Underrepresentation of Women in Science: A Literature Review

Executive summary
Purpose: This literature review covers 441 papers, published in journals with the highest impact factor from 1985 to 2018, about the factors that influence the access, participation and progress of women in scientific careers.
This paper will allow the reader to understand that the lack of female participation in science is a multicausal and complex phenomenon.
Design/methodology/approach: This paper analyzes the literature related to the underrepresentation of women in the scientific field published from 1985 until 2018, in order to identify the factors that affect this underrepresentation and to propose a comprehensive framework of the factors identified in previous studies.
Findings: The factors that influence women's access, participation and progress in careers related to Science and Technology (ST) are a complex problem with multiple interdependent factors. In addition, these vary according to the stages of women's lives and cultural contexts. This paper proposes, based on the literature review, a comprehensive framework to explain the factors that influence the access, participation and progress of women in ST careers. The factors are grouped as follows: (a) individual, (b) family, (c) social, (d) educational and, (e) labor-economic.
Originality/Value: The proposed research is useful for researchers and policy makers because it introduces this phenomenon schematically and orderly, identifies the gaps in past research studies, and evidences the need to conduct further research on this topic.
Keywords: Women, Women in Science, Literature Review, Women in Academic Science, Women and STEM
Type of paper: Literature Review

Introduction

Science and Technology (ST) are essential elements for the social and economic progress in the world. The decisive resource for global development is the skilled human capital (Manassero & Vasquez, 2003). However, throughout history, ST work has been divided and influenced by gender and social factors (Inter-American Development Bank, 2010), and women are underrepresented in this area in most countries (Blickenstaff, 2005). An equal access to science is not only a social and ethical requirement for development, but also a necessity (UNESCO, 1999). The concern about gender gaps in ST is related to equity, social justice, the correct use of social and individual investment in human capital, talent, socio-economic development, and competitiveness (Vázquez-Cupeiro, 2015). In this sense, there are several precedents on gender equity policies in ST, such as the Beijing Declaration and Platform for Action in the Fourth World Conference on Women (Beijing, 1995); the Declaration on Science and the Use of Scientific Knowledge (Hungary, 1999); and Declaration in the first Meeting of Experts on Gender and Science and Technology (Washington, 2004). Many countries are actively promoting women policies in higher education, research and development (R&D) careers; however, these are still insufficient if we look for a greater representation of women in ST.

The factors that influence women's access, participation and progress in ST careers are a complex problem. This phenomenon does not only involve the subject, but also the internal structure. Giddens (1976) stated that every social action has a structure, and all

structures imply a social action where human practices are the result of both elements. Giddens also noted the agency capability of the subject and the ability to make changes in the social world. Bourdieu (1984) emphasized the dialectic that exists between the structure and the way people constitute their reality based on their positions in the social space. His analysis focused on the concepts of agent, field, capital and habitus. The agent consists of the individuals, groups, and institutions that struggle to maintain or change the field. The field is a relatively autonomous space, time, space and specific actors. The capital is the agent's position in the field. Capital can be economic, social, cultural or symbolic. The habitus is the subjects' set of schemata that organize people's practices, that is to say, how they interpret the world, think, feel, see, and act, which seem natural but are, in fact, social.

One of the several social problems is occupational segregation by sex. The following theories approach this issue: the neoclassical theory, the theory of labor division, and sociosexual theories. The neoclassical economic theory—based on the analysis of the systematic differences in human capital accumulated by men and women—points out that women, due to their low level of education and experience, are less qualified for certain occupations. The theory of labor division notes that labor markets are fragmented and this contributes to a reduction of women's wages; however, this fails to explain why occupations are divided by sex. Socio-sexual theories, which are the most complete, help us to understand that: (a) occupations mainly performed by women reinforce stereotypes of femininity; (b) women have less experience because they spend more time taking care of their children; (c) the reason why, in some countries, women are excluded from certain occupations that involve a public contact between men and women; (d) job opportunities are less and more restricted due to occupational segregation; (e) labor flexibility is frequent in female occupations because they are women, not because they need flexibility to perform the tasks; (f) why, despite high unemployment rates, women in industrialized countries do not want to engage in traditionally female occupations (Anker, 1997). Socio-sexual stereotypes result in negative aspects during professional training and education, which will increase gender inequalities. Researchers usually explain gender-based occupational segregation based on the verb "prefer", that is, when a person prefers an occupation, or when an employer prefers to recruit mainly men or women for a specific job. However, these preferences result from the ideas and values that society has about the functions and attributes of each gender. The data show that there is a notorious similarity in the sociosexual classification of occupations, which might lead to the creation and reinforcement of stereotypes (Anker, 1997).

Labor barriers that hinder women's performance and growth tend to be explained based on three metaphors: (a) glass ceiling, (b) glass labyrinth, and (c) sticky floor. The most used metaphor is the "glass ceiling". The metaphor was first used in 1986 by The Wall Street Journal to describe the invisible barriers faced by highly qualified women during their promotion to leadership positions in organizations. The barriers they face are the result of discriminatory attitudes and prejudices that impeded them to have leadership positions (The Economist, 2009). This concept has two aspects: "the objective aspect, as a discriminatory reality toward women that exists in the majority of organizations, and as a subjective reality that imposed a setback in women's work projects" (Burin, 2008, p.76). According to the Economist (2009), the factors that explain the "glass ceiling" women face are: (a) time, because women are unable to find the time to obtain the academic degrees necessary to reach top corporate positions; (b) maternity, because

women set aside their careers to stay home and take care of their children; hence, they are unable to travel abroad and perform others tasks; (c) the lack of female role models, because there are few women who achieved impressive merits. Eagly and Carli, cited by Chris (2007), proposed to replace the “glass ceiling” metaphor by the “glass labyrinth” because the “glass ceiling” metaphor has lost usefulness. The term “glass labyrinth” is proposed because women not only face a barrier during the penultimate phase of their careers; they are actually in a labyrinth because it reflects the different challenges encountered during their professional development. The “glass labyrinth” can be described as the itineraries women have, i.e. a triple workload: productive, reproductive and household work and, in some cases, community work. Ardanche (2011) stated that there is another metaphor called “sticky floor” that attempts to illustrate women's problems. The “sticky floor” metaphor refers to the barriers faced by educated women in top positions. The term focuses on analyzing women who are in low hierarchy positions with low wages, have informal and low-quality employment, have few prospects for progress, and did not have training opportunities. In this sense, the metaphor suggests that something has women stuck to the floor.

The “leaky pipeline” metaphor is used in CT to imply that women are underrepresented in the labor market. This points out the “leaks” that causes a lower presence of women as they move forward their life cycles (early childhood, adolescence, university, admission to graduate school/work), due to a set of factors that lead to a sexual unbalance in CT (Blickenstaff, 2005; Pell, 1996).

In this context, this paper aims to analyze—based on the literature review—the factors that influence women's underrepresentation in CT, considering the factors that affect their career choice (access to higher education), career persistence (participation, pursuing undergraduate and graduate science courses) and career advancement (progression, pursuing careers in science) (Ahuja, 2002; Cronin & Roger, 1998). Women's underrepresentation in ST has been studied in several countries of the world from various perspectives. This paper reviews and organizes the quantitative and qualitative academic papers to identify the factors that affect the underrepresentation of women in science, and to answer the following research question: Why are women underrepresented in science careers? In addition, the paper proposes a comprehensive model about the different factors identified in the literature.

The structure of this paper is the following: first, the methodology is described; second, the different factors that influence women’s access, participation and progress in ST careers are introduced; third, a model that integrates these factors is included; and fourth, the findings and recommendations for future research are discussed.

Methodology

This literature review followed three steps: First, the criteria to select and classify the papers are defined. Second, the statistical results of the journals with more publications, the most cited authors and countries of origin are included. Third, the selected papers are analyzed and a comprehensive model that explains the possible causes of the lack of women in CT is proposed.

Concerning the first step, the literature review was conducted from January to June 2018, considering the following keywords: “women”, “science”, science subjects,

engineering, and mathematics. The search covered papers written in English with an SJR impact factor that were available until June 2018, as cited in Web of Science database.

One of the problems encountered during the literature review is that there is no consensus on science careers. These are usually related to the STEM (Science, Technology, Engineering, and Mathematics) concept. However, the term "STEM" is also defined in different ways. Some studies include physical, biological and agricultural sciences, IT, engineering and mathematics. The social sciences, behavioral sciences, psychology, health-related careers, medicine and nursing are excluded (Hill, Cobertt, & St. Rose, 2010). It is also common to categorize sciences as "hard" (physics and mathematics) and "soft" (biology, psychology, social science). According to the Royal Spanish Academy (2006), the "sciences" include the required knowledge of the exact sciences, physics, chemistry and natural sciences, excluding social sciences and humanities. The International Standard Classification of Education (UNESCO, 1997) includes as sciences the life, health, physical, mathematical, agriculture, architecture and engineering sciences. In addition, the Organization for Economic Cooperation and Development (OECD, 2007) classified ST careers in five areas: Natural Sciences, Engineering and Technology, Medical and Health Sciences, Agricultural Sciences, Social Sciences and Humanities. The lack of homogeneity of the definition of ST makes it difficult to compare the various studies. In this literature review, only papers related to the presence of women in natural sciences, technology, engineering and mathematics careers—classified as "ST careers"—were considered. Social sciences, behavioral sciences and health-related careers were excluded.

The keywords identified 441 papers. The implementation of a search protocol allowed selecting 59 papers that addressed the research question. Additionally, 15 papers were identified taking into account the main references of previously selected papers in compliance with the selection and exclusion criteria. The number of papers is sufficient to answer the research question of this study. These 74 papers were classified according to the main topic. The selected papers helped to identify the factors that influence women's underrepresentation in ST and the proposed approaches for future research and development.

Concerning the second step, the Journal of Research in Science Teaching published seven papers on the subject, followed by Psychology of Women Quarterly with six papers. These two journals accounted for more than 17% of the analyzed papers. Table 1 includes the ten most cited papers. The results showed that the most cited paper (2.573 citations) was Steele (1997), who introduced a general theory of domain identification to describe the barriers that women still face in advanced quantitative areas. These obstacles are referred to as the stereotype threat (the fear caused by the expectation that one will be judged or treated based on a negative stereotype of one group). This can be one of the causes affecting women's underrepresentation in ST. The second most cited paper was Carlone and Johnson (2007) with 311 citations, followed by Blickenstaff (2005) and Ceci, Williams and Barnet (2009). It is worth to note that Stephen Ceci is the author of the majority of papers mainly focused on understanding the access and development of women in science.

Finally, in the third step, research on women in science can be categorized in five groups of factors that explain the low female participation in science careers: (a) individual, (b) family, (c) social, (d) educational, and (e) labor.

Author(s)

Results of the literature review

Web of Science indexed 441 papers using the search string, from which only 74 papers answered the research question. Figure 1 and Figure 2 describes the trend in these 74 papers, which denotes the growing academic interest in the topic, mainly in developed countries. Figure 3 shows the main research approaches: educational research, psychology, women studies and sociology.

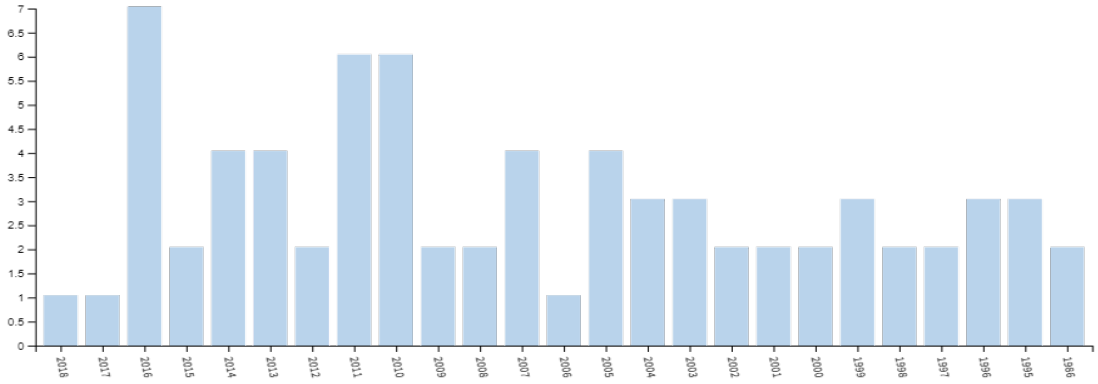

Figure 1. *Publications trends about women´s underrepresentation in science*

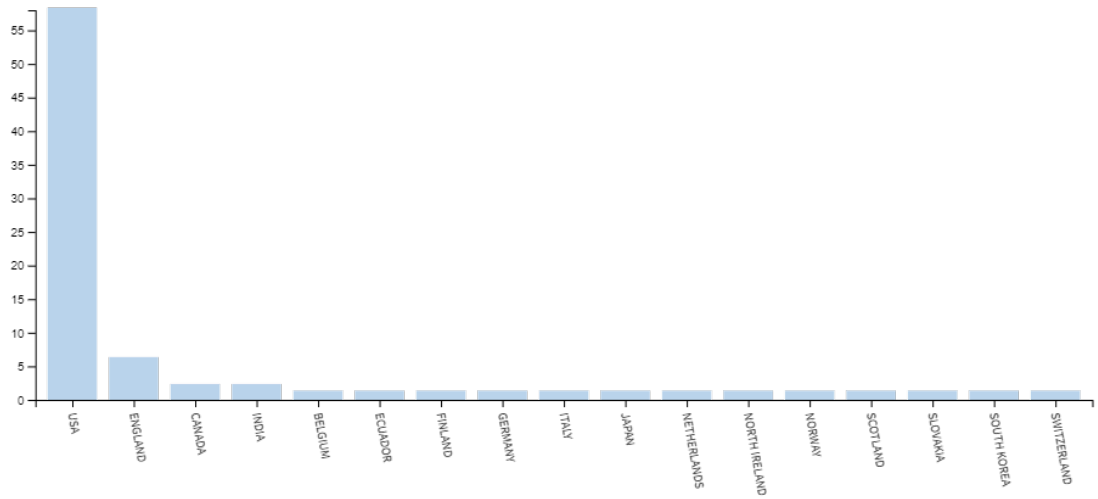

Figure 2. *Countries with more publications about women's underrepresentation in science*

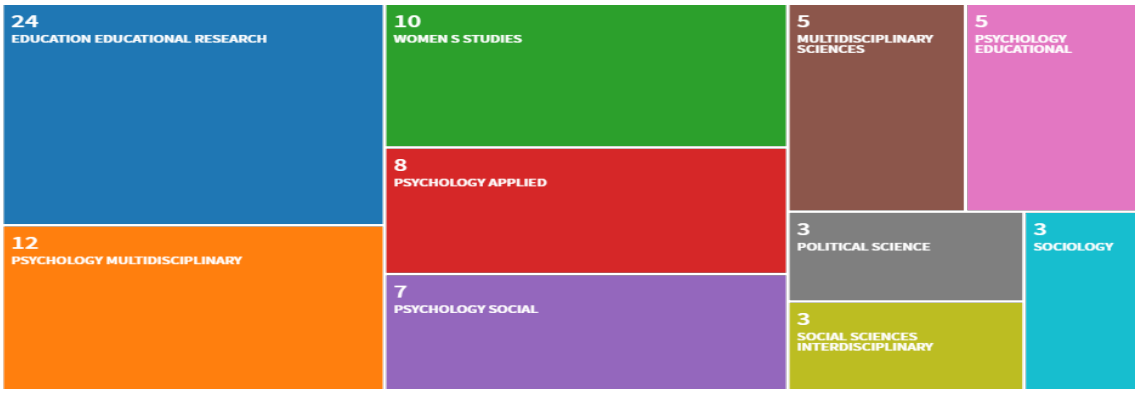

Figure 3. *Countries with more publications about women's underrepresentation in science*

Analysis of the literature review

During the last decade, researchers have taken great interest in understanding women's underrepresentation in ST. These studies have addressed the issue from different perspectives:

(a) Papers focused on one age group, students with a specific level of education, or specific populations such as teachers, researchers or scientists. Most of the conclusions about the lack of women in ST are based on the study of women scientists in academia, mainly in the United States. Professional women in ST careers in the business world and the factors are not considered.
(b) The studies are limited to certain countries and consider the specific cultural characteristics that might condition the factors related to the access, participation and progression of women in ST. In this sense, there are studies on women in scientific careers in the United States, Japan, Singapore, India, Slovakia, Australia, Germany, Spain, Brazil, Russia, Iran, Turkey, Malaysia, Libya, United Kingdom, Scotland, Ecuador, among others.
(c) The studies focused on a certain area of ST, such as chemistry, biology, physics, computer science or math, in order to identify the particularities in certain fields of science. These studies take into consideration that, while women are generally underrepresented in ST, there are noticeable differences among these areas.
(d) The studies focused on specific factors that may affect the presence of women in ST, such as the presence of role models, stereotypes about gender roles, work-family and family-work conflicts, or family environment.
(e) The studies focused on analyzing if these factors are similar for men, women or different ethnic groups.
(f) Studies focused on the evaluation of programs to increase the presence of women in science.

Very few papers comprehensively study the different factors that affect the underrepresentation of women in ST. The studies are mainly focused on one main age group, students with a specific level of education or specific populations, such as teachers, researchers or professionals, but very few comprehensively analyze women's decisions, considering the various stages of women's lives. In terms of methodology, the first studies used the qualitative approach (ethnography or case study). Subsequently, over time, quasi-experiments and quantitative studies on diverse populations were

conducted. In addition, since it is important to understand the evolution of women, some studies are longitudinal in order to identify factors that build the “pipeline” of women in science.

Sonnert (1999) proposed two models to explain women's underrepresentation in science: the deficit model and the difference model. In the first model, women as a group have fewer chances and opportunities in their career and, for this reason, they collectively have worse career outcomes as a result of the structural deficits of the scientific environment that provide them with fewer opportunities and more obstacles than men (e.g., gender discrimination, limited networking, patterns of inclusion or exclusion in research groups, selective access to human and material resources, different practices and standards of evaluation, the portray science as highly competitive and a masculine domain). The second model considers that the causes of gender disparities in career achievement lie in women themselves (women attitudes, behaviors, skills, abilities, values and experience). In addition, other authors refer to the model of social and structural factors (Ahuja, 2002). Social factors relate to social and cultural biases that women have of themselves (self-expectations) and the external view of women (stereotyping, social expectations, work-family conflicts) that society has in general. The structural factors refer to the institutional structure that can limit women's opportunities, for instance, the occupational culture and the lack of role models.

However, the factors that influence women’s access and development in ST careers “appear to be a complex web of interdependent factors” (Cronin & Roger, 1999, p. 643). It also varies according to the stages of women’s lives and contexts. In this sense, the study proposes, based on the conducted literature review, a comprehensive framework to explain the factors that influence the access, participation and progress of women in ST careers. The factors are grouped as follows: (a) individual, (b) family, (c) social, (d) educational and, (e) labor-economic, which are explained below. The selected publications are included in Table 2 and organized according to the different factors that affect the access, participation and progress of women in ST careers.

3.1 Individual Factors

Individual factors are the external variables in the subject based on his/her agency, i.e. the ability to interpret, assimilate, redefine, and/or reproduce. The following individual factors have been identified: (a) biological aspects, (b) personality and self-efficacy, (c) personal expectations and (d) attitude toward science.

Biological aspects.
The unequal participation of women in science was studied initially from the biological point of view. The analysis focused on the anatomical differences between men and women, essentially the size of the brain, which was initially linked to the intellectual inferiority of women. However, the idea was progressively discarded since it was discovered that there are genius men with small brains and there was no evidence of biological differences between men and women’s capacities (Blickenstaff, 2005; Hyde, 1996). Irwing and Lynn (2005) conducted a meta-analysis of 22 papers that studied sex differences in university students. The authors stated that it has frequently been asserted that there is no sex difference in average general intelligence, but the variance is greater for men. The study results showed something different: men students obtained higher

average IQ scores than women, and science students obtained higher average IQ scores than arts students.

Hyde (1996) affirmed that there are no significant differences between the cognitive ability of both sexes in science. In addition, even though abilities play an important role, these are not the only factors that influence the low participation of women in engineering. According to this author, cognitive development studies with biological support failed to explain the preponderance of men in math and science. IQ tests show that there is no average difference between men and women, although psychologists pointed out that there are types of "intelligences" and men have better math and spatial skills, while women have better verbal skills (Blickenstaff, 2005; Hyde, 1996). The studies on "brain structure and function, of hormonal modulation of performance, of human cognitive development, and of human evolution have not found any significant biological differences between men and women in performing science and mathematics that can account for the lower representation of women in academic faculty and scientific leadership positions in this fields" (NAS, 2007, p. 4). In addition, another aspect that demonstrates that the lack of women in ST is not explained by biological aspects is that women with high-level mathematical skills choose careers in the humanities more often than men who have similar skills (Ceci, Williams & Barnet, 2009).

Personality and self-efficacy.

Some studies stated that there is a relationship between the types of personalities and career choices (Kimingo, Kindiki & Misigo, 2016). Holland's Theory of Career Choice (1985) affirmed that personality influences an individual's decision and he/she tends to choose a profession according to the degree of satisfaction it gives him/her. Individuals choose work environments where they can develop their type of personality (Bejar, 1993; Holland, 1985). Holland (1985) stated that each type of personality is the result of cultural and personal factors, since each person performs tasks that constitute a predisposition to prefer a type of work. Other studies indicate that personality traits related to the career choice are less important than the interests and perceptions of one's skills (Farias, Garcia, Monforte & Protto, 2013).

In addition, several studies addressed self-efficacy, and men and women who chose ST careers. According to Bandura (1977), self-efficacy is defined as the expectation of successfully completing the tasks required to achieve a desired goal. This might influence the individual's career choice and career persistence. Research results showed that women majoring in science reported significantly higher scientific self-efficacy than those who were undecided or chose non-science majors (Scott & Mallinckrodt, 2005). Moreover, women who reported high levels of their math skills self-concept were more likely to report STEM-related career goals (Sax, Lechman, Barthélemy & Lim, 2016).

Attitude towards science.

One of the factors identified in the literature to explain if ST careers are attractive for women is the personal attitude toward science. Muñoz and Weaver (1997) analyzed science students in Ecuador and found that the main reason for female students to choose a science career was their predilection and interest in sciences more than the prestige or good employment prospects. On the other hand, VanLeuvan (2004) examined the desirable versus undesirable aspects of science of 66 young women who

completed surveys in Grades 7 and 12. The results showed that, over time, the participants' aspirations and interest in science, engineering, and mathematics careers decreased. The most undesirable aspects about a ST career were “to do mathematics, the hard work and the lack of interest to work in these fields” (p. 253). The students did not describe these careers as a male domain or an inappropriate field for women. In addition, Weinburgh (1995) conducted a meta-analysis of the literature published from 1970 to 1991 in order to determine gender differences in attitudes. The results showed that male children have a more positive attitude toward science than females in all fields of science. According to Blickenstaff (2005), it is clear that there are significant differences between female and male attitudes toward science, because women are less attracted to science than men. Blickenstaff considers that it is important to make efforts to improve girls’ views of science by changing the curricula and pedagogy.

3.2 Family Factors

Family factors are the transfer of knowledge, norms and values previously constructed in society, which occur within a social relation—usually with blood relatives. The family is one of the social agents that have the most influence on career aspirations, since choosing a career is not only an individual decision (Brown, 2004; Dahling & Mindi, 2010; Shin & Kelly, 2013; Turner & Lapan, 2002). Schultheiss *et al*. (2001) pointed out that the family (parents, brothers and sisters) give support, emotional closeness and the stimuli for the person to decide about his/her career. The following individual factors has been identified: (a) stimulation and family support; (b) family background; (c) educational level of parents; (d) stereotypes in the family about science; and (e) household demands: work and family conflict.

Stimulation and family support.
Rayman and Brett (1995) studied the factors related to the persistence of women who majored in science and mathematics during their undergraduate studies at a leading women's college in the US. The results showed that family encouragement, more than family background (father's occupation), is one of the factors that predicted women's persistence in science. Parents who encourage their children to pursue a ST career and provide access to learning experiences related to ST influences the children’s interest in these areas (Aschbacher, Li, & Roth, 2010; Rayman & Brett, 1995). Different studies indicate that parents significantly influence the development of their daughters’ skills to get involved in ST (Frome & Eccles, 1998; Hanson, 2007; Scott & Mallinkckrodt, 2005; Astin & Sax, 1996). Sax, Lehman, Barthelemy and Lim (2016) noted that parents who enrolled their daughters in math and science courses influenced their subsequent choice of a ST career. These findings are important “because it opens up possibilities for intervention strategies, including enlisting the informed support of parents in regard to their daughter’s educational and career aspirations” (Rayman & Brett, 1995, p. 405).

Christine, O'Neill, Rutter, Ypung and Medland (2017) concluded that the successful recruitment, retention and eventual success of students in ST careers mainly depend on the type of support offered during their schooling and college transition, especially for young women.

Family Background: parents in science.
Having parents who studied science seems to influence women to choose a major in science or mathematics, that is to say, it seems to influence them to be involved in

science. Bevins et al. (2005) interviewed 1,000 scientists in England. In 29% of the cases, their parents had a strong influence in their career choice and, from these; three-quarters had parents who were also scientist. Another study conducted in the United Kingdom found that young persons with family contacts or acquaintances linked to ST tend to choose a career related to that field (Bevins et al., 2005). However, Rayman and Brett (1995) concluded that family characteristics (i.e. having parents in science) were not significantly related to persistence in science after graduation, although these are often very important when choosing a major in science or mathematics.

Educational level of the parents.

Some studies state that the parents' educational level influences their children's career choice. Therefore, women with parents with a high level of education are more likely to choose ST careers (Ware, Steckler & Leserman, 1985; Astin & Sax, 1996). This family influence seems to be explained by three reasons: (a) when parents have a high level of academic achievement "are more likely to instill in their sons and daughters the notion that such accomplishments are possible, desirable and even expected (Ware, Steckler & Leserman, 1985, p. 77); (b) highly educated parents are more likely to afford their children's education and they will have "less conventional ideas about what constitutes appropriate behavior for women and will be more willing to encourage their daughters in nontraditional pursuits" (Ware, Steckler & Leserman, 1985, p. 77).

Stereotypes about science in the family.

Since family is an institution that influences in social reproduction (Bourdieu, 1984), it also influences gender stereotypes, which include the parents' beliefs about the relationship between genders and careers (Watt & Eccles, 2008) and the models in the professional career (Sonnert, Fox & Adkinks, 2007). Stereotypes in the family are an important component that affects women's choice to pursue a ST career.

Household demands: work and family conflict.

In many cultures, taking care of the children, elderly or disabled is an activity delegated entirely to women. When women have a professional career and decide to have their own family life, specifically to become mothers, they face other challenges. This can be a controversial process due to the double workday (Maffia, 2008). Professional women, in addition to having a paid job, they also perform unpaid housework that takes a great deal of time. The division of time between work and family responsibilities explains many of the differences between the jobs accepted by men and women. In the case of women in science, a study conducted by Maffia (2008) pointed out that women resolve the conflict of family and professional roles by delaying motherhood, abandoning the scientific career, giving up personal time, pursuing more modest and manageable careers, or not having children.

Goulden, Mason and Frasch (2011) studied women who held a PhDs in science (Unites States) and found that family formation (marriage and childbirth) account for the largest leaks in the pipeline between the doctoral degree receipt and the acquisition of tenure for women in the sciences. Another study conducted in India highlighted the importance of supportive mechanisms at the workplace (e.g. providing accommodation on campus, transportation, childcare, elder care facilities) that are crucial to ensure the retention of women in science (Kurup & Maithreyi, 2011). Fox, Fonseca and Bao (2011) studied faculty members in nine highly ranked research universities in the US and found that children in scientists' households tend to increase the work-family conflict. The conflict

varies depending on the age of children, the direction of work-family interference and the faculty's gender. Howe-Walsh and Turnbull (2016) conducted a research on the barriers that women in academia face when they want to achieve leadership positions in ST in UK universities. The results showed that family responsibilities are more complex for women in science than in other professions due to high levels of competition, the pressures of securing grants and funding for the research projects, and work patterns of science, which require to monitor experiments over the weekends and to allocate laboratory time. This becomes even more complex when the institutions lack of family-friendly policies (Barnard et al., 2009).

Also, according to Sonnert (1999), many married women scientists "face the challenge of synchronizing the often conflicting demands of three clocks, their own career clock, their partner's career clock, and their biological clock" (p. 41). Since many women scientists are married to scientists, they have problems to find two scientific jobs in the same geographical area. In addition, since women are usually younger than their partners and they are at an earlier stage of their career, they usually end up giving preference to the husband's career development (Sonnert, 1999).

3.3 Social Factors

Social factors are characterized by socio-cultural constructions of global and local groups that are transmitted through social relations. Human beings live within interpersonal networks and cultural contexts that shape their development, behavior, opportunities and choices. The skills people have are not only the result of a biological process, but also of social and cultural influences that start at birth and are maintained throughout life (National Academy of Science, 2007). Social factors are: (a) the cultural beliefs about gender and science; (b) lack of congruence of roles; (c) "chilly environment" (segregation in scientific communities, lack of networking activities) (d) racial barriers and; (e) lack of role models.

Cultural beliefs about gender and science (stereotypes).
Stereotypes are "the pictures in our head that simplify the world that save us the trouble of thinking too much when we come into contact with other people. These pictures are expectations of what people will be like and what they can and cannot do, and are usually generalized to all members of the group" (Lippman, 1992 cited by Delisle, Guay, Senecal & Larose, 2009, p. 469).

Steele (1997) studied the *stereotype threat* and defined it as the fear caused by the expectation that one will be judged or treated in terms of a negative stereotype of one group. According to Steele (1997), negative stereotypes about women's science skills can affect their career choice; the influence of professors and parents can affect the idea of what women can achieve and develop. Stake (2003) proposed that, to address this problem, it is necessary to create programs that can provide a pro-woman learning environment to support young women's science interests and thereby mitigate the influence of the stereotype threat.

Societies have specific stereotypes about gender. These start in early childhood when society treats boys and girls differently, stereotyping their skills (Condry & Condry, 1976). Ceci, Williams and Barnet (2009) noted that the underrepresentation of women in mathematics probably have more socio-cultural causes than biological causes. The

literature considers several cultural beliefs about gender and science that influence the low female participation in science.

First, the fact that science and math continue to be stereotyped as masculine (Young, Rudman, Buettner & Mclean, 2013). Reskin, Koretz and Francis (1996) stated that the roots of women's underrepresentation in science “lie in cultural beliefs about gender and science. Children so thoroughly absorb the belief that science is a male endeavor that a small minority of female secondary students express interest in scientific careers” (p. 64). According with Sandker and Saadjer (1994, cited by Stout, Dasgupta, Hunsinger & McManus, 2011), in US high schools, girls are subtly reminded that “science is for boys” by the lack of reference to women in science in curricula, teachers and textbooks. Moreover, Deemer, Thoman, Chase and Smith (2013) studied female undergraduate students enrolled in chemistry and physics laboratory classes in the US. The results showed that the stereotype threat exerted a significant negative indirect effect on women’s science career choice in physics but not in chemistry. However, this stereotype is not similar in all cultures. Lagesen (2008) studied higher computer science education and found that there are more women in this field. This field is not considered “masculine” and, on the contrary, it is deemed as providing suitable jobs and good careers for women.

Second, some studies affirm that women are exposed to the stereotype that their performance in science and math is worse in comparison with their male peers. According to Furnham, Reeves and Budhani (2002), elementary school parents have lower expectations in math and science for girls than for boys. Stereotypes may be reinforced by the teachers who have different expectations for boys versus girls in science courses (Van Leuvan, 2010). Research conducted in Germany and North America suggested that gender stereotypes about women’s lower ability in domains, such as math and reasoning, have the potential to undermine women’s self-perceptions of their ability, performance and interest in pursuing a career in counter-stereotypic masculine disciplines (Eccles, 1987 cited by Smeding, 2012; Steele, 1997; Deemer, Lin & Soto, 2015). Previous studies state that the belief about their ability in a particular field affects the decisions students make when they choose their careers, that is to say, students who believe they have science skills are more likely to choose a science career (Deboer, 1986). Therefore, since women believe that they do worse than men in science do, this could have an effect on choosing a science career.

Reuben, Sapienza and Zingales (2014) conducted an experiment and found that when an employer had no information other than the candidates' physical appearance, women were only half as likely to be hired as men, because they were (erroneously) perceived as less talented for arithmetic tasks. Both men and women expected women to perform worse. Moreover, Sheltzer and Smith (2014) analyzed the representation of women in biology and found that male faculty members strive to employ fewer female graduate students and postdoctoral researchers (postdocs), while female faculty did not exhibit a gender bias in employment patterns. Hopkins (2015) reflected on the progress for women in science and concluded that there is an unconscious gender bias in scientific communities, in which “men of lesser accomplishment often had more accouterments of success than women who were better scientists and had made more important discoveries” (p. 160).

Third, stereotypes about the level of commitment to their work in science. Ellemers et al. (2004) examined the possible explanations for the underrepresentation of women among university faculty. They analyzed doctoral students in the Netherlands and Italy, and found that faculty members perceived female students to be less committed to their work than male students and female faculty endorsed these gender-stereotypical perceptions most strongly. The study concluded that stereotyping of women emerges as a plausible reason that women have more difficulties to have a successful academic career in science than men do.

Fourth, stereotypes related to science as a solitary and extremely demanding work can also affect the female presence in this field (Astin & Sax, 1996).

It is important to note that these cultural aspects are not identical in the several countries. Research results show that even though the nature of problems appears to be similar to those faced by women in science, the specific form of biases varies, and the cultural context molds the specific forms of discrimination (Gupta, 2007).

Lack of role coherence.

Several studies suggest that women's underrepresentation in science is explained by the theory of role coherence, which suggests that persons are rewarded and feel more positive when they assume social roles consistent with cultural expectations. Other research studies affirm that the existence of stereotypes might be a factor of the underrepresentation of women.

Career decisions are influenced by the extent to which one perceives an occupation as being consistent with his or her self-concept. Carli, Alawa, Lee, Zhao and Kim (2016) studied the stereotypes of successful scientists and found that “women are thought of as having less agency and being more communal and more passive than a successful scientist; women are perceived as less similar to scientists than men are” (p. 256). Stout, Grunberg and Ito (2016) indicated the there is a widespread belief that sciences careers involve working with inorganic materials in isolation, being paid well with little opportunity to maintain relationships, and working to serve others. Diekman, Brown, Johnston and Clark (2010) stated that one of the reasons for the lack of women’s presence in science is that these careers were perceived to impede communal goals. Traditionally, the feminine role has been related to community and service activities, that is to say, activities that allow helping other people and working with people. In this sense, women interest in communion and expectations that science careers do not provide the opportunity to work to serve others, can explain women's relatively low interest and negative attitudes towards science (Stout, Grunberg & Ito, 2016). According to Sax, Lechman, Barthélemy and Lim (2016), “interest in service and people oriented careers, combined with a perception that STEM fields present limited opportunities to help others, dissuade many women from pursuing a STEM field” (p. 3). The authors suggested that the lack of fit between the female gender role and the role of a scientist might undermine people's evaluation of women scientists.

“Chilly environment” (segregation in scientific communities, lack of networking activities)

Science is not an autonomous and isolated space from social life because it is a social construction defined by scientists. Several studies related to gender and science

indicated that there is sexism and androcentrism in science that harms the income and development of women in this academic and professional field (Rodríguez, 2010).

Some studies suggest that one of the factors influencing the lack of female participation in science is the “chilly environment”. This factor is related to women's exclusion from study groups, sexist remarks in classes and labs, sexual harassment and unsupportive academic environments (LaCosse, Sekaquaptewa & Bennett, 2016; Hollenshead et al., 1994, cited by Reskin, Koretz & Francis, 1996; Ramsey & Betz, 2013). Knights and Richards (2003) researched the employment of women at universities in the United Kingdom and pointed out that academic careers are outlined according to the male vision of success: active research and an uninterrupted career, where the meritocratic systems of inequality reflect and reproduce the discourse of masculinity practices that has disadvantages for most women and some men. The meritocratic model of equal opportunities includes sex discrimination but, due to the unequal internal division of labor and gender asymmetry in childcare, meritocracy also reinforces the advantage of men over women. Moreover, Settles, Cortina, Malley and Stewart (2006) studied “the climate” for women in academic science and found that a sexist climate, sexual harassment and gender discrimination create serious obstacles for women scientists, while a positive climate and strong leadership are factors that promote positive outcomes for women in science. The findings suggest the importance of the workplace environment for women scientist and the fact that women may be *in* science but not *of* the social science community (Cole, 1981).

In terms of social support, Morganson, Jones and Major (2010) studied the social support coping (includes looking to others for emotional support as a way to deal with the challenges and get help from other person to overcome the stressors) to explain the gender gap in undergraduate students in science in the US. The study results showed that women reported to use the social coping more than undergraduate men.

About networking, Howe-Walsh and Turnbull (2016) studied the barriers faced by women in academia to achieve leadership positions in ST at UK universities. The results showed that the culture is dominated by men and it affects the day-to-day practices. The results also showed that they are excluded from the networks and this limits the opportunities for career development. The culture dominated by men makes women to feel intimidated and, hence, they consider leaving their academic careers. Fox (2010) studied faculty members in nine highly ranked research universities in the US and found that women are less likely than men to report research studies. This shows the lower integration of women researchers in the science community. Stamm (2010) stated that, for scientists, it is essential to participate in research networks, since it allows them to know what is going in their research fields and to interact with other colleagues. In this sense, participation in international networking activities can help women to promote their academic careers.

Racial barriers.

Some studies suggest that women's race and ethnicity impact their experiences in ST fields (gender discrimination, educational environments that perpetuate negative racial stereotypes, minority student’s experience with isolation from white peers and faculty and stereotype threat) (Quentin & Hermann, 2015; Beasley & Fischer, 2012). Ong, Wright, Espinoza and Orfield (2011) pointed out that women of color are underrepresented in ST not because they are less interested than white women, but

rather due to a set of factors related to inequities in education. Although they were ultimately successful, their career paths were more difficult because, in part, their recognition was disrupted by the interaction with gender, ethnic, and racial factors (Carlone & Johnson, 2007). In addition, African American, Latino, Native American and low socio-economic women are underrepresented in several disciplines and only Asian women are overrepresented in ST (Sax, Lehman, Barthélemy & Lim, 2016).

The absence of role models.

Studies have shown that students are more likely to select careers when they can identify a role model in that career path. Further research has shown that the success of this strategy is enhanced by the use of gender-matched role models (Buck, et al., 2008). The existence of models seem to influence women's choice for ST careers (Smith and Erb, 1986; Glenn, 1996; Stout, Dasgupta, Hunsinger & McManus, 2011; Sonnert, 1999; Smith, 2011; Cheryan, Drury & Vichayapai, 2012). Sonnert, Fox and Adkins (2007) found that the proportion of women among undergraduate science majors is related to the percentages of women among faculty in these fields. The findings suggest that female science professors benefit female students because they identify them as role models. Young, Rudman, Buettner and Mclean (2013) found that when female professors were seen as positive role models, women automatically identified with science and stereotyped science as more feminine field. Moreover, viewing professors as positive role models was associated with pro-science career aspirations and attitudes (both implicit and explicit), for men and women. The authors conclude that female STEM professors not only provide positive role models for women, but they also help to reduce the implicit stereotype that science is masculine. Stout, Hunsinger and McManus (2011) conducted several experiments with undergraduate women majoring in STEM disciplines. The results suggested that increasing young women's exposure to female scientists, mathematicians and engineers shall strengthen female self-identification with STEM, enhance feelings of self-efficacy, positive attitudes and motivation to pursue STEM careers. Early (2017) noted the importance of school programs oriented to promote girls' participation in projects in which they interview and meet women scientists in an area of interest in order to realize that this career path is available to them. However, it is important to distinguish between role models (people with whom you can identify) and mentors (someone who takes interest in another person, provides opportunities and encourages him/her to continue in a ST career) (Dryburgh, 2000). On the other hand, authors also suggest modifying illustrations and photographs of scientific texts, where the majority of scientists are illustrated as men (Walford, 1981).

However, the small population of women in science is a problem because it generates a lack of role models for young students (Grant, 1995), as well as the possibility of obtaining information about career options in these fields. In addition, a low proportion of women in a field are likely to send a message to women saying that that discipline is not attractive for women (Blickenstaff, 2005).

On the other hand, Morganson, Jones and Major (2010) studied the social support coping (includes looking to others for emotional support as a way to deal with the challenges and get help from other person to overcome the stressors) to explain the gender gap in undergraduate students in science in the US. The study results showed that women reported to use the social coping more than undergraduate men.

3.4 Educational Factors

Educational factors are institutional and educational pedagogical issues. Since these transmit knowledge between individuals, these factors are social too. Educational factors are: (a) pedagogy in science; (b) academic performance; (c) belief about science skills and; (d) vocational stereotypes and expectations.

Science curriculum and pedagogy.
Some studies consider that pedagogy in science tend to promote a high level of competence, portraying science careers as lonely and excessively demanding (Astin & Sax, 1996). Seymour (1995) conducted an ethnographic study on seven campuses in US to understand why students leave the science programs. The results showed that pedagogy was a concern of over 90% of students who chose to switch careers. In addition, students found science faculty to be aloof and indifferent, unapproachable, mainly focused on research and lacking motivation for teaching.

Chavez (2018) pointed out that the hidden curriculum reproduces gender stereotypes within educational dynamics; therefore, faculty speeches, school trends, among others, reveal the unequal treatment of faculty towards female and male students. Whitelegg (2001) stated that the equal opportunities approach is not enough to generate positive scientific experiences for young women within the classroom. Blickenstaff (2005) noted the teaching methods in science clearly have an effect on how students perceive the subject. The pedagogy can reinforce girls' negative attitudes about science if their contributions are devaluated. For instance, Warrington and Younger (2000) concluded that there are sexist aspects in the faculty. According to their study, teachers tend to be flexible with boys' test scores, while they tend to underestimate girls' scores in the same tests. In addition, even though boys were not doing their work, they managed to pass the exams, while girls who regularly completed their tasks were not taken seriously. The studies emphasized the need for a "female-friendly" teaching.

Blickenstaff (2005) affirmed that sex bias should be eliminated in school textbooks and make science courses more accessible to women by covering less material in greater depth, instead of emphasizing on the breadth of the topics. It is also clear that the manner in which science is taught has an effect on how students perceive the course; therefore, when the contribution of female students are devalued, their negative attitude toward science is reinforced.

Academic Performance.
Some studies attribute the lack of women in ST careers to the different academic performance of men and women. In the Educational Testing Service (ETS) report, which is the outcome of a different tests given to students in US schools, points out that there is not a dominant gender that stands out in the classrooms. The difference in the average performance in all subjects between the sexes is almost zero. However, this indicates that the gender difference changes through time, that is to say, there is less differences between sexes in elementary school and more in high school. In this process, there is a small advantage of men in math and science, while females have the advantage in humanities (Cole, 1997; Eccles, 1994).

Some researchers suggested that sex differences in mathematics and science derived from innate predispositions to learn different things, because boys are oriented to

objects and girls to persons (Baron-Cohen, 2002). Nevertheless, several studies have shown that this is inaccurate, since both sexes early in life show interest in individuals and objects (Maccoby & Jacklin, 1974). Baillargeon, Kotoyksy and Needham (1995) affirmed that when there is gender differences in science, girls temporarily excel in these areas. Spelke (2005) found that, in infancy and childhood, boys and girls reveal the same ability to perceive and represent objects, spaces, and numbers. This means that the skills that underlie the achievements in science and mathematics are likely to be developed with a complex interaction of intrinsic capabilities perfected by everyday experience and instruction. In accordance with Blickenstaff (2005), despite the fact that women are equally or better prepared than men for scientific or technical majors, they still drop out from science programs to greater rates. "If very well prepared women are still leaving STEM, then there must be other factors causing departure" (Blickenstaff (2005, p. 374).

Belief about ability in science.

Several studies found that the belief about the students' ability in science during their school years affects the science decisions that these students make when they start college; students who believe they have ability in science are more likely to choose a science curriculum in college than those who do not (Aspires, 2013; Deboer, 1986).

Farmer, Wardrop and Rotella (1999) found that both women and men in science careers, in comparison with those in nonscience careers, took more high school elective science courses because they wanted to aspire to high prestige careers as young adults, and they attributed their math success more to their ability. This result is consistent with Bandura (1986, cited by Farmer, Wardrop & Rotella, 1999), who affirmed that success in math and science course work "influence people's belief in their ability to succeed in these types of activities in the future and to increase the likelihood that people will choose to engage in and persist in these activities in the future" (p. 767). Moreover, Ecles (1994) stated that people tend to persist in activities in which they believe they will succeed. A study conducted with students in Bogotá (Colombia) found that students will more likely choose a career in engineering if they get high grades in Biology, Chemistry, Physics, and/or Mathematics tests (Pineda, 2015).

Vocational expectations and stereotypes.

About the students' vocational expectations, the Organization of Ibero-American States for Education, Science, and Culture (OEI) conducted a research between 2008 and 2010 with high school students in Paraguay, Colombia, Argentina, Peru, Spain, Uruguay and Brazil. The results showed that, from the adolescents' perspective, there is a decline or stagnation in scientific vocations in natural sciences and engineering (Polino, 2012).

Also, the ROSE project (Relevance of Science Education), a research conducted in 41 countries, pointed out that the vocation of ST is not attractive for high school students, especially for women (Schreiner & Sjøberg, 2004). Based on this study, Vázquez and Manassero (2008) found that, in developing countries there are less gender differences and students like science courses. In contrast, in developed countries, science is not perceived as a nice subject and women like it less than men. Concerning work expectations, in developing countries the answer is positive, while in most industrialized countries the answer is negative, especially from women. However, a study in Malaysia found that there are large numbers of women in computer science. This field is not

perceived as “masculine”, it is rather considered as a field that provides suitable and good jobs for women (Lagesen, 2008).

In relation to student stereotypes, a research conducted in primary and secondary schools in London concluded that there are stereotypes of white men in scientific careers, more than a female image. In addition, girls aspire to “arts” and “care” careers. Young women defined as “very feminine” are less likely to aspire to ST careers. Girls who aspire to ST careers tend to be more academic and prone to be described as “not feminine” (aspires, 2013).

3.5 Labor-economic factors

The elements that include the subject’s involvement in an activity are considered labor factors. The objective may be to satisfy a need (biological, financial, personal etc.) Labor factors are: (a) lack of information about careers in science; (b) vertical segregation; (c) horizontal segregation; and (d) wage gaps.

Lack of information about careers in science.
A study conducted with Peruvian school students (CONCYTEC, 2015) found the different barriers for developing science courses at schools. These are: (a) students’ scarce “scientific culture” and their misinformation of what is a ST career; (b) the limited school experiences with ST issues in both quantitative and qualitative aspects; (c) the lack of role models in ST who can demonstrate that these professions can offer personal and economic stability and satisfaction; (d) young people’s stereotypes with regard to ST professionals; (e) the general perception that ST jobs are of vital importance for society, but these are not recognized or valued by the Peruvian government; (f) the lack of teachers who are informed about the variety of ST professional careers and work opportunities; (g) the influence some private colleges have during school visits to provide information (and, in many cases, immediate admission) about the careers these offer; (h) the limited support and guidance available to young people when choosing a career. The cited study revealed the particularities of a Latin American country. The lack of information about what a ST career means and the lack of professionals to inform students about ST careers can be attributed to the lack of ST professionals.

Vertical segregation.
Vertical segregation refers to the distribution of occupations, where women are focused on “feminine” activities according to the traditional division of labor, in which there are highly masculinized or feminized careers (Anker, 1997). Vertical segregation in science reflects the barriers women have to face when they obtain high responsibility positions. For this reason, women manage fewer projects; they rarely achieve top corporate positions and they are almost never involved in decision-making processes related to science policy (Maffia, 2008). The few women in leading R&D positions could be explained by several reasons, such as the balance between work and personal life, patterns and approaches to gender specific productivity, and performance measurement criteria and promotion (UNESCO, 2007). Several studies address vertical and horizontal segregation in academia and research institutions (Piscova, 2003).

However, Ceci and Williams (2011) pointed out that discrimination, as an explanation to the underrepresentation of women in the field of mathematics, is out of date. Women

who get jobs that offer less benefits are not excluded from job interviews because they were recruited. If they do not receive subsidies and their work is not published in magazines is not because of their gender. On the contrary, the problem lies in the factors surrounding the family education, upbringing of children, gender expectations, lifestyle choices and preferences of careers, since some women already prefer a professional career before or during adolescence. The differences between sexes in mathematical performance should be considered during the admission exams to graduate schools. Finally, the factor of fertility and work-life balance should also be taken into account. In this sense, according to Ceci and Williams (2011), the underrepresentation of women nowadays is the result of various interrelated factors and it is not a consequence of a vertical segregation.

Horizontal segregation.

Horizontal segregation, also considered as disciplinary segregation, is the hierarchical division in the same occupation. This segregation refers to the division of labor market where, in many cases, women opt to pursue careers that are socially less valued, peripheral and monotonous care tasks, teaching, among others (Anker, 1997). Women can play stereotyped gender roles in science (Maffia, 2008). This can be noted in the high participation of women in humanistic research, while there are few women in scientific research (Borrás, & Bucci, 2016). According to Borras and Bucci (2016), there are three principles that are reproduced: (a) extension of household chores: teaching, care, service; (b) women do not have authority over men, so they are assigned assistance tasks; and (c) men have a monopoly on technical objects and machines. This does not mean that other careers are less important; these still reproduce traditional gender stereotypes when choosing and practicing a professional career.

Even though there are several factors related to the social context of science, gender stereotypes are particularly key elements in low-income women in science (Kuwahara, 2001). Holland (1985) pointed out that, when choosing a career, people are bounded by the occupational stereotypes, which are based on the population's generalized visions about some careers. The social factors that influence young people, with the so-called professional "myths", divide careers based on the stereotypes that define them as female or male occupations (Croxford, 2002). Miranda (2007) stated that there is a belief that women do not have to work in careers of technology. This reinforces the stereotype related to the "natural" inequality for women.

Wage gaps.

When choosing a professional career, there are intrinsic values that involve several aspects, such as affections, feelings and intellect; but there are also extrinsic values, such as choosing a career for the prestige, money, etc.

Several studies show that, when young people enter into the professional labor market, the trend is to have equal salaries for both men and women. However, due to the multiple roles of unpaid work—that is, maternity or the little help from their parents to take care of children—women lose the opportunity to obtain raises or bonuses, and their relative wage decreases in comparison with men's salaries. In addition, it is important to note that wage differences are more evident in highly qualified professionals, since the salaries of male scientists, professionals and technicians double the salaries of women in the same position (Birgin, 1995).

According to UNESCO (2007), women who work in ST are paid less than men, even though they are both equally qualified. Women are less likely to be promoted; therefore, they are lowly ranked in lower levels of ST classification and receive lower salaries. Gunderson (1994) stated that there are different reasons for the wage gap between men and women: (a) differences in the accumulated capital (education, experience, etc.); (b) wage differences in the same occupation; (c) different wages for equal work; (d) difference in unwanted jobs; and (e) differences in available jobs. There is a wide range of international information about the segregation of women in industries and occupations with low wages. In addition, Junt (2016) studied women who worked in engineering in the United States. The results showed that the main reasons of the higher exit rate of women from engineering are the dissatisfaction with the salary and promotion opportunities. Family-related reasons were considered as secondary factors. However, Ceci and Williams (2011), who studied women in academic science in the United States, indicated that "nearly all current salary differences can be accounted for by factors other than discrimination, such as women being disproportionately employed at teaching-intensive institutions that pay less" (p. 3160), or because women are more likely to work fewer hours and at part-time positions to achieve work-family balance.

Conclusions

The lack of women in ST has been mainly addressed since Rossi's publication: *Women in science: why so few?* in 1965 in the United States (Vázquez-Cupeiro, 2015). The literature review shows a wide range of variables that try to explain the low participation of women in ST careers in specific stages of their life. However, few studies address the phenomenon with a longitudinal approach, taking into account the various stages of women's lives. In addition, due to the complexity of the phenomenon, the papers introduced the different variables in an unclear way.

Previous research used the qualitative and quantitative approaches. The qualitative studies focused on delving into particular and barely visible aspects of women in science; however, in spite of the approach, there is certain consistency to reach a consensus with respect to the factors that influence the access, participation and progress of women in ST.

Quantitative studies focus primarily on correlating a specific variable or factor with the participation of women in ST in a specific stage of their life cycle, that is to say, women at school, university or women professors. Research results showed that most of structural models that explain the intention to pursue a career in science can be traced back to the theoretical bases developed by Bandura (1977), since almost all of these include self-perceived self-efficacy as an explanatory variable. However, there is no consensus on the contextual factors (e.g., family support, learning opportunities, or financial difficulties), because researchers only included some of these factors. In addition, contextual factors were not included in the conceptual models in an integrated way. The previously reviewed literature didn't find conceptual models—based on structural equations—that explain the decision of women to pursue (or continue in) a ST career, based on the interaction among individual, family, social, educational and work factors. The literature review found studies that examined the relationship between specific components separately; for instance, occupational factors related to the intention to pursue a specific career, educational factors and the choice of a ST career,

The problem of the access, participation and progress of women in ST careers is a complex and multicausal event that varies according to the women's life stages and contexts. Some authors have called these stages as career choice (access), career persistence (participation), and career advancement (progression) (Ahuja, 2002). The literature leads us to conclude that the low participation of women in science is not due to biological aspects or to a lack of skills or performance, neither, of course, to a lack of an "innate taste". On the contrary, the literature shows that there are different factors and specific variables related to socio-cultural parameters in the different life stages of women. These influence women's taste for science and their choice to pursue and complete a ST career.

According to Ceci, Ginther, Kahan and Williams (2018), who studied academic women in science, the evidence allows concluding that the main causes of the low participation of women happened before women chose their careers. The causes are related to "the ability-related beliefs, stereotypes, and preferences starting in early elementary school… By the time women reach graduate school, there is evidence that they are as successful as their male counterparts in being interviewed and hired for tenure-track positions, funded, and published (p. 22). Likewise, Ceci and Williams (2011) and Ceci et al. (2018) considered that discrimination is not the main cause of the low participation of women in science. This is mainly related to choices linked to fertility/lifestyles and career preferences (women often prefer careers that focus on people, as opposed to things) freely made or constrained by gendered expectations related to work-family balance, "coupled with inflexibility in tenure-track timetables and employment options" (p. 3160). The low participation of women in math-intensive fields is due to: (i) women preferences, (ii) women with high math competence are more likely to have high verbal competence, which allows greater choice of professions and (iii) women with children are penalized in promotion rates (Ceci, Williams & Barnet, 2008).

However, these conclusions have several problems: (a) do not take into account the different countries and may not be applicable to other cultures, where discrimination and gender aspects have different stereotypes. (b) are focused only on US careers because it is the "home of science, a country where markers are more publicly defined, and it is the place where future scientists are trained" (Long, 2001 cited by Henly, 2015, p. 668), and does not take into account the different professional areas where women in science and engineering specialize. (c) are centered in math-intensive fields; the reasons in other areas of science may be different. (d) other authors believe that, although it seems that academic measures of success appear neutral, women experience subconscious biases and discrimination as a result of the subjective measures of success that disadvantage them (Henley, 2015).

The conducted literature review allowed us to propose an integrated framework of five factors that influence the participation of women in ST careers: (a) Individual factors, which are external variables in the subject based on his/her agency, i.e. the ability to interpret, assimilate, redefine, and/or reproduce; (b) Family factors, which are the transfer of knowledge, norms and values previously constructed in society and occur within a social relation—usually with blood relatives; (c) Educational factors, which are institutional and educational pedagogical issues. Since these transmit knowledge between individuals, these factors are social too; (d) Social factors, which are characterized by socio-cultural constructions of global and local groups that are transmitted through social relations. These can be institutional or symbolic. Social

factors, which involve political and scientific factors, are cross-sectional to the above-mentioned factors; and (e) Labor-economic factors, which are elements that include the subject's involvement in an activity. The objective may be to satisfy a need (biological, financial, personal etc.)

The proposed research will be useful for researchers and policy makers because it schematically and orderly introduces the factors that affect the access, participation and progress of women in ST careers, and identifies the gaps in past research studies. The lack of evidence on these factors in different cultures, countries, fields of science, and stages of women's lives, makes evident the need to continue conducting research on this topic in the future.

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Table 1 Most Cited Articles Regarding Women Underrepresentation in Science

Author(s)	Article's Title	Journal	Citations	Methodology	Findings:
Steele, C.M. (1997)	A threat in the air: How stereotypes shape intellectual identity and performance	*American Psychologist*	2.573	Quantitative research methodologies	They argue that one important reason for this discrepancy is that STEM careers are perceived as less likely to fulfill communal goals than careers in other fields. Such perceptions might disproportionately affect women's career decisions, because women tend to endorse communal goals more than men. They found that STEM careers, in comparison with other careers, were perceived to impede communal goals.
Carlone, H. B., & Johnson, A. (2007)	Understanding the science experiences of successful women of color: Science identity as an analytic lens	*Journal of Research in Science Teaching*	311	Ethnographic interviews	Authors developed a model of science identity to make sense of the science experiences of 15 successful women of color over the course of their undergraduate and graduate studies in science and into science-related careers.
Blickenstaff, JC. (2005)	Women and science careers: leaky pipeline or gender filter?	*Gender and education*	285	Meta-analysis	This paper explored the broad array of explanations for the absence of women in STEM put forth in the literature over the last 30 years.
Ceci, S., Williams, W., & Barnett, S. (2009)	Women's underrepresentation in science: sociocultural and biological considerations	*Psychological Bulletin*	279	Meta-analysis	Factors unique to underrepresentation in math-intensive fields include the following: (a) Math-proficient women disproportionately prefer careers in non-math-intensive fields and are more likely to leave math-intensive careers as they advance; (b) more men than women score in the extreme math-proficient range on gatekeeper tests, such as the SAT Mathematics and the Graduate Record Examinations Quantitative Reasoning sections; (c) women with high math competence are disproportionately more likely to have high verbal competence, allowing greater choice of professions; and (d) in some math-intensive fields, women with children are penalized in promotion rates. The evidence indicates that women's preferences, potentially representing both free and constrained choices, constitute the most powerful explanatory factor.
Ceci, S., & Williams, W. (2011)	Understanding current causes of women´s underrepresentation in science	*Proceedings of the National Academy of Sciences of the Unites States of America,*	260	Critical review	To better understand women's underrepresentation in math-intensive fields and its causes, we reprise claims of discrimination and their evidentiary bases. Based on a review of the past 20 years of data, we suggest that some of these claims are no longer valid and, if uncritically accepted as current causes of women's lack of progress, these can delay or prevent to understand the contemporary determinants of women's underrepresentation.
Spelke, E. (2005)	Sex differences in intrinsic aptitude for mathematics and science?: a critical review	*American Psychologist*	250	Critical review	The article provides evidence that mathematical and scientific reasoning develop from a set of biologically-based cognitive capacities that males and females share. These capacities lead men and women to develop equal talent for mathematics and science.

Frome, P. M., & Eccles, J. S. (1998)	Parents' influence on children's achievement-related perceptions	*Journal of Personality and Social Psychology*	241	Quantitative research methodologies	Data from 914 sixth-grade adolescents and their parents were used in this paper. Results showed that parents' perceptions mediate the relation between children's grades and children's self and task perceptions in both domains.
Weinburgh, M. (1995)	Gender differences in student attitudes toward science: A meta-analysis of the literature from 1970 to 1991	*Journal of Research in Science Teaching*	201	Meta-analysis	This analysis examined gender differences in student attitudes toward science, and correlations between attitudes toward science and achievement in science. Results of the analysis of gender differences in attitude, as a function of science, indicate that boys show a more positive attitude toward science than girls in all types of science.
Stout, JG, Dasgupta, N., Hunsinger, M., & McManus, MA (2011)	Steming the Tide: Using Ingroup Experts to Inoculate Women´s Self-concept in STEM	*Journal of Personality and Social Psychology,*	195	Experiments	Two cross-sectional controlled experiments and one longitudinal naturalistic study in a calculus class revealed that exposure to female STEM experts promoted positive implicit attitudes and stronger implicit identification with STEM (Studies 1–3), greater self-efficacy in STEM (Study 3), and more effort on STEM tests (Study 1).
Diekman, AB; Brown, ER; Johnston, AM & Clark, EK (2010)	Seeking Congruity between Goals and Roles: A New Look at Why Women Opt of Science, Technology, Engineering, and Mathematics, Careers	*Psychological Science*	158	Quantitative research methodologies	They argue that one important reason for this discrepancy is that STEM careers are perceived as less likely to fulfill communal goals than careers in other fields. Such perceptions might disproportionately affect women's career decisions, because women tend to endorse communal goals more than men. They found that STEM careers, in comparison with other careers, were perceived to impede communal goals.

Table 2. Integrated framework of the factors that explain women's underrepresentation in science

Factors	Definition	Factors	References
Individual factors	Individual factors are the external variables in the subject based on his/her agency , i.e. the ability to interpret, assimilate, redefine, and/or reproduce.	Biological aspects	Hyde, 1996; Blickenstaff, 2005; Irwing & Lynn, 2005; NAS, 2007; Ceci, Williams & Barnett, 2009
		Personality and self-efficacy	Bandura, 1977; Holland, 1985; Bejar, 1993; Scott &Mallinckrodt, 2005; Farías, García, Monforte & Protto, 2013; Kimingo, Kindiki & Misigo, 2016; Sax, Lechman, Barthelemy & Lim, 2016
		Attitude towards science	Weinburgh, 1995; Muñoz y Weaver, 1997; VanLeuvan, 2004
Family factors	Family factors are the transfer of knowledge, norms and values previously constructed in society, which occur within a social relation—usually with blood relatives.	Stimulation and family support	Rayman & Brett, 1995; Frome & Eccles, 1998; Astin & Sax, 1996; Aschbacher, Li, & Roth, 2010; Scott & Mallinkckrodt, 2005; Hanson, 2007; Sax, Lehman, Barthelemy y Lim, 2016; Christine, O´Neill, Rutter, Ypung & Medland, 2017.
		Family background	Rayman & Brett, 1995; Bevins et al., 2005
		Parents' educational level	Ware, Steckler & Leserman, 1985; Astin & Sax, 1996
		Stereotypes about science in the family	Bourdieu, 1984; Sonnert, Fox & Adkinks, 2007; Watt & Eccles, 2008
		Household demands: work and family conflict	Sonnert, 1999; Maffía, 2008; Barnard et al., 2009; Goulden, Mason & Frasch, 2011; Kurup & Maithreyi, 2011; Fox, Fonseca & Bao, 2011; Howe-Walsh & Turnbull, 2016
Social factors	Social factors are characterized by socio-cultural constructions of global and local groups that are transmitted through social relations.	Cultural beliefs about gender and science	Condry & Condry, 1976; Deboer, 1986; Reskin, Koretz & Francis, 1996; Astin & Sax, 1996Steele, 1997; Furnham, Reeves & Budhani, 2002; Stake, 2003; Ellemers et al., 2004; Gupta, 2007; Lagesen, 2008; Delisle, Guay, Senecal & Larose, 2009; Ceci, Williams y Barnett, 2009; Van Leuvan, 2010; Stout, Dasgupta, Hunsinger & McManus, 2011; Young, Rudman, Buettner & Mclean, 2013; Deemer, Thoman, Chase & Smith, 2013; Smeding, 2012; Reuben, Sapienza y Zingales, 2014; Sheltzer & Smith, 2014; Hopkins, 2015; Deemer, Lin & Soto, 2015
		Lack of role coherence	Diekman, Brown, Johnston & Clark, 2010; Stout, Grunberg & Ito, 2016; Sax, Lechman, Barthelemy & Lim, 2016; Carli, Alawa, Lee, Zhao & Kim, 2016
		"Chilly environment" (segregation in scientific communities, lack of networking activities)	Cole, 1981; Rodriguez, 2010; Reskin, Koretz & Francis, 1996; Knights & Richards, 2003; Settles, Cortina, Malley & Stewart, 2006; Morganson, Jones & Major, 2010; Fox, 2010; Stamm, 2010; Ramsey & Betz, 2013; Howe-Walsh & Turnbull, 2016; LaCosse, Sekaquaptewa & Bennett, 2016
		Racial barriers	Ong, Wright, Espinoza & Orfield, 2011; Beasley & Fischer, 2012; Quentin & Hermann, 2015; Carlone & Johnson, 2007; Sax, Lehman, Barthelemy & Lim, 2016

		The absence of role models	Walford, 1981; Smith and Erb, 1986; Grant, 1995; Glenn, 1996; Sonnert, 1999; Dryburgh, 2000; Blickenstaff, 2005; Sonnert, Fox & Adkins, 2007; Buck, et al., 2008; Morganson, Jones & Major, 2010; Smith, 2011; Stout, Dasgupta, Hunsinger & McManus, 2011; Stout, Hunsinger & McManus, 2011; Cheryan, Drury & Vichayapai, 2012; Young, Rudman, Buettner & Mclean, 2013; Early, 2017
Educational factors	Educational factors are institutional and educational pedagogical issues. Since these transmit knowledge between individuals, these factors are social too.	Pedagogy in science	Seymour, 1995; Astin & Sax, 1996; Warrington y Younger, 2000; Whitelegg, 2001; Blickenstaff, 2005; Chávez, 2018
		Academic performance	Maccoby & Jacklin, 1974; Eccles, 1994; Baillargeon, Kotoyksy y Needham 1995; Cole, 1997; Baron-Cohen, 2002; Spelke, 2005
		Belief about ability in science	Deboer, 1986; Ecles, 1994; Farmer, Wardrop & Rotella, 1999; ASPIRES 2013; Pineda, 2015
		Vocational expectations and stereotypes	Schreiner & Sjøberg, 2004; Lagesen, 2008; Vázquez y Manassero; 2008; Polino, 2012; ASPIRES, 2013
Labor-economic factors	The elements that include the subject's involvement in an activity are considered labor factors. The objective may be to satisfy a need (biological, financial, personal etc.)	Lack of information about careers in science.	CONCYTEC, 2015
		Vertical segregation	Anker, 1997; Piscova, 2003; UNESCO, 2007; Maffia, 2008; Ceci & Williams, 2011
		Horizontal segregation	Holland, 1985; Anker, 1997; Kuwahara, 2001; Croxford, 2002; Miranda, 2007; Maffia, 2008; Borrás, & Bucci, 2016
		Wage gaps	Gunderson, 1994; Birgin, 1995; UNESCO, 2007; Ceci & Williams, 2011; Junt, 2016