic communities that constructed and legitimized knowledge and by expelling qualities attributed to "the feminine" in the epistemic space.

In the words of Schiebinger, they were part of a complex historical process based on the exclusion of women, first, from university spaces with the conformation of modern universities and second, with the assignment of supposedly feminine characteristics as opposed to the values of objectivity and reason necessary for the correct exercise of the sciences (Schiebinger, 2004). In this sense, rationality, logical capacity, capacity for abstraction and

ultimately, universality, the possibility of access to objectivity was attributed to a masculine ideal; while that which subtracted epistemic value for belonging to scientific communities, such as sensitivity, singularity and ultimately, subjectivity, was attributed to a feminine ideal. Both categories, dichotomous and mutually exclusive, Diana Maffia established a relationship between women and science as a forced conjunction of two categories historically defined (under androcentric thinking) not to unite (Maffia, 2007).

In more recent works such as "The invention of the sexes", Ciccia (2022) explains in a very schematic and clear way the ways in which the dichotomization of sexed bodies, together with their assignment in cognitive roles according to gender and under the view that the mind is located in the brain, is understandable more as a result of a historical process in dispute of powers than as an effect of given biological realities.

It explains a historically mobile sexual difference that played a fundamental role in the process of dichotomization of sexed bodies and in the assignment of cognitive roles in an exclusive and hierarchical way, which in the eyes of neuroscience, biology and the philosophy of cognitive sciences, would be unsustainable. Ciccia recognizes the project of modern science as a process where social dichotomy is projected onto bodies as sexual dimorphism (Ciccia, 2022, p. 41). In this same sense, the work of Richardson's (2010) points out that androcentric biases and the dominant forms of knowledge production put women at a disadvantage in the sciences and philosophy. To which we

would add that it is precisely the current forms of these biases in their cis-hetero-sexist version that should be brought to the explanation of the gender gaps in STEM when talking about the current exclusion mechanisms at play within some scientific spaces both for women and for people of gender diversity.

Richardson (2010) presents the arduous path involved in establishing new ways of establishing scientific explanations and promoting educational developments of non-hegemonic communities. The inclusion of these communities is not enough, for example, women's access to science does not imply the exercise of science with a gender perspective or feminist science, which is necessary to establish critical perspectives in the face of explanations that reiterate and justify inequality.

The elements of reflection that we propose from a feminist perspective to dismantle biological determinism in understanding the gender gaps in STEM areas in Mexico are primarily, though not exclusively, aimed at initiating reflection within scientific communities where beliefs linked to stereotypes and gender roles about the limited presence of women in these areas still prevail. This perspective could have a positive impact on the processes of mentoring, teaching, awareness, and training of all members of academic communities, and additionally, catalyze the processes to incorporate the gender perspective in STEM areas in a cross-cutting manner. These processes are still in the process of consolidation, at least in Mexico.

Conclusions

This work presents different points of view related to gender division jobs in science and the importance of gender roles to explain these phenomena in STEM areas and in society in general. Those are the first steps towards attention to analyze the problem related to gender stereotypes, and gender bias, also to examine their direct and collateral effects.

In recent decades, the supposed biological and psychological differences between men and women were defended as natural and inevitable, which shows the role that science has played in the process of naturalization of gender inequalities in STEM science education.

When explanations occur that naturalize complex social conditions, the warnings from the philosopher Caponi can occur:

> Naturalization can promote conservative attitudes and can contribute to legitimizing the status quo, which in addition to being undesirable and unfair, would also be unchangeable [...] to the extent that naturalization can result in some form of legitimation, critical thinking must always seek to distort what wants to impose itself as ineluctable. (Caponi, 2018, p. 188)

In a critical sense, the philosophical relevance of questions about gender and science, of the feminist philosophy of science, goes beyond the identification and diagnosis of gender bias in different areas of science and philosophy (Richardson, 2010). Its usefulness must do, above all, with the approaches that are generated from there, in addition to the original, inclusive and challenging questions about science, and in this case, about the gender gaps that we find in technosciences.

In this way, what is privileged in the feminist perspectives, and that we rescue in this work, is the recognition of the existence of sociocultural and historical processes and relevant social normative categories in the scientific and university communities.

The research argues that dismantling these biases is not just an academic exercise, but a necessary step for social justice in Mexico. Some of the proposals, given the context in STEM areas, are: (1) to eliminate the "occupational division" (the idea that women are naturally better suited for care roles and men for technical/STEM roles), women can access high-growth, higher-paying sectors. Dismantling the bias that men are "naturally" more competent in STEM helps ensure equal pay for equal work; (b) mitigating vulnerability to violence in an academic environment, i.e. changing the "hegemonic masculine" culture in STEM classrooms to reduce the symbolic and structural violence that often pushes women out of these careers; (c) give women more representation and leadership in these fields, the power dynamics shift, making it harder for cultures of harassment or

exclusion to persist, and (d) adding gender perspective to our institutional public policy reforms to reglamentations, guides and protocols in Superior Educational Institutions like the UNAM, to create support systems that treat gender inequality as a structural problem to be solved, rather than an inevitable biological fact.

The exclusion processes can be varied, they can be understood as forms of exercise of gender violence, as long as it is mediated and mediating hierarchical exercises of power that constrain access to spaces, rights (such as education), and resources of certain communities; while privileging others. Works such as that of Cerroni and Simonella (2012) and Ortman (2016) have shown that the exclusion process can be an effect of symbolic violence in STEM areas. Mexican feminist philosophers have already pointed out that the participation and incorporation of women and, we will add, the new policies linked to a culture of inclusion and diversity in STEM areas, occur simultaneously with different forms of exclusion still present in academic circles, from education up to the highest positions of power in the scientific structure (Blazquez, 2008; Cerroni & Simonella, 2012; Ortmann, 2016). In particular, discrimination and gender bias have been important components in identifying the exclusion of different vulnerable groups such as women, who have been assumed in the different knowledge production spaces such as classrooms, laboratories, seminars, etc. These forms of exclusions must be eliminated at all levels in formal education, in particular in higher education spaces, including UNAM, from where we have been doing our latest

work. In the same way, it is extremely important to establish the bases to teach with a gender perspective and with feminist epistemologies in the field of biology and in general in STEM sciences.

Feminist epistemologies constitute critically relevant tools for addressing these issues; however, we are aware of the need to incorporate intersectional analyses into scientific education globally, but especially in countries like Mexico (see "Future Work" section).

These analyses can address previously identified issues such as the underrepresentation of women from racial or ethnic minorities in STEM education, which has been recognized as a fundamental problem in global scientific education processes (Riegle-Crumb & King, 2010; Ong et al., 2011, as cited in Frederick et al., 2019).

In the scientific education provided by Mexican universities in general, and particularly within the Faculty of Sciences at UNAM, research aimed at addressing the gender gaps in STEM areas continues to be relevant for gender studies, especially when it brings into view the historical, sociocultural and institutional levels of analysis. Similarly, these processes still constitute a relatively unexplored field and therefore hold great potential for future research that could also benefit from a situated feminist perspective, capable of finely weaving observations of problems that affect realities as diverse as those found in Mexico.

Futu work

The next step of this work is to study the case of the Faculty of Sciences of the UNAM, in the interest of identifying, naming, and finding some strategies to eliminate gender inequalities, gender stereotypes, inequality salaries, and gender bias in science areas, it should be able to attend and to eliminate all those forms of gender violence in the Mexican context of Higher Education Institutions at the undergraduate level: Science School at UNAM.

Building upon the findings of the present study, we suggest that one of the future researches formally could adopt an intersectional methodology. This shift will allow us to investigate how gender gaps at UNAM are exacerbated by other factors such as socioeconomic status, geographic origin, and ethnicity, providing a more granular understanding of exclusion in Mexican STEM education. Besides, another possible line of future research would be to conduct this same type of analysis with members of the LGBTIQ+ community and compare the data obtained. Furthermore, the research could be framed within a relational methodology to identify other categories that could enrich this type of study.

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