Women's participation in science and technology: Analysis undertaken in Guanajuato, Mexico

Participación de la Mujer en Ciencia y Tecnología. Análisis en Guanajuato, México

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Abstract

Objective: To analyze the participation of women scientists in the state of Guanajuato (Mexico) using data from National System of Researchers (SNI, in the Spanish acronym) of the National Council of Science and Technology of Mexico for the years 2014 and 2015 **Method:** A descriptive research methodology was followed; documentary analysis was conducted for primary and secondary information sources. **Results:** It was found that the male–female ratio of SNI members in the state of Guanajuato is lower than the national average. Only 25.7% of the researchers registered in the SNI in the state in 2014 were women; in 2015, this figure increased to 26.38%, still well below the 35.36% at the national level. With regard to the knowledge domain, it was found that in the fields of biology and chemistry the ratio was more in the number of registered female researchers, with respect to the number of male researchers. **Discussion:** Science is a key factor in the development of nations, and gender equality should be fostered in this arena; however, this is far from the situation in the state of Guanajuato. **Conclusion:** It is evident that there has been progress regarding the positioning and recognition of women in the scientific field in Guanajuato (Mexico). However, this progress has been slow and incomplete because of the existence of invisible barriers blocking the promotion of women in science in higher education institutions, in addition to the second work shift involving domestic tasks that women perform daily and which often take the time and energy they could spend on scientific activities.
Keywords: science, technology and innovation; gender gaps, women scientists
JEL classification: J16, O32, O34, O54.

Resumen

Objetivo: analizar la situación y participación de la mujer Científica en el estado de Guanajuato (México), teniendo en cuenta los datos del Sistema Nacional de Investigadores (SNI) del Consejo Nacional de Ciencia y Tecnología de México (CONACYT) para los años 2014-2015. **Método**: La investigación es de alcance descriptivo, fundamentado en análisis documental de fuentes de información primarias y secundarias. **Resultados**: Se encontró que la proporción hombres-mujeres miembros del SNI en el estado de Guanajuato es inferior a la media nacional. Solo 25.7% del registro de investigadores del estado registrados durante 2014 en el SNI, eran mujeres y para 2015 incrementó a 26.38%, todavía muy por debajo del 35.36% en el país. Respecto al área de conocimiento se halló que en el área de Biología y Química es donde se registra una condición más equitativa del número de investigadoras mujeres, respecto al número de investigadores hombres. **Discusiones:** La ciencia al ser un factor clave para el desarrollo de las naciones, debiera gestarse en condiciones de igualdad de género, situación que se encuentra lejos de existir en el estado de Guanajuato **Conclusiones**: Se evidencia que sí ha existido un avance respecto al posicionamiento y reconocimiento de la mujer en el ámbito científico en Guanajuato (México), sin embargo, éste avance ha sido lento y se encuentra incompleto, lo cual obedece, entre otras cuestiones, a la existencia de barreras invisibles para su ascenso dentro de las Instituciones de Educación Superior, además de la segunda jornada "doméstica" de trabajo que la mujer realiza a diario y le resta muchas veces tiempo y energía para dedicarse, a actividades científicas.
Palabras clave: ciencia, tecnología e innovación; brechas de género, mujer científica.

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Introduction

Etzkowitz, Kemelgor, Neuschatz, and Uzzi (1992) noted that science is largely organized based on a male approach that excludes and undervalues women. Anlló (2017), similarly, states that only 28% of researchers in the world are women and that the percentage of women in STEM (Science, Technology, Engineering and Mathematics) is even lower.

The historical examples of Hypatia in antiquity and Trotula of Salerno or Hildegarda of Bingen in the Middle Ages show that women have time and again been able to overcome the stereotypes attributed to their sex and strengthened their positions in male-dominated fields of rigorous knowledge generation. Women have been actively involved in every scientific field recognized today and have served as key role models in the disciplines in which they have worked.

The cases of Cecilia Payne, Rosalind Franklin, and Joselyn Bell, who were in one way or another deprived of the merit of their findings and discoveries, or at least disregarded in terms of the impact of their contributions by their male colleagues, bring to our attention the adverse conditions under which their work has historically developed, even in instances of demonstrable ability and talent. Schiebinger (2000) points to the bad reputation that the term "feminism" has garnered over time, but she mentions that it is thanks to feminists that several influential studies have begun to be made public and in which women's contributions had previously been completely omitted.

Therefore, this study's aim was to analyze women scientists' situation and positioning in the state of Guanajuato, Mexico, from 2014 to 2015, based on data from the Registration in the National System of Researchers (SNI) of the National Council of Science and Technology (CONACYT), and to identify the areas of knowledge and the levels women hold within this system.

The study introduces some theoretical and contextual approaches to perspectives on gender and discrimination in Mexico, defining the terms and illustrating the legal frameworks that exist in this regard. This is followed by the concepts that have been applied to the specific context of the study, which is the state of Guanajuato in Mexico and also the realms of science and technology. Next, the research results are presented, with supporting tables and graphs, followed by a discussion of the results, and, finally, the study conclusions.

The decision for selecting the state of Guanajuato for this study was informed by the recent creation of the Guanajuato State Innovation System (SIEG, in the Spanish acronym) and the Secretariat for Innovation, Science and Higher Education (SICES, in the Spanish acronym), initiatives approved and enacted in December 2015 by the 63rd constitutional legislature of the state of Guanajuato (Official Gazette of the Government of the State of Guanajuato, 2015). In addition to the increasing importance of this state at a national level, for example, the gross domestic product (GDP) of this entity in 2015 was 4.3%, ranking sixth in the country. Furthermore, there were 258,747 economic entities or businesses that year, representing 5.1% of the total in Mexico. Guanajuato is a state that is undergoing major development and because of its privileged geographical location, it has become a strategic place for foreign investment (Ministry of Economy, 2016).

Theoretical background

Gender perspective and discrimination in Mexico.

There have been varied discussions on the issues of gender-based discrimination and inequality. At the international level, the Convention on the Elimination of All Discriminatory Practices against Women (CEDAW) was adopted in 1979 and has since become an international treaty.

While there has been a shift in gender stereotypes since the second half of the 20th century, there are still many challenges ahead, and the workplace is no exception, as many practices that foster inequality are still found in this area. According to Horbath and Gracia (2014), "Behavior can be discriminatory in the labor market when employers or workers treat individuals differently in the process of recruitment, performance, and promotion" (p. 466).

Differential treatment in this case is assumed to be based on sex (male or female) or gender (feminine or masculine). An individual is assigned their gender at birth, and gender socialization happens in one's family, school, and other institutions and is reinforced throughout life by the conditioning of rules, norms, messages, and social discourse. One of the characteristics of this classification is that it is consistent with social roles and stereotypes that pigeonhole the activities and identities of men and women (National Women's Institute, 2008).

Several studies show that discriminatory behaviors are rooted in many prejudices, which are deeply rooted and difficult to change. However, Zabludovsky (2007) asserts that:

> Beyond these cultural patterns, there is a need to consider other factors at a more specific level of what we might call organizational culture, where the different characteristics of the feminine and masculine are often reproduced exponentially (p. 26).

On the other hand, Castro and Vázquez (2008) stated that:

> […] The core attribute of gender-based violence is that it is violence perpetrated against women because of the fact that they are women. These are specific forms of violence (emotional, physical, sexual, economic) that are based on the structures of gender inequality and legitimized by a set of norms and beliefs that define women as being subordinate to men. When such perceptions have been incorporated in the form of a habit, the conditions are provided to reproduce this violence in the form of symbolic violence; in other words, to obtain women's unconscious complicity in perpetuating the social project of domination that subjugates them. (p. 589)

In Mexico, there is an extensive legal framework that promotes equality and non-discrimination, including gender discrimination. The Political Constitution of the United Mexican States, Article 1, prohibits any discrimination based on ethnic or national origin, gender, age, disability, social and health status, religion, opinions, preferences, marital status, or other grounds that violate the dignity of persons. Similarly, Article 4 establishes equality between men and women before the law, and Article 123 establishes that equal wages shall be paid for equal work, regardless of gender or nationality (Political Constitution of the United Mexican States, 2018).

Moreover, the Federal Labor Code (2012, Art. 4) provides that work shall be provided and performed under conditions that ensure life, health, and a decent economic level for the worker and their family, without making distinctions among workers on the basis of race, age, religious belief, political doctrine, or social status. Similarly, the Federal Law on the Prevention and Elimination of Discrimination (2018, Art. 1, Part III) establishes that discrimination shall be understood as

Any distinction, exclusion, or restriction based on ethnic or national origin, gender, age, disability, social or economic status, health status, pregnancy, language, religion, opinion, sexual preference, marital status, or any other grounds which has as an effect of preventing or annulling the recognition or exercise of rights and the effective equality of opportunity for persons.

In turn, Article 2 of the same law provides that the State shall promote the conditions for the freedom and equality of persons to be real and effective. Further, Article 9 mentions that the following are discriminatory practices: prohibiting the free choice of employment or limiting the opportunities of access; permanence and promotion in it; and establishing differences in remuneration, benefits, and working conditions for equal work.

Moreover, the General Law on Women's Access to a Life Free of Violence (2018, art. 10) defines workplace violence as that which:

> is perpetrated by persons who have an employment, teaching or similar relationship with the victim, regardless of the hierarchical relationship, consisting of an act or omission abusing power and thus damaging the victim's self-esteem, health, integrity, freedom, and security and hinders his or her development and violates equality [...].

Similarly, Article 11, affirms that workplace violence is:

> The unlawful refusal to hire the victim or to respect their permanence or general working conditions; the disqualification of the work performed, threats, intimidation, humiliation, the behaviors referred to in the Federal Labor Law, exploitation, the prevention of women from availing the breastfeeding period provided for by law, and all types of discrimination based on gender.

Similarly, according to the General Law for Equality between Men and Women (2018, art. 5, no. III), discrimination against women is understood as:

> Any gender-based differentiation, exclusion, or limitation that has the effect of impairing or annulling the recognition, enjoyment, or exercise of human rights and fundamental freedoms in the political, economic, social, cultural, civil, or any other sphere, regardless of the woman's family status.

The Mexican Official Standard, NMX-R-025-SCFI-2015, establishes the requirements for the certification of practices for labor equality between men and women.

> This sets forth the requirements for public, private, and social workplaces, of any activity and size, to integrate, implement, and execute within their management and human resources processes practices that foster labor equality and non-discrimination favoring the comprehensive development of workers. Its purpose is to establish the basis for the public recognition of workplaces that evidence the adoption and compliance with processes and practices in favor of labor equality and non-discrimination (National Women's Institute, 2015).

According to the Mexican Ministry of the Interior, this standard is a voluntary mechanism whereby workplaces that have practices in the area of labor equality and non-discrimination are recognized for promoting the integral development of workers.

The Federal Public Administration in the National Development Plan (PND) 2013–2018 had a cross-cutting gender equity strategy that was reflected in the plans of each government agency. For example, Goal 3 of the PND: Mexico with Quality Education, considered the transversal nature of the gender perspective, by mentioning that one of the goals is the promotion of women's participation in all fields of knowledge, especially in science and research. It is important to mention this because the period analyzed in this research corresponds to this six-year period.

During the same period, the Gender Equity Model (2003–2015) was implemented in Mexico. It was conceived as a tool for work centers to commit to reviewing their internal policies and practices, reorganizing and defining mechanisms to incorporate the gender perspective, and implementing affirmative action in favor of personnel, so that in the short and medium term there would be equitable conditions for women and men in their workplaces. The main actions of this model were based on promoting work-life balance; recruiting and selecting staff on the basis of equal opportunities; promoting training and professional development; improving the physical conditions of workplaces to ensure healthy work environments; preventing and addressing sexual harassment; remedying problems of occupational segregation; and increasing the number of women in senior management and equal pay.

At the federal level, the National Women's Institute has been operating since 2001 with the general goal of promoting and fostering conditions leading to non-discrimination; equal opportunities and treatment among genders; and the exercise of women's rights and their equal participation in the country's political, cultural, economic, and social life.

In the current federal government, the gender perspective is identified in the National Plan for Development (2019–2024) in Section III of the Transversal Axis, specifically in the first entitled "Gender Inequality, Discrimination, and Exclusion of Population Groups for Various Reasons," which outlines the recognition of several inequalities due to different causes, including sex and gender, and which provides for the planning, design, implementation, monitoring, and evaluation of policies, programs, and actions in all sectors, fields, and territories from a gender, non-discrimination, lifecycle, intercultural, and territorial development perspective.

In 2001, the Women's Institute of Guanajuato (IMUG) was created with the aim of coordinating actions necessary to create equal conditions for women's equality and participation in different state areas, including the fields of science and technology.

The 2035 Guanajuato State Development Plan for the six-year period 2012–2018 consists of four dimensions: 1) Human and Social, 2) Public Administration and Rule of Law, 3) Financial, and 4) Environmental and Territorial. Science and technology and gender equality are under the first dimension: both human and social areas, incidentally, are completely unrelated (Secretariat of Social and Human Development, 2012).

Similarly, in the State of Guanajuato's Development Plan 2040 for the current six-year period, 2018–2024, there is a strategic action plan titled "Science, Technology and Innovation," which seeks to

"consolidate the development of science, technology, and innovation as engines for the economic and social development of the entity" (Institute of Planning, Statistics and Geography of the State of Guanajuato 2018, p. 40) and another strategic plan titled "Employment and Competitiveness," whose first goal is "to promote quality, inclusive and well-paid employment, with training and skills for employability, with equal opportunities for women and men" (ibid., p. 37). Thus, as in the case of the previous government plan, the subjects are present but in a disconnected manner.

Like the federal government, the state government is undergoing a period of change in which some policies for the promotion of science and technology and the search for gender equity have been readjusted but in a disconnected manner. An example of this is the recent modification of the Law on Women's Access to a Life Free of Violence for the State of Guanajuato (POGTO, 2018), approved by the sixty-third Constitutional Legislature of the Congress of the State of Guanajuato.

With regard to the exclusive theme of science and technology, the Education Sector Program 2013–2018, at the federal level, had as one of its objectives the promotion of scientific and technological education as an essential element for the transformation of Mexico into a society of knowledge, taking into account for its achievement two types of gender-related strategies: the Transversal Strategy 3 named "Equal Opportunities and Non-Discrimination against Women" and "The Strategy to Improve the Management of the Education Sector 2," with the aim of promoting gender and human rights planning and evaluation processes in the education sector. It is worth mentioning that the current federal government (2019–2024) has not yet made public its program for the education sector, and the last amendment to the Law on Science and Technology (still in force) was in 2015, and one of its policies provides as follows:

Promoting the inclusion of the gender perspective with a transversal vision in science, technology, and innovation, as well as the equal participation of women and men in all areas of the National System of Science, Technology, and Innovation. (Art. 2, 2015, Fraction III)

Similarly, article 12, section V provides that:

> The policies, instruments, and criteria with which the Federal Government promotes and supports scientific research, technological development, and innovation should seek the greatest beneficial effect of these activities on the teaching and learning of science and technology; on the quality of education, mainly higher education; and on the link with the productive and service sectors. It should also encourage balanced participation without discrimination between women and men and develop new generations of researchers and technologists.

Since 2019 and following the government change, the proposal has been initiated for the Law on Humanities, Science and Technology, which repeals the aforementioned Law on Science and Technology; however, there have been objections to the initiative for various reasons. A major criticism is that experts

in the field were not consulted during its elaboration (Consultative Forum Scientific and Technological, 2019).

These institutions, plans, programs, and past and present regulatory frameworks prove that, at least in discourse, some preventive and corrective measures have already been taken to avoid discrimination and achieve gender equality in the field of science and technology. However, there is a disconnection between the two issues, in addition to the fact that their outcomes are still far from reality; such a situation is seldom seen and is due to the government change that took place in December 2018.

As mentioned at the onset, the university environment, especially in the development of science and technology, is no stranger to gender myopia, so we believe that it is imperative for the Honorable Congress of the State of Guanajuato to link the issues of gender equality and equity with science and technology because there is no common bridge between the Commissions for Education, Science, and Technology and the Commission for Gender Equality. A clear example is the recent modification of the Law for the Promotion of Scientific Research, Technology, and Innovation in the state of Guanajuato (POGTO, 2015, 2017), in which there is no reference to the gender perspective or the principle of gender equality.

In this regard, Pietri, Johnson, and Ozgumus (2018) believe that the existing gender gap in STEM is not intentional or deliberate but is often automatically and unknowingly perpetrated by both women and men; however, whether intended or not, this gap exists and needs to be closed.

Further, Strauss, cited in Valls (2008), conducted a study comparing 31 universities in 16 different countries, concluding that there is a trend for young and highly educated women to experience gender-based violence. This can be linked to the so-called "Matilda effect," a term coined by Margaret W. Rossiter, which refers to the principle of discrimination, lack of recognition, and even denial that women have historically experienced in the field of science. It is called the "Matilda effect" or the "Harriet-Matilda effect" in honor of two famous women: Matilda Joslyn Gage and Harriet Zuckerman (Rossiter, 1997).

For women, access and recognition in science begins when they pursue professional studies, specifically postgraduate studies (Rossiter, 1997); this is because they face the so-called "glass ceiling," a term referring to the barriers that exist for the upward mobility of women in their professional lives (Guil, 2008).

In this regard, Seetles, O'Connor, and Yap (2016) in a study of female STEM students found that the relationship between a negative academic environment and women's lack of identity as scientists affected their psychological well-being. They concluded that women in STEM should have good gender identification with scientific work, which can be facilitated by creating networks for women in STEM, conceived from the educational system, while working simultaneously to reduce sexism and improve the academic climate.

The UNESCO (2017) recognizes the gender gap by stating that:

> Despite significant efforts over the past decades to reduce the gender gap in science, technology, engineering, and mathematics (STEM) education, large inequalities still persist (Parr. 1).

To reduce this gap, the United Nations General Assembly declared that February 11 is the International Day for Women and Girls in Science, aiming to achieve equal access and participation in scientific activities, arguing that "science and gender equality are critical in achieving the Sustainable Development Goals" (UN, 2018).

According to Vessuri and Canino (2006, pp. 23–24), some of the indicators that are discussed at the international level when analyzing the women–science–technology triad are as follows:

1. The number of women trained as scientists and technologists and their participation in research activities.
2. Horizontal segregation refers to the polarization level or concentration in scientific fields and institutional sectors.
3. Vertical segregation is related to the mobility of women in the scientific-technical hierarchy.
4. Fairness and success rates aim to determine whether women are receiving funding at the same rate as men and whether they are proportionately represented in project funding and in leadership and decision-making positions.
5. Stereotypes in science are an indicator associated with the stereotypes of scientific roles and the measures that counteract them.
6. Analyzing the working conditions of men and women in industrial research, occupational, and sectoral segregation and the underrepresentation of women in scientific and technical occupations.

In such a case, it would be appropriate to carry out applied research taking into consideration these six indicators. However, Daza and Pérez (2008) criticize these six metrics and argue that we need to approach the issue from a different angle because the traditional metrics privilege androcentric ways of conducting science, thus requiring a rethinking of the questions and goals with which metrics are traditionally constructed.

As argued throughout this study, the path to equality in science and technology has not been an easy one. According to Montoya (2010), the recognition and exercise of women's social, cultural, and economic rights, including the right to work, has been progressive and possible thanks to the results of prolific social

and academic movements in different sciences and disciplines, which have required inclusion and advocated for equal treatment between men and women, as well as for differential considerations based on gender. (p. 258)

Since the 1980s, several movements began in Mexico to recognize the role of women in science. Pérez (2010) states that the first of these was the Group for Women in Science (GPMC), which managed to create the first program to promote the inclusion and participation of Mexican women in science. Shortly thereafter, the Group of Women in Science in the Physiology Area (GMCF) was formed, and later, at the end of the 1980s, women from other fields of knowledge joined the movement and the Mexican Association of Women in Science was founded with the goal of "stimulating the participation of women in science in Mexico and promoting the professional development of Mexican women scientists" (p. 45).

In addition to the aforementioned groups, there are also several research networks interested in gender studies. These include the thematic networks of CONACYT, the regional and national collaborative networks of ANUIES (National Association of Universities and Higher Education Institutions), and the collaborative networks of academic institutions of PRODEP (Teacher Improvement Program of the Ministry of Public Education).

All these movements have succeeded, over the course of three decades, in driving women to organize themselves with the determined goal of making the work of women scientists in Mexico visible through forums, meetings, publications, and other academic and scientific activities. Although many of them have disappeared because of a lack of financial resources or other difficulties, the interest of Mexican women scientists in achieving equality in their professional activities has not.

Women, Science and Technology in Guanajuato

According to United Nations Development Program (UNDP, 2014), Guanajuato ranked eighth nationally in terms of the Gender Inequality Index (GII) in 2012, with 0.369. This index indicates lost health, empowerment, and labor market achievements with regard to gender inequality. The figure is close to 0 when development prospects are equal and it is close to 1 when women's disadvantages increase compared to men. Although this index seems encouraging, reality is far from it.

Guanajuato has at least 15 higher education institutions and 8 research centers, including the Center for Research and Advanced Studies of the National Polytechnic Institute (CINVESTAV); the National Institute of Forestry, Agricultural and Livestock Research (INIFAP); the Center for Research in Mathematics (CIMAT);

the Center for Research in Optics (CIO); the University of Guanajuato; polytechnic universities; and technological universities.

As mentioned above, the SICES of the State of Guanajuato was created by means of a decree on December 29, 2015, and it is the agency responsible for promoting improvement through planning; programming; developing; promoting; and evaluating higher education, science, technology, and innovation and their connection with productive sectors.

There are also other regulations that promote science and technology in the state. These include SIEG; the State Government Plan 2012–2018 and its Comprehensive Plan 2035; the Science and Technology Plan of the State of Guanajuato (PCITEG) 1998–2020; the State Science and Technology Program of Guanajuato (PECYT GTO) 2030; and the State Program for the Dissemination of Science and Technology 2013–2018 (Scientific and Technological Advisory Forum, 2014).

What is revealing about the problem under analysis herein is the lack of a cross-cutting policy on gender equality in these institutions and programs despite, on the one hand, the increasing presence of women in science and technology, as we will see below, and, on the other hand, the cross-cutting policy on gender equality stemming from the current National Development Plan or international recommendations for integrating this subject, such as those of UNESCO (2017) and the UN (2018).

As per Bonder (2004), if committed to promoting the economic and cultural development of societies through science and technology, it is essential to recognize that these are shaped and moved according to the needs, experiences, contributions, and visions of both genders. Therefore, to define the priorities and approaches of a program or scientific-technological policy oriented towards development, as well as for its execution, it is essential to integrate the resources and social capital of women and men (p. 30).

Method

The research is descriptive, quantitative in scope, and cross-sectional in a period of one year. It was based on documentary analysis of information sources and primary and secondary databases. To obtain the databases from the National System of Researchers (SNI), the Mexican National Institute for Access to Information (INAI) was used through the National Transparency Platform, through a request with Reference No. 2016005983 specifically addressed to the National Council of Science and Technology (CONACYT). Analysis was conducted 100% of the total population of the database provided, which included 21,358 participants for 2014 and 23,316 for 2015.

There were three main study variables—gender, level in the system, and area of knowledge—which were analyzed first per country and then for the state of Guanajuato. All the variables were treated as independent variables. The information was analyzed using the software SPSS, version 25, through basic descriptive statistical measures.

Results

One of the most widely used science and technology indicators in Mexico is SNI membership, and it was with this indicator in mind that this study analyzed the databases of this organization.

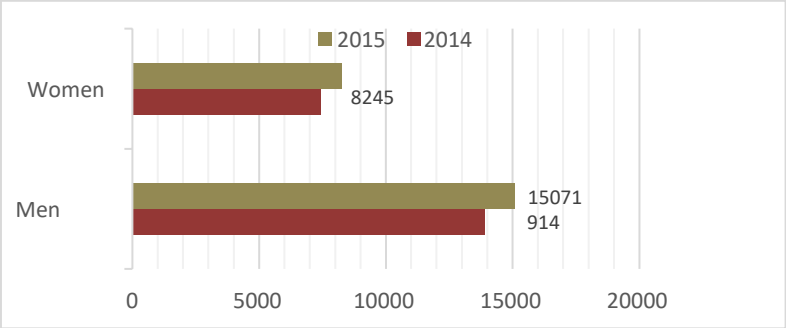
In 2014, it was found that there were a total of 21,358 researchers nationwide who were members of the SNI, out of which 13,914 were men and 7,442 were women. In 2015, the system had a total of 23,316 researchers, of which 15,071 were men and 8,245 were women.

Table 1. *SNI Members in Mexico, 2014–2015*

Year	Men	Women	Total
2014	13914	7442	21358
2015	15071	8245	23316

Source: Prepared by the authors based on CONACYT (2016).

Graph 1. *SNI Members in Mexico, 2014–2015*



Source: Prepared by the authors based on CONACYT (2016).

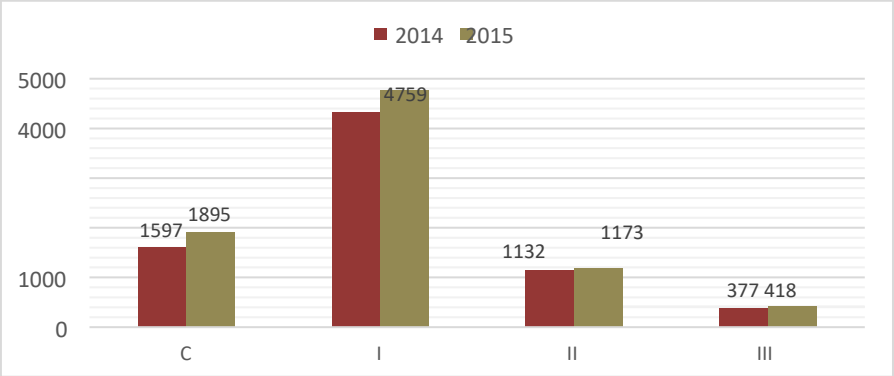
In 2014, 34.84% of SNI members were women. By 2015, the figure increased to 35.36%, that is, percentage-wise, an increase in 803 women admitted by the system represented a 0.52% progress in numerical equality among researchers recognized by the SIN

Table 2. *Level of women in the SNI in Mexico, 2014–2015*

Level	2014	2015
C	1597	1895
I	4336	4759
II	1132	1173
III	377	418
Total	7442	8245

Source: Prepared by the authors based on CONACYT (2016).

Graph 2. *Level of women in the SNI in Mexico, 2014–2015*



Source: Prepared by the authors based on CONACYT (2016).

It can be seen in the graph that the level most held by SNI women researchers is Level I, followed by Candidate level and then Level II.

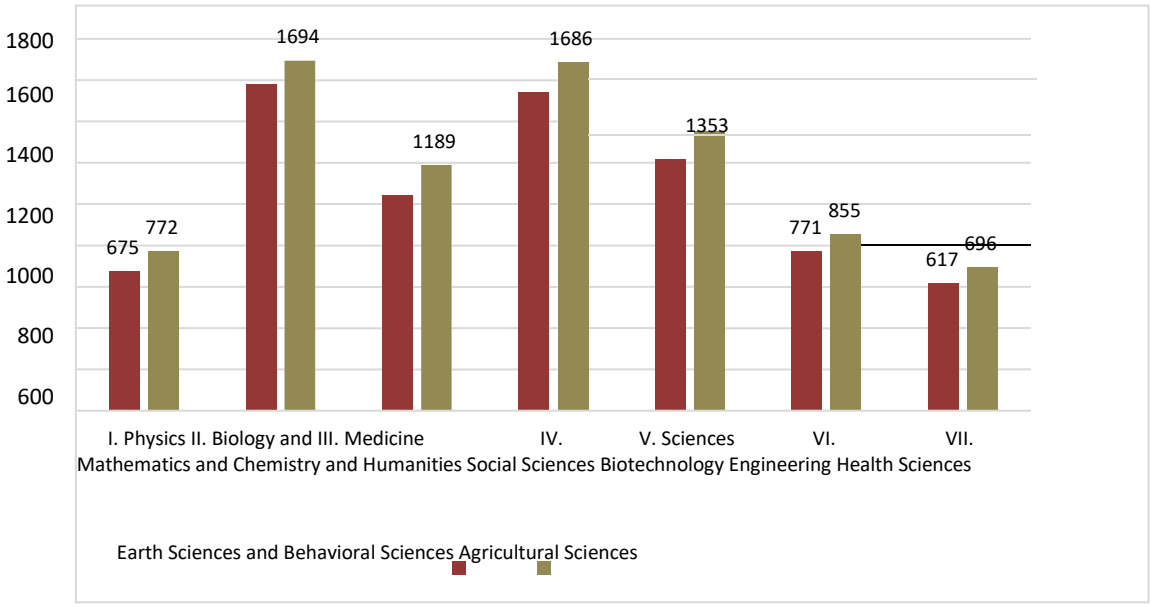
Table 3. *Areas of knowledge of women in the SNI in Mexico in 2014–2015*

Area	2014	2015
I. Physics, Mathematics, and Earth Sciences	675	772
II. Biology and Chemistry	1580	1694
III. Medicine and Health Sciences	1042	1189
IV. Humanities and Behavioral Sciences	1539	1686
V. Social Sciences	**1218**	**1353**
VI. Biotechnology and Agricultural Sciences	771	855
VII. Engineering	617	696
Total	7442	8245

Source: Prepared by the authors based on CONACYT (2016).

Regarding the area of knowledge in which more women in the country are recognized by the SNI, we find Area II, Biology and Chemistry; followed by area IV, Humanities and Behavioral Sciences; and in third place, Area V, Social Sciences.

Graph 3. *Areas of knowledge of women in the SNI in Mexico, 2014–2015*



Source: Prepared by the authors based on CONACYT (2016).

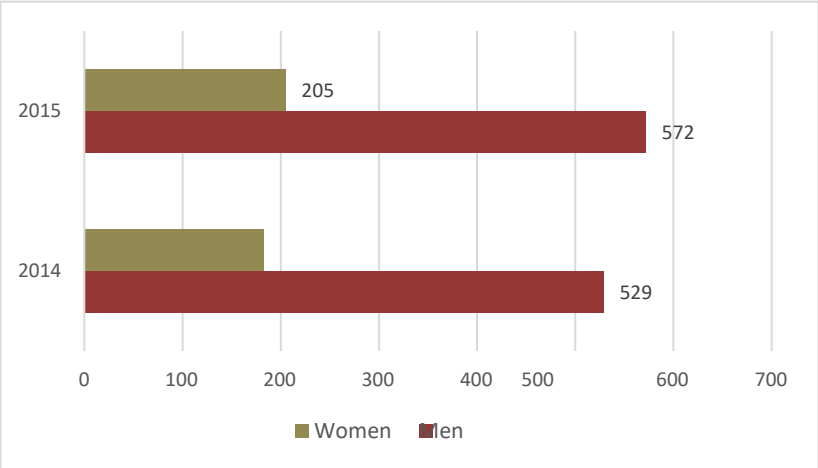
In the state of Guanajuato, the male-to-female ratio of SNI members is significantly lower than the national average. Only 25.7% of the state's researchers registered during 2014 in the SNI were women (compared to 34.84% registered in total at the national level). In 2015, it increased to 26.38%; although it is still well below the 35.36% at the country level, with a 0.68% progress towards numerical equality, it is slightly higher than the progress in the national indicator which was only 0.52%.

Table 4. *SNI Members in Guanajuato, 2014–2015*

Year	Men	Women	Total
2014	529	183	712
2015	572	205	777

Source: Prepared by the authors based on CONACYT (2016).

Graph 4. *SNI Members in Guanajuato, 2014–2015*



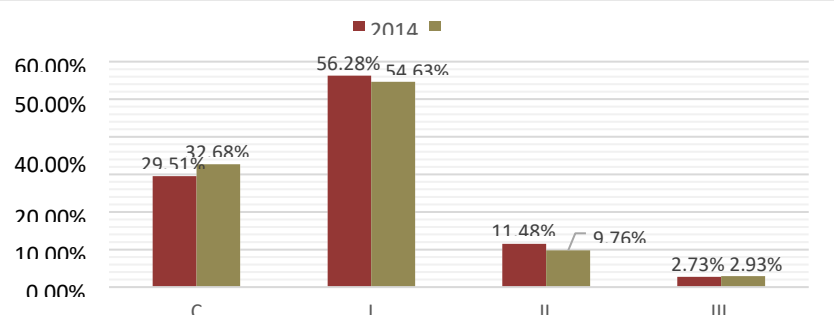
Source: Prepared by the authors based on CONACYT (2016).

Table 5. *Level of women in the SNI in Guanajuato, 2014–2015*

Level	2014	2015
C	29.51%	32.68%
I	54.28%	54.63%
II	11.48%	9.76%
III	2.73%	2.93%

Source: Prepared by the authors based on CONACYT (2016).

Graph 5. *Level of women in the SNI in Guanajuato, 2014-2015*



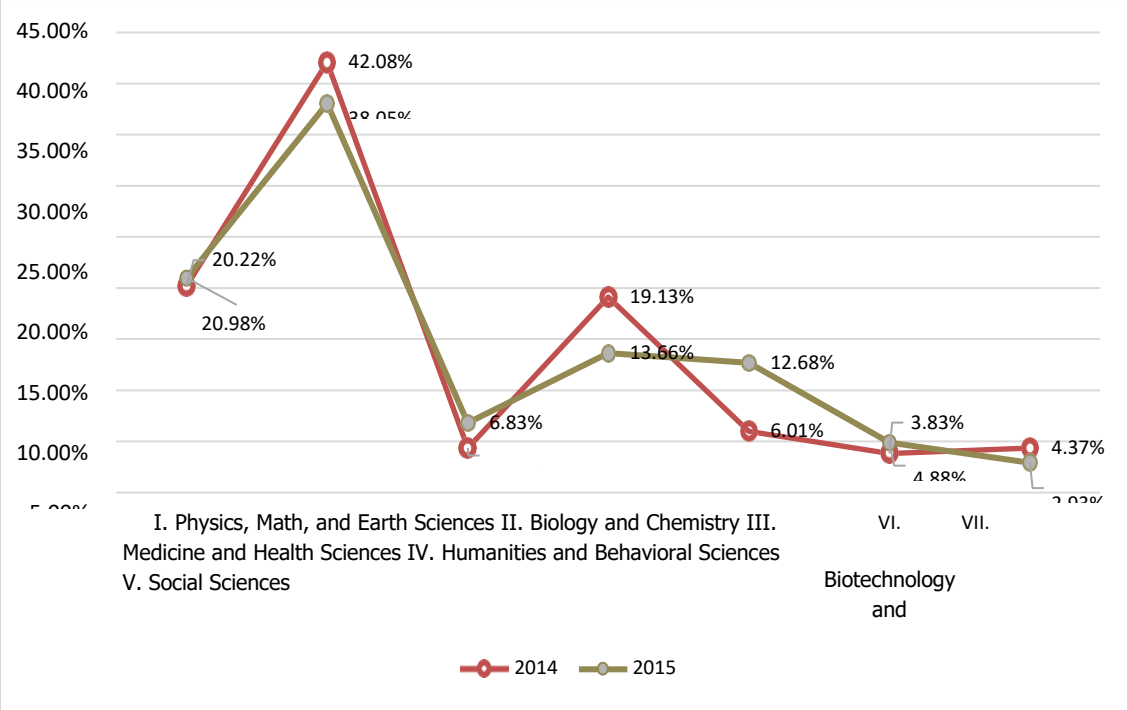
Source: Prepared by the authors based on CONACYT (2016).

As it can be seen, between 2014 and 2015, in the state of Guanajuato, more than 50% of the women members of the SNI hold Level I, followed by Candidate level. This is not far from the national average, which also follows this pattern.

Table 6. *Fields of knowledge of the women in the SNI in Guanajuato in 2014–2015*

Field	**2014**	**2015**
I. Physics, Mathematics, and Earth Sciences	20.22%	20.98%
II. Biology and Chemistry	42.08%	38.05%
III. Medicine and Health Sciences	4.37%	6.83%
IV. Humanities and Behavioral Sciences	19.13%	13.66%
V. Social Sciences	**6.01%**	**12.68 %**
VI. Biotechnology and Agricultural Sciences	3.83%	4.88%
VII. Engineering	4.37%	2.93%

Source: Prepared by the authors based on CONACYT (2016).



Source: Prepared by the authors based on CONACYT (2016).

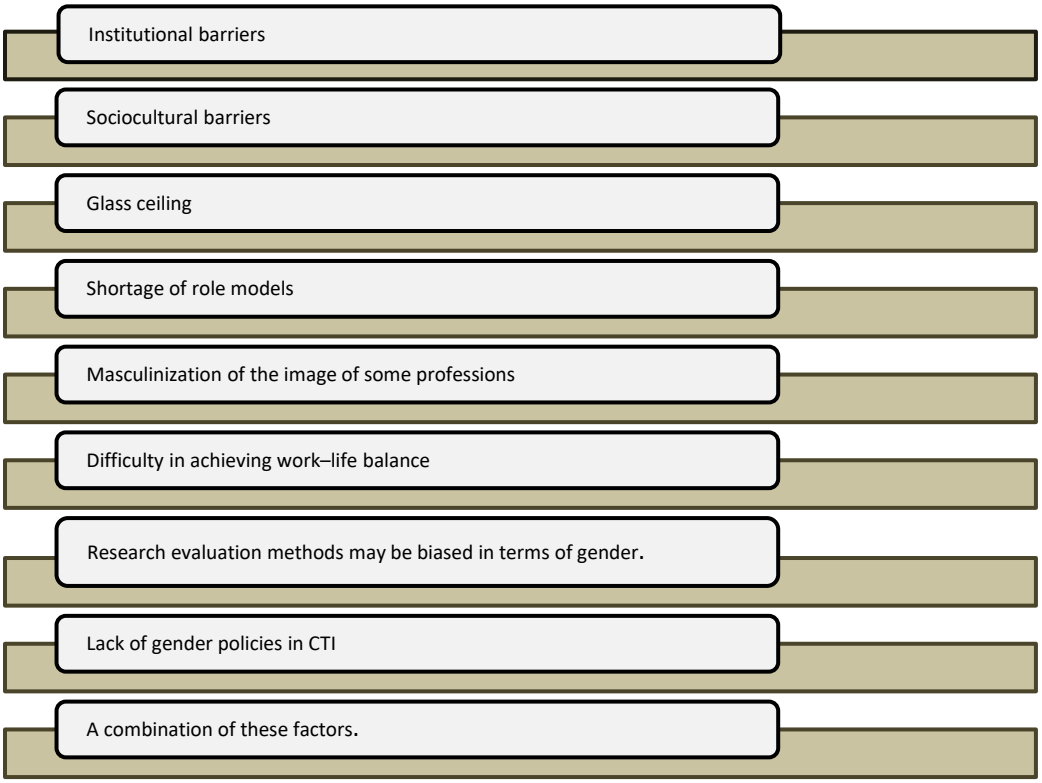
Similarly, in the state of Guanajuato, as in the country as a whole, there are more women registered in the field of biology and chemistry, although approximately 2 out of 5 researchers in these disciplines are women. It is worth noting a subtle decrease of 4.02% between 2014 and 2015. In fields such as the mathematical-physical and earth sciences and social and behavioral sciences, effectively, one in five researchers were women in 2014. In 2015, this ratio remained the same in the fields of physics and mathematics, but it decreased significantly in the humanities. By contrast, in 2014, not even 1 in 10 women

researchers were registered in the remaining fields considered by the SNI. However, in the social sciences, the percentage doubled in 2015, with 1 in 100 researchers in the field being women.

The reasons for these differences call for further analysis. For the time being, we propose as a possible cause (while acknowledging that, like any complex phenomenon, it responds to multiple factors) that the traditional values of the region Bajo de México permeate even at the level of higher education institutions, and the limitations that women face in their daily work in different areas, because of certain ideas regarding their role, are reflected in their academic development (see Figure 1). In other words, universities and research centers are not exempt from gender issues. The challenge remains to understand whether discrimination and inequality mechanisms are the same or perhaps more subtle, the higher the level of education of those involved.

It is also puzzling why the number of women researchers recognized by the SNI has doubled in one year in the social sciences and decreased in areas such as the human and behavioral sciences.

Figure 1. *Principal barriers of gender equity in science and technology*



Source: Prepared by the authors based on Anlló (2017).

Discussion

Although CONACYT itself states that the participation of women in SNI has increased at a higher rate than that of men (CONACYT, 2017), their positioning in decision-making positions in science and technology is still not representative, despite the fact that in the results obtained, the percentage of women in the SNI is lower than that of men in the state of Guanajuato.

The findings confirm that progress is being made in terms of the positioning and recognition of women in science in Guanajuato (Mexico), but this progress is slow because, as demonstrated by Carli, Alawa, Lee, Zhao and Kim (2016), women are often considered to lack the necessary qualities to become successful scientists, which may be contributing to discrimination and prejudice against female scientists.

In turn, Waldman (2018) argues that all women and men in scientific contexts experience gender relationships in science. As with leadership, there are implicit values and ideas embedded in the concepts of science and the scientist. For example, the notion of a dominant scientist has excluded women for many years and has always been stereotypically associated with men. Nevertheless, the future looks promising, as gender roles adjust, albeit slowly, in the direction of greater flexibility in gender, family, and social life.

However, recent research works such as that of Haines, Deux, and Lofaro (2016) shows that gender stereotypes are as strong today as they were thirty years ago, which is reinforced by the OECD's Education Overview Report (2017) when noting that

Mexican women face slightly higher unemployment rates than men and have one of the largest gender gaps in earnings among OECD countries. Similar to other OECD countries, women with tertiary education earn 32% less than men (OECD's average is 27%), but women are more likely to graduate in high-paying fields such as science, mathematics, and computing, compared to the situation in other countries (p. 1).

The presence of women in the scientific field has been the subject of discussion so far, but we must also delve into the payment gap that exists between women and men, since studies such as those conducted by McNabb and Wass (1997) and Morales (2014) have exposed inequality not only in terms of the recognition of women's scientific work but also the financial compensation they receive. This adds to the second unpaid "domestic" work shift that women do, which takes time away from their research activity and scientific output. Thus, Pietri et al. (2018), by way of conducting varied experiments, discovered that in order for women to properly identify with scientific work and continue to remain working despite the violence and discrimination that exists, they must first learn about the gender bias or gender gap in STEM, which, from our point of view, includes the recognition of domestic work as part of their identity as women scientists.

The greatest challenge is that the institutions, organisms, or regulations in charge of managing scientific and technological life should value the role of women and the way they balance work and personal life. Further, this aspect should also be taken into consideration in evaluation and recognition processes, and even within these processes, there should be gender parity. It is well known that the majority of scientific and technological assessment committees are dominated by men, who are often insensitive to, for example, women's double workload, in addition to the gender stereotypes that exist and that constitute invisible barriers to their progress in universities.

Blickenstaff (2005) argues that the problem of female underrepresentation in STEM is not straightforward, thus, it requires time and a holistic and comprehensive solution that also recognizes the importance of the role of educators and employers in reducing gender gaps (Jesse, 2006). While the presence of women in higher education institutions and research centers is on the rise, their positioning is not in strategic roles, meaning that if they manage to attain a strategic position, they generally do so at low levels, where their decisions do not have any influence, and their participation is often invisible (acts of micro-inequality). Thus, the gender gap in scientific fields persists despite the fact that women's participation at the higher education level has increased (UN, 2018).

Furthermore, Waldman (2018) argues that while the problem of unequal gender representation in scientific leadership at all levels is recognized, the commitment to transformative change is uneven. According to Mendieta (2015), the development of women in science and research in Mexico is still an area to be addressed.

Therefore, it is imperative for agencies promoting science and technology at the federal, state, and municipal levels, as well as the institutions where women develop, to make radical structural changes in the definition of evaluation criteria in accordance with women's life trajectories, which must take into account the mainstreaming of the gender perspective. In this regard, UNESCO (2017) affirms that ensuring that girls and women have equal access to STEM education and, ultimately, to careers related to these subjects is essential from the perspective of human rights, science, and development.

In the state of Guanajuato, a new secretariat is being created to develop programs for the promotion of science and technology. However, there is currently no transversal policy for gender equality, which means an impasse for the women dedicated to this activity because at federal level there is a transversal agenda in the current National Development Plan and even in the Law of Science and Technology still in force. Thus, all these aspects should be aligned and affirmative actions should be promoted to recognize and promote the role of women in science and technology, as mentioned by Etzkowitz et al, (1992, 1994). Gender dimensions of science must be reconstructed to transcend the norms of gender roles.

Based on the aforementioned, we believe that aspects such as gender quotas or gender parity in initiatives and support for the promotion of science and technology are not enough, as argued by Kiss, Barrios, and Álvarez (2007). In most cases, the recognition of women is not actually achieved; such initiatives merely constitutes compliance with regulations regarding a number to be met, and it is not aimed at capacity or quality recognition.

Kochen, Franchi, Maffia and Atrio (2001) consider that, in addition to the formal structures for recognizing the work done by women in science, it is necessary to include in this type of study the concept of micro-inequalities, which undermine the rights of women to practice their profession freely and with dignity. According to these authors, a micro-inequality is defined as follows:

> A set of behaviors that have the effect of somehow singling out, setting aside, ignoring, or disqualifying an individual on the basis of immutable characteristics independent of will, effort, or merit, such as gender, race, or age (p. 37).

For example, the fact that women do not have the opportunity to hold important decision-making positions or to be scientific leaders but are given places in insignificant institutional bodies represents severe micro-inequalities. Thus, progress is expected in both formal and practical terms, since "the full incorporation of women into science and technology systems is not simply an egalitarian demand, but an economic and social need" (Pérez, 2001, p. 17).

Although this document is limited to women in science and technology, the problems identified should not be limited to this field because as stated by Savage (2010), Women are disadvantaged in society simply because of the fact that they are women. This situation occurs in all spheres of life, although its forms and mechanisms may vary. These forms and mechanisms depend on the specific social spheres in which they develop (state, institutional, work, educational, domestic, affective and sexual) (p. 71).

For example, several studies have shown that women face similar problems in the management arena, including the prevalence of gender stereotypes; the existence of a glass ceiling preventing them from promotions; the payment gap; little presence in positions of authority or decision making; differentiated assignment of tasks regardless of position; the presence of harassment and gender-based violence; and the predominance of the male leadership style (Moncayo & Zuluaga, 2015; Pigeyre & Vernazobres, 2013; Zabludovsky, 2007).

It is evident that the presence of each of these issues depends on several factors, including, internally, the size of the organization, organizational culture, and the type of leadership that prevails, and externally, the country, the industry or industrial sector, the institutional regulatory framework, social structures, and overall sociocultural factors (Saeed et al., 2019).

Conclusions

In every society, gender inequalities exist in scientific and technological activities and in the decision-making surrounding these vital activities (Etzkowitz et al, 1992 and 1994; Kiss, Barrios & Álvarez, 2007; Waldman, 2018; Mendieta, 2015; Blickenstaff, 2005; Jesse, 2006; Pietri et al., 2018; McNabb & Wass, 1997; Morales, 2014; Haines, Deux & Lofaro, 2016; Anlló, 2017; Seetles, O'Connor & Yap, 2016; Vessuri & Canino, 2006; Daza & Pérez, 2008). Thus, there is an urgent need to raise awareness among current and future generations of scientists and technologists about the absence of sex and gender in research, innovation, science, and technology.

It should be made clear that the idea is not that gender equality should be mandatorily put forward or that women should be given positions regardless of their skills or ability but that there should be a structure that breaks gender stereotypes and treats women and men equally with regard to access to jobs, recognition, and remuneration.

This study's purpose was to analyze the situation and positioning of women scientists in the state of Guanajuato in 2014 and 2015, according to SNI data. A task that remains is to conduct a more exhaustive longitudinal study at the state level and then at the national level, considering the changes that have occurred since the creation of the system in 1984 till the present day. According to the results obtained, at the national level, the proportion of female researchers registered in the SNI was 34.84% in 2014 and 36.36% in 2015, that is to say, between three and four women for every 10 researchers in the system. At the state level, the picture is even bleaker, with 25.7% in 2014 and 26.38 a year later. It is true that the participation of women in the system has increased from one year to the next, but by a very small amount (0.52% at the national level and 0.68% at the state level).

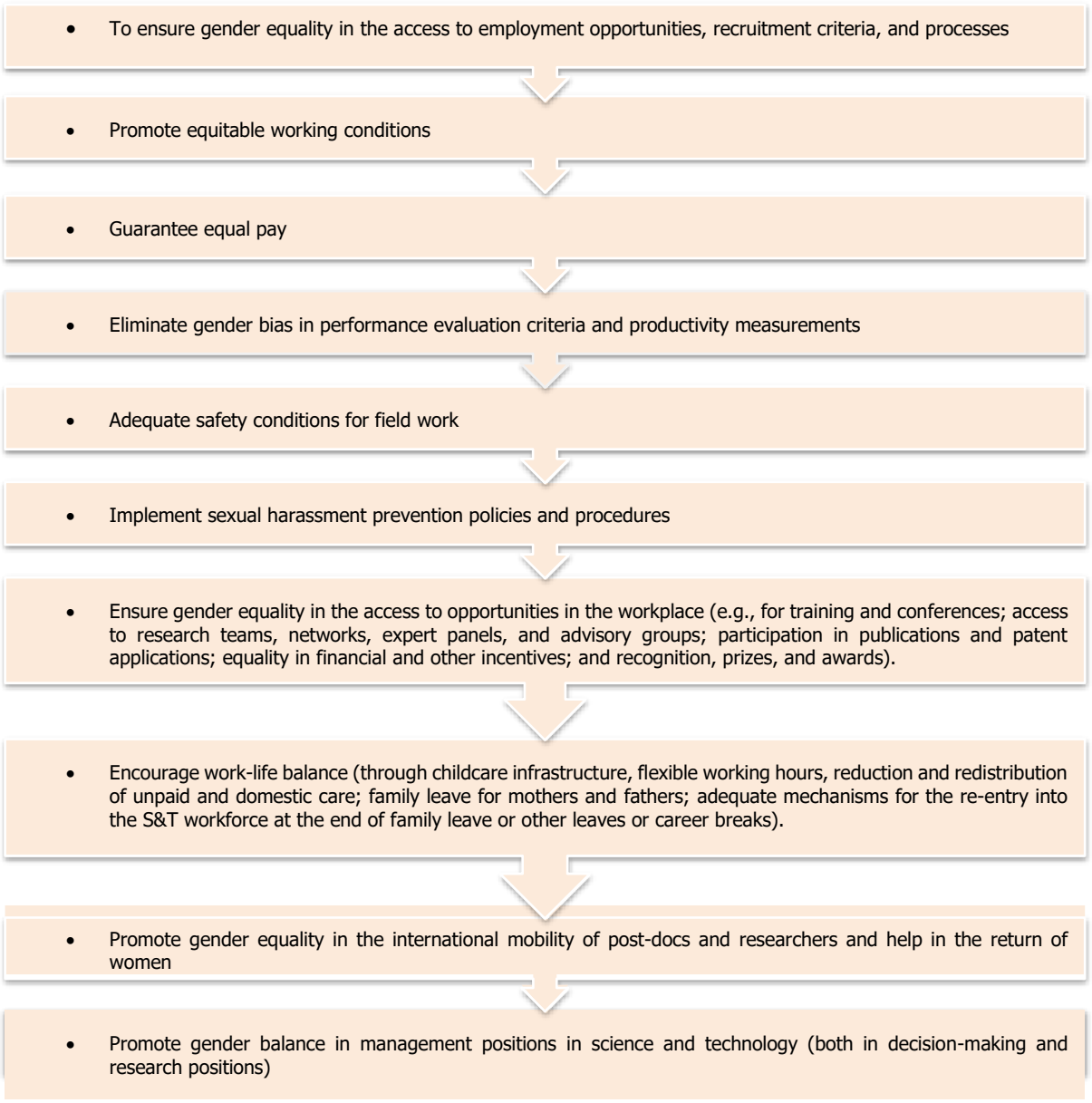
The field of biology and chemistry represent the highest participation of women in the system, both at the national and state level; in turn, the SNI level with the highest number of women, both at the national and state level, is Level I (more than 50% of the total number of women belonging to the system in 2014 and 2015). These data are revealing, and their causes are interesting to explore and should be the subject of more in-depth study in future research.

Based on the results obtained, it is possible to affirm that the achievement of gender equity in science and technology in Mexico and, specifically, in the state of Guanajuato, is still in its nascent stage. The reason for this, as mentioned above, is the lack of standardization of public policies. Further, there has not been sufficient progress in the reduction and elimination of gender inequality on the part of higher education institutions, although the problem is becoming increasingly visible and is a matter of public concern.

It is clear that reducing the gender gap in scientific and technological activities is no easy task, and it is in recognition of this reality that the UNESCO has created the SAGA program (STEM and Gender Advancement), which seeks to reduce this gap from different angles, such as public policy, education, and culture. What concerns this study is set out in goal number four of the program, which is "Gender equality in the professional careers of women scientists, scientists, engineers." To achieve this, some strategies are suggested, as shown in the following table.

To conclude, it is necessary to quote Schiebinger (2004), who stated more than a decade ago "It is time to transform science and society so that power and privilege are no longer distributed according to gender" (p. 397), a yearning that is not limited to the field of science and technology but also applies to the managerial sphere.

Figure 2. *Strategies for gender equality in science and technology professions*



Source: Prepared by the author, based on Anlló (2017).

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