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Gender Gaps in Science: Systematic Review of the Main Explanations and the Research Agenda

Brechas de género en la ciencia: revisión sistemática de las principales explicaciones y agenda de investigación

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A R T I C L E I N F O

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A B S T R A C T

Despite improvements in incorporating women in tertiary education and science, several gender gaps persist today in some scientific and technological areas worldwide. Understanding the factors that determine these gaps is essential to incorporating women into knowledge societies on equal terms. The present research sought to explore and systematize the explanations given to this phenomenon by the international literature in the last four decades. The objectives were: (1). Analyze the evolution of the leading research agendas and categorize these into groups (or clusters) of explanations, and (2) discuss the challenges that research agendas face in addressing the phenomenon in a multi-causal way. The data were obtained from the articles contained in the Web of Science (WoS) and were subjected to a systematic review using bibliometric and qualitative techniques. The analysis reveals an essential growth of research in this area within the social sciences, which is grouped into five main types of explanation: (1) student performance in STEM areas, (2) influence of gender stereotypes and models, (3) interests and educational-learning experiences, (4) educational-occupational expectations and choices, and (5) uneven advancement and performance in scientific careers. Evolution shows that explanations about performance and individual choice have diminished noticeably in the present, giving rise to explanations regarding the influence of gender stereotypes and models within educational systems and socialization stages. This study thus contributes to understanding the causal factors that have determined gender gaps in science while identifying some new issues in research agendas.

Palabras clave:
Brechas de género
Ciencia y tecnología
Revisión sistemática de literatura
Agenda de investigación

R E S U M E N

A pesar de las mejoras en la incorporación de mujeres en la educación terciaria y la ciencia, aún persisten brechas de género en el ingreso y avance en áreas científico- tecnológicas a nivel mundial. Entender cuáles son los factores que determinan estas brechas es clave para la plena incorporación de las mujeres en las sociedades del conocimiento en términos de equidad. La presente investigación buscó explorar y sistematizar las explicaciones dadas a este fenómeno por parte de la literatura internacional en las últimas cuatro décadas. Los objetivos fueron: (1) Analizar la evolución de las principales agendas de investigación y categorizar estas en grupos (o clúster) de explicaciones, y (2) discutir los desafíos que las agendas de investigación presentan para dar cuenta del fenómeno de forma multicausal. Los datos se obtuvieron mediante una búsqueda en Web of Science (WoS) y fueron sometidos a una revisión sistemática utilizando técnicas bibliométricas y cualitativas. El análisis revela un crecimiento importante de la investigación en esta área dentro de las ciencias sociales que se agrupa en cinco grandes tipos de explicación: (1) desempeño de estudiantes en áreas STEM, (2) influencia de estereotipos y modelos de género, (3) conformación de intereses y experiencias educativas y de aprendizaje, (4) expectativas y elección educativo-ocupacional, y (5) desigual avance y desempeño en las carreras científicas. La evolución muestra que las explicaciones sobre el desempeño y la elección individual han perdido peso en el presente, dando lugar a explicaciones sobre la influencia de los estereotipos y modelos de género dentro de los sistemas educativos y ámbitos de socialización. Este estudio contribuye así a una mayor y más ordenada comprensión sobre los factores causales que han determinado las brechas de género en la ciencia al tiempo que identifica algunos vacíos en las agendas de investigación.

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1. Introduction

In the mid-1960s, the American sociologist Alice Rossi (1965) denounced the low presence of women in science worldwide. “Why so few?” she asked. More than 30 years later, the psychologist Virginia Valian (1999) rephrased the question to include the speed of the integration of women in science. “Why so slow?” she asked. Despite significant progress, questions about gender gaps in the integration, advancement, and consolidation of women in tertiary education and academic science remain relevant.

Women have overcome the gaps in gross enrollment rates on tertiary education in North America and Western Europe since the early 1980s. The same phenomenon occurred in Latin America and the Caribbean 20 years later and is currently ongoing in some countries of Central Asia (UNESCO, 2011). However, a bias persists in terms of the selection of scientific fields. The so-called STEM (Science, Technology, Engineering, and Mathematics) areas are considered the most rigid for women to enter. In all these areas combined, women represent 35% of enrollments worldwide (UNESCO, 2017). Although most students at bachelor and master levels are young women, this number decreases at the doctorate level (UNESCO, 2017). Several countries reach parity in research staff. However, women tend to be the majority among researchers who make up the pyramid base (with the lowest status and salaries) and disappear as they advance to the highest positions of scientific stratification (European Commission, 2019; UNESCO, 2018).

Currently, there is an essential growth in studies on gender gaps in science and an increasing interest in the subject shown by Science and Technology (S&T) institutions. There are a wide variety of hypotheses to explain gender gaps in scientific fields and within academic science. The explanations range from direct discrimination against women, through the influence of personal characteristics and socialization processes, to gender differences in performance and outcomes. Over time, some of these agendas have received more attention, raising some issues for debate, and neglecting others. The double objective of the paper is (1). analyze the evolution of the main research agendas and categorize them into groups (or clusters) of explanations, and (2) discuss the challenges that research agendas face in addressing the phenomenon in a multi-causal way. A systematic review based on articles published on the Web of Science (WoS) was carried out using an indirect grouping technique: bibliographic coupling. The analysis is complemented with a qualitative review of the main papers, selected by citations and centrality measures.

2. Theoretical framework

Gender and science studies arise as a marginal field of research that has become relevant to the present thanks to the contribution of various disciplines. These studies have taken a fundamental step in recognizing that science, understood as a particular social institution, reproduces the prevailing gender systems in their contexts and cultures. On the one hand, pioneering studies were focused on how gender relations affect the cognitive and epistemological content of knowledge production, criticizing the questions that science does not ask or the results that it does not reach when excluding women (Keller, 1995). On the other hand, some studies focused on gender relations as a dimension of stratification patterns within academic science (Rossi, 1965; Valian, 1999; Zuckerman & Cole, 1975).

Science and gender literature identify at least three critical points for gender equality in the academic sector: (i) the underrepresentation of women in certain scientific fields (horizontal segregation), (ii) the difficulties to advance through the academic path’s levels (vertical segregation), (iii) the limited access to higher-ranking positions in the stratification of science (glass ceilings). Horizontal segregation generates an overrepresentation of women in areas related to medical science and health, social sciences, humanities, and administration, and underrepresentation in areas such as engineering, technology, physics, and mathematics. This phenomenon is similarly observed in many socioeconomic and cultural contexts (European Commission, 2019; López-Bassols et al., 2018; UNESCO, 2011). Horizontal segregation has been associated with the sexual division of labor, i.e., the expected division based on the sex of the individual and the place they will occupy in the market (Benería, 1979).

On the other hand, vertical segregation refers to the accumulation of women at the lowest levels of scientific stratification and their resulting underrepresentation in the highest positions. The lower proportion of women in higher-ranking positions is also maintained in feminized enrolment disciplines (European Commission, 2019; UNESCO, 2018). Women’s barriers in accessing higher-ranking positions have been widely denounced based on another classic metaphor, the *glass ceilings*. Around the end of the 80s, this metaphor sought to make explicit the invisibility of the barriers faced by women. However, Eagly and Carli (2007) argue that today, the exclusion process of women from leadership positions is varied and not necessarily as obvious as it was in the past. The notion of the glass ceiling assumes the presence of an absolute barrier at a specific level of an organization's hierarchy and thereby ignores the heterogeneous and complex barriers that women must face on their way to leadership. This idea could be complemented with an old concept from the sociology of science to help us understand the academic path of women: the principle of cumulative advantages. Developed by Merton (1977) to analyze the *Matthew effect* in science, this principle assumes that a relatively favorable starting position becomes a resource that produces future gains (DiPrete & Eirich 2006). Rossiter (1993) reformulated Mertonian ideas to show that women are affected differently by the cumulative advantage and proposed the *Matilda effect*. The minor disadvantages that women experience from the early stages of their careers could become significant differences in academic consolidation.

Over time, the emphasis on the most critical points of segregation in science has changed, as well as the answers on their leading causes. This article seeks to map research agendas on gender gaps in science and their changes in the last 40 years.

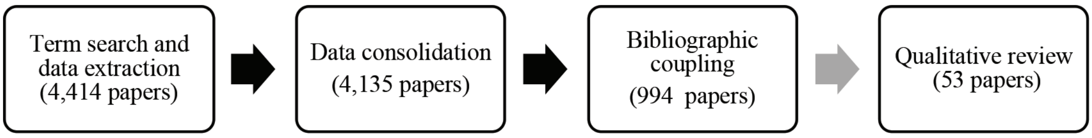
3. Materials and methods

The literature was extracted from articles indexed in the core collection of the WoS within the broad field of social sciences and humanities, using a term search criterion applied to summaries, titles, and keywords. The search terms were:

(TS = (Gender AND (gap OR difference OR bias) AND Science).

This resulted in 4,414 articles published between 1985 and 2018. For data consolidation, articles outside the study fields and duplicates were removed according to their title and DOI. A body of 4,134 articles was included in the dataset containing the articles' metadata and their bibliographic sources. The dataset was extracted in January 2020. Figure 1 summarizes the data collection.

Figure 1. Stages of data collection and processing.



A bibliographic coupling analysis was performed within a subgroup of articles to identify the main bibliographic communities to explore the topics. The technique was applied using VOSviewer software. Finally, a qualitative revision of articles was carried out to synthesize the main research themes in each community.

The technique of bibliographic coupling was introduced by Kessler (1963) and defined as the link between texts that are coupled or have a significant relationship between them when they share a common bibliography. The basic assumption is that if two documents show similar bibliographies, they have an implicit relationship. To perform the bibliographic coupling, VOSviewer developed a five-step process to link documents that combine a bibliographic search by the first author's name, year of publication, volume number, first-page number, and DOI. In the bibliographic coupling network, the nodes are the articles, and the links are established when they cite a common bibliography. The link between two articles is calculated by the full count method, i.e., the number of papers cited in both bibliographies. The article network is made up of articles that share 10 or more common sources in their bibliography. The final dataset included 994 articles. The cluster analysis identified five communities using a resolution of 0.08 according to the VOSviewer algorithm described in Waltman et al. (2010)[1].

To characterize each cluster, a qualitative review component was added. Articles were selected according to three indicators: (i) number of citations, (ii) standardized citations (number of citations of an article over the average number of citations of all articles in the same year), and (iii) centrality degree (number of adjacent nodes). Within each cluster, the five articles with the higher scores in each indicator were selected. Although citations and centrality degree are not an indicator of the quality of the research, these allowed a description

1. To check the robustness of the VOSviewer cluster algorithm, the dataset was exported to Gephi software and a modularity analysis was performed. Using a resolution of 1.0, the Gephi modularity algorithm (Blondel et al., 2008) also identified five similar communities.

based on the most read and integrated articles. Since some articles shared more than one requirement, a total of 53 articles were reviewed (see Table 1).

Table 1. Selected papers for qualitative review.

Cluster	Qualitative review *
1	Eagly and Wood (2013); Else-Quest et al. (2010); Feng et al. (2007); Hyde and Mertz (2009); Hyde et al. (2019); Petersen and Hyde (2014); Reilly (2012); Reilly et al. (2015); Stern et al. (1995); Tenenbaum and Leaper (2003); Uttal et al. (2013); Voyer and Voyer (2014)
2	Bian et al. (2017); Cheryan et al. (2009); Cheryan and Plaunt (2010); Cheryan et al. (2011); Cheryan et al. (2017); Dasgupta and Asgari (2004); Diekman et al. (2015); Harackiewicz et al. (2016); Miller et al. (2018); Nosek et al. (2009); Schmader (2002); Stout et al. (2011)
3	Archer et al. (2010); Bennett et al. (2007); Bøe et al. (2011); Correll (2001); Howe and Abedin (2013); Jones et al. (2000); Kahle et al. (1993); Krapp and Prenzel (2011); Riegle-Crumb et al. (2006); Sikora and Pokropek (2012); Vincent-Ruz and Schunn (2017); Weinburgh (1995)
4	Carter et al. (2003); Cliff (1998); Cross (2001); Eccles (1994); Else-Quest et al. (2013); Krueger et al. (2000); Lent et al. (2018); Sadler et al. (2012); Sax et al. (2015); Steele (1997); Wright and Holttum (2012)
5	Bendels et al. (2018); Carli et al. (2016); Ceci and Williams (2011); Ceci et al. (2014); Charles and Bradley (2002); Cole (2009); Fox (2005); Lee and Bozeman (2005); Ma (2011); Morgan et al. (2013); Moss-Racusin et al. (2012); Nittrouer et al. (2018); Riegle-Crumb et al. (2012); Shields (2008); West et al. (2013)

* Source: Based on WoS (as of January 2020).

4. Results: Five main strands on the gender gap in science

Publications on the gender gap in science have grown, showing greater intensity in the last five years (see Figure 2). Within this growing number of articles, five communities were identified: (1) students' STEM performance, (2) gender stereotypes and models, (3) interests and educational experiences, (4) educational-occupational expectations, and (5) performance and advancement in scientific activities and careers (see Figure 3).

Disciplines such as psychology and educational sciences lead the study of student performance in STEM and the role of gender stereotypes and models (communities 1 and 2) as ways to explain horizontal segregation (see Table 2). The role of educational sciences becomes more relevant in community 3, focused on studying conformation of interests in science based on educational experiences. In this community, other disciplines emerge, such as communications, history, and philosophy of science. Psychology and education also dominate the production of articles by community 4, focusing on shaping educational expectations and occupational choice. Unlike previous communities mainly focused on forms of horizontal segregation, in community 5, the analysis of vertical segregation is guided fundamentally by economics, education, science and technology studies, and sociology.

The relevance of these research topics has varied over time. Studies on student performance in STEM areas and socialization processes and educational experiences show a greater relevance towards the end of the 80s, decreasing. However, it remains one of the main lines of publication on gender gaps in science. On the other hand, studies on the influence of gender stereotypes and models as explanatory factors of horizontal segregation are growing. The same occurs with the study of the forms of vertical segregation, which has

Figure 2. Publication on the WoS (1985–2019). Source: Based on WoS (as of January 2020).

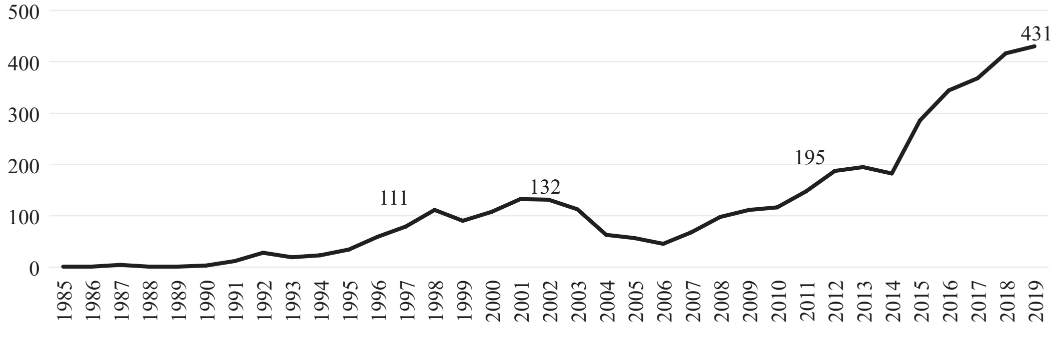


Figure 3. Bibliographic coupling in published articles. Source: Based on WoS (as of January 2020).

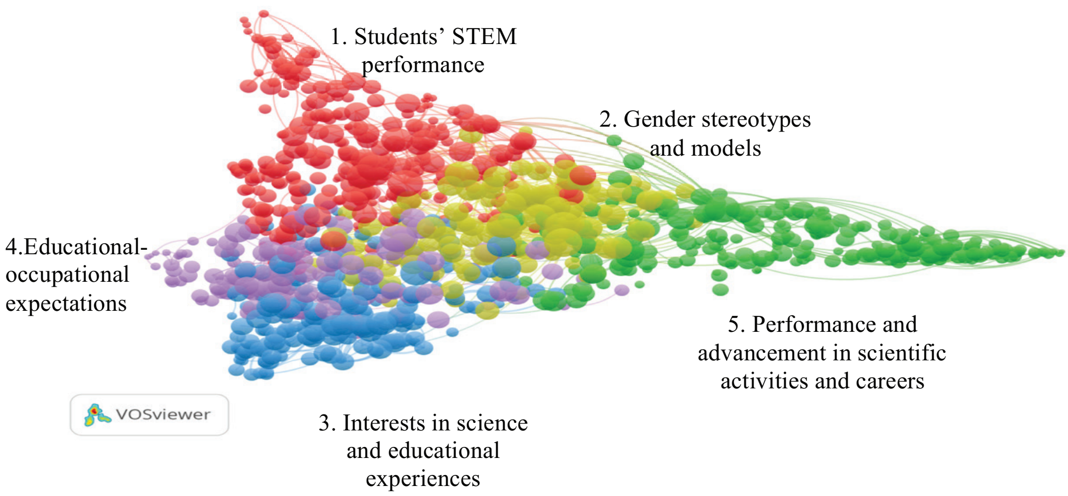


Table 2. Main disciplines, keywords, and community's participation (1987-2018).

Community	Disciplines	Keywords*	Nº of pub	1987-1998	1999-2008	2009-2018
1.Students' STEM performance	Psychology; Education & Educational Research; Women's Studies Science & Technology and Business & Economics	Performance; Individual-Differences; Achievement; Spatial Ability; Meta-Analysis; Knowledge; Personality; Students; Working-Memory; Intelligence; Mathematics	269	45%	33%	20%
2.Gender stereotypes and models	Psychology; Education & Educational Research; Women's Studies Science & Technology; Sociology	Stereotype Threat; Performance; Achievement; Threat; Math; Students; Identity; Achievement Gap; Attitudes; Math Performance	152	0%	8%	22%
3.Interests in science and educational experiences	Education & Educational Research, Psychology; Communication; History & Philosophy of Science and Women's Studies	Achievement; Students; Attitudes; Education; Mathematics; School Science; High-School; Performance; Choice; Self-Concept	211	34%	27%	16%
4.Educational-occupational expectations	Psychology; Education & Educational Research; Women's Studies Business & Economics and Information Science & Library Science	Self-Efficacy; Performance; College Students; Choice; Achievement; Motivation; Beliefs; Career-Development; Publication; Academic-Performance	131	15%	15%	12%
5.Performance and advancement in scientific activities and careers	Business & Economics; Education & Educational Research; Science & Technology; Sociology and Psychology	Scientific Productivity; Research Productivity; Choice; Publication Productivity; Scientists; Students; Careers; Gap; Higher-Education; Performance	231	6%	18%	30%
			994	100%	100%	100%

* *Words that appear in all clusters (gender, science, women, sex-differences, gender-differences) have been removed. Source: Based on WoS (as of January 2020).*

gained ground from the late 90s to the present. These results are compatible with previous reviews, such as the one carried out by Caprile (2012) on the specialized European literature. According to the authors, these studies begin by problematizing gender socialization at an early age and how this shapes educational and professional choices. Later, in the 90s, there was a shift towards vertical segregation studies, focusing on organizational and professional levels, their implicit norms, and power relations. The main content of the five groups is presented below.

4.1. Students' STEM performance

This group of literature seeks to explain the STEM performance of students in primary and secondary school and its potential influence on gender gaps in higher education and science. Among these, comparative studies of quantitative scales in mathematics have gained attention. However, there is no agreement on the existence of a gender gap in mathematics scores. At least three hypotheses can be found in the literature: (i) similarities in cognition, which argues that gender differences in mathematics performance are minimal and have not varied in the past two decades (Hyde & Mertz, 2009; Reilly et al., 2015); (ii) male variability, which indicates an over-representation of males among the highest performing students (Hyde & Mertz, 2009); and (iii) gender stratification, which demonstrates how performance is related to gender equality and cultural variables (Else-Quest et al., 2010; Reilly, 2012). Another group in this literature explores performances in language skills in favor of women (Hyde & Linn, 1988; Reilly, 2012; Voyer & Voyer, 2014) and spatial skills, including mental rotation, in favor of men (Else-Quest et al., 2010; Feng et al., 2007; Reilly, 2012; Voyer et al., 1995).

Some of these articles delve into the complex link between performance, attitudes, and values within the nature vs. nurture debate (Eagly & Wood, 2013). There is an emphasis on the socialization process and how the sexual division of labor determines factors to understanding the performance in each society (Else-Quest et al., 2010). This literature also explores the influence of hierarchy and peers in shaping boys' and girls' values, attitudes, and self-confidence (Tenenbaum & Leaper, 2003).

4.2. Gender stereotypes and models

This group analyzes how gender stereotypes determine performance and expectations. Several works focus on these dimensions at an early age and the subsequent biases in the occupational choice (Bian et al., 2017; Cvencek et al., 2015; Nosek et al., 2009). Other studies observe the influence of stereotypes in the environment and masculinized cultures of scientific fields, particularly computer science and informatics (Cheryan et al., 2009, 2017; Cheryan and Plaut, 2010). Contributions from experimental psychology have researched the effects of gender stereotypes as social identity threats (Schmader, 2002). Some studies experiment with the malleability of attitudes and beliefs considering positive stimuli on gender models, particularly changes in the family environment, the classroom, or educational institutions (Cheryan et al., 2011; Dasgupta & Asgari, 2004; Stout et al., 2011).

4.3. Interests in science and educational experiences

The interest of children and adolescents towards science is one of the main themes of these papers. The foundation of interests is approached from diverse perspectives that consider individual characteristics, relational and structural dimensions, such as the organization of the educational system and the curriculum (Krapp & Prenzel, 2011). Most of the studies in this group recognize that: (i) interests in science vary throughout the life cycle and (ii) the difference in boys' and girls' interests at an early age is fundamental in explaining the educational choice (Archer et al., 2010; Maltese & Tai, 2010). Many of these studies illustrate how self-confidence, self-perception, and self-esteem develop differently depending on the gender due to different socialization experiences. Some of this research indicates that men report greater self-confidence than their female peers and that difference grows as students advance in the educational system (Correll, 2001; Hyde et al., 1990; Weinburgh, 1995). Another subject in these articles is the teaching of scientific methods and educational experiences as a determining factor of gender gaps in selecting scientific fields (Kahle et al., 1993). The role of peer groups (Riegle-Crumb et al., 2006), the importance of extracurricular experiences (Jones et al., 2000), and the organization of classroom work (Howe & Abedin, 2013) are other subjects of study. Some research shows how supporting science learning can generate positive effects on girls' interests and performances.

4.4. Educational-occupational expectations

This group of articles shares many of the themes of the previous clusters, focusing on the processes of shaping educational and occupational expectations based on joint contributions of psychology and educational sciences. One of the most influential works in this cluster is the expectation-value model developed by Eccles (1994), which outlines the motivational factors that underlie the educational decisions of women and men. The main focus is that educational choices are closely linked to two sets of expectations: (i) individual success and (ii) perceptions about valid options according to gender roles. The model links causal factors, such as cultural norms, gender roles, socialization processes, and the influence of parents and teachers, with the expectations that individuals have for future success. Several empirical studies have provided evidence along this line (Else-Quest et al., 2013). Other works seek to understand educational decisions and expectations not only at an early age but also at the undergraduate and graduate level (Cross, 2001; Fouad et al., 2010), in research activities (Wright & Holttum, 2012), and the performance as professionals in the private and business world (Cliff, 1998), among others. A subgroup of articles emerges regarding the study of decisions and expectations in using the Internet or computers (Coffin & MacIntyre, 1999; Durndell & Haag, 2002).

4.5. Performance and advancement in scientific activities and careers

This group focuses on gaps in scientific activities, recognition, and access to hierarchal positions. An important topic in this group assesses the differences in productivity and shows lower publication rates for women. Some of the papers on the factors that determine these differences explore the characteristics of the scientific activity itself, for example, the impact of collaborations on productivity (Lee & Bozeman, 2005) or the forms of authorship (West et al., 2013). On the other hand, some studies focus on the effects of maternity, care responsibilities, and marital status on productivity (Fox, 2005).

The literature based on the leaky pipeline model to explain gender gaps is reflected in these groups of articles, with a focus on women in STEM. This model has served to illustrate the path and loss of women through different academic career levels. The initial standard of the pipeline is the number of women who enter undergraduate training, to then observe their representation in the following levels of training and promotion until they reach a top-level position. The assumption behind this argument is that in the absence of discrimination, the total number of women at all levels should remain stable compared to their male counterparts. Some researchers in this cluster try to broaden the focus of the pipeline model, for example, to include secondary education as a critical transition point (Ma, 2011; Morgan et al., 2013). Other topics reviewed are the gender pay gap in academia and business (Goldin, 2014), the influence of gender stereotypes (Carli et al., 2016), particularly in the recruitment and evaluation of women's performance (Moss-Racusin et al., 2012), as well as the biases in the award and recognition of women's scientific work (Lincoln et al., 2012), and in the selection of speakers for conferences and colloquiums (Nittrouer et al., 2018).

On the other hand, Ceci et al. (2014) and Ceci and Williams (2011) argue that the main barriers to participation in intensive fields in mathematics today are no longer related to discrimination factors within the scientific field and universities but are rooted in socialization, in pre-university education and in the subsequent probability of specializing in scientific fields. However, another group of authors considers these explanations insufficient and demands comprehensive approaches, including the influence of power relations, gender systems, and sociocultural inequalities on horizontal and vertical segregation in science (Charles and Bradley 2002; Riegle-Crumb et al., 2012).

5. Discussion

This systematic review allows us to observe the development of this field of study in recent decades, not only in quantitative terms, increase in the number of publications, but also in qualitative terms, diversification of answers over time. The latter includes a shift away from approaches on women's performance to focus on the socialization processes of boys and girls, the influence of educational experiences, and the influence of stereotypes, power relations, and gender models.

The study of horizontal segregation has focused almost exclusively on areas considered strategic for the entry of women in science, in particular STEM areas. Although this is a critical point to gender equality in the knowledge society, its excessive attention neglects the reality of women in other scientific fields, such as the social sciences or medical and health sciences. Also, studies that challenge the gender division and the status of scientific fields are marginal. Pursuing equity in science implies changing gender systems so that more women choose to study physics and more men choose to become nurses.

Explanations of the comparative performance in mathematics have been one of the main focuses of interest and publications over time. While these studies have made substantial contributions, much of the empirical research indicates that gender gaps in mathematics performance have decreased in the present (Riegle-Crumb et al., 2012). One critical problem with this literature is that most of the empirical evidence reflects only the reality of North America, which makes it difficult to compare (Reilly et al., 2015).

The systematization highlights the growth of explanations about the differential socialization processes of boys and girls and the importance of educational experiences in shaping attitudes, beliefs, and preferences towards science. A key contribution of these approaches has been the development of quasi-experiments that confirm the malleability of attitudes and preferences in light of positive stimuli, particularly from non-stereotyped female leadership models.

Vertical segregation studies have been gaining ground since the late 90s. Within this literature group, some authors understand factors that determine segregation before entering the scientific activity, such as pre-university education. Another group of explanations considers that discrimination and prejudice towards female scientists are the leading cause of segregation and glass ceilings in science. An important focus within this literature addresses gender gaps by problematizing scientific productivity. Much of the effort has put together the productivity puzzle (Cole & Zuckerman, 1984). From the pioneering studies on the sociology of science in the mid-1980s to the current works of scientometrics that process aggregated information worldwide, there is a similar trend: women publish less than men. The productivity gaps and their causes are not conclusive but present variability according to the samples and the stage of the academic careers analyzed. The uncritical use of publication indicators seems to forget that gender differences in productivity could be both the cause and consequence of gender inequalities in science. Explanations are focused almost exclusively on characteristics of the scientific activity itself, neglecting the influence of gender roles and the sexual division of labor. A smaller portion of the literature evaluates this influence, for example, the impact of motherhood on productivity. These studies show significant variability; some suggest that having children does not affect individual productivity, others find a positive effect, while others suggest a negative effect (Long, 1992; Kyvik & Teigen, 1996; Fox, 2005).

Within vertical segregation studies, an important part continues to use the pipeline model to analyze the careers and achievements of women in science. Although this model has been helpful for the public agenda, its uncritical use affects the comprehensive understanding of gender gaps in science. This model is based on at least two normative assumptions regarding academic careers: the consecutive and linear progression of academic careers and the full-time commitment of researchers to their careers. However, men and women have different possibilities for investing time and effort in their vocation. The diverse and complex trajectories that women go through in science are not captured by linear and progressive models of academic careers. Interruptions or discontinuities can act as disadvantages that accumulate throughout women's careers. Gender theory has taken a fundamental step in recognizing that the division of productive and reproductive spheres has especially high costs for women. Framing the explanations of gender gaps in the life course and gender roles can be recognized the interdependence of roles and the diversity of trajectories (Elder, 1998). According to Fox et al. (2011), within academic science, both women and men show levels of conflict between work and family. However, significant gender differences are observed in the intensity with which women experience these conflicts.

Although science and gender research avenues address a wide variety of topics, some key dimensions of the problem have been rarely explored. Some studies show gender gaps in academic mobility at the international level and their effects on women's careers (Shauman & Xie, 1996). However, a lack of studies contributes to understanding the patterns of skilled migration and international mobility in demographics terms. Even though the number of studies that consider the intersection between ethnic, social class, sexual orientation, and gender inequalities is increasing, there is a need to reinforce these studies in contexts of greater economic and social inequality. Another important unexplored issue in this research agenda is development studies focused on how gender gaps in science affect economic and social dimensions in developed and developing countries.

6. Conclusions

The explanations of social and human sciences about the main causes of gender gaps in science have diversified over time, showing that it is a multidimensional phenomenon. The future research agenda faces several challenges; three of them are brought to light by this systematic review.

First, the need to advance in a comprehensive theoretical framework on gender and science. On the one hand, some studies address the gaps between men and women without problematizing gender relations. On the other hand, studies incorporating gender relations often do not problematize science as a social institution with its norms, values, and stratification patterns.

Second, a fundamental problem that must be solved is the generation of empirical evidence that allows integrating the academic trajectories of men and women along with gender roles throughout the life course. The vast majority of studies that analyze the influence of gender roles in academic careers do so in a cross-sectional manner; only a minor group uses longitudinal data to study the interactions between gender roles and various transition points in academic careers and the life course (Mason & Goulden, 2004; Wolfinger et al., 2009; Morrison et al., 2011).

The third challenge of this research agenda is the complexity of translating the evidence into policies that jointly address the multiple fronts of horizontal and vertical segregation in science. Policy recommendations focused almost exclusively on the entry of women into masculinized areas, such as STEM, which could reinforce other inequalities. The promotion of gender equality in science should promote the entry of more women into higher scientific status and remuneration. At the same time, it seeks to generate changes in the scientific culture, particularly in the conceptions of career development based on male models.

Finally, it is essential to mention some limitations of this study. Although the bibliometric techniques allow us to map a large volume of information, this has often been criticized. Some authors point out that the bibliographic coupling technique only shows the probability of a relationship among papers (Weinberg, 1974). Recommendations to overcome this limitation are to complement the analysis with other bibliometric and qualitative techniques. In addition, the analysis is based on a limited part of the scientific knowledge indexed in WoS. In the future, other databases, such as Scopus and Dimensions, should be explored. All these databases present biases in terms of language, geographic location, and disciplines of the publications, so the use of other sources of information would be desirable (Mongeon & Paul-Hus, 2016). This is especially important for the social sciences where possible biases in research agendas may result from publication strategies within disciplines or the influence of funding, e.g., specific topics are likely to be of greater interest to the agendas of developed countries and others to developing countries.

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