A Brief Analysis of the Situation of Women in Science, Technology, Engineering and Mathematics

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Abstract. Probably, the global discussion about the differences between men and women in all contexts is reaching its climax and maybe in a few years, we no longer have to discuss because it becomes a settled controversy, but that moment has not yet arrived. The aim of this paper is to present a brief discussion of actual data about women's presence in Science, Technology, Engineering and Mathematics (STEM), an overview of the past and present is provided. Next to the present analysis, some reflections of other author and their own point of view will be presented to help the reader to acquire his own criteria about this subject.

Keywords: Women; Science; STEM; Scientific research; equity.

1 Introduction

A few centuries ago, it was completely accepted that the Earth was flat when some began to reflect on the possibility of it being round, the controversy start. Surely we will never know how many discussions or how many failed experiments were conducted before that all assumed that our planet, the Earth, is round. Today this truth is taught as if we have always known it, and if some uneasy question is not flat, it will be looked at with a strange expression or with hilarity: so illogical now sounds what has been accepted as truth for generations! Humanity is called to advance and develop in all aspects; on the intellectual plane, science is a useful path to this end, and not only in the field of Mathematics, Biology or Computer Science but in all sciences: experimental (Physics, Chemistry, Biology, etc.) and experiential (Sociology, Psychology, Philosophy, etc.) [1]. The fact that there are few advances means that more work is needed. And that far from having immovable truths, one has opportunities to discuss issues open to debate and to reflect and continue developing knowledge.

Today, whether the planet is flat or round is no longer a controversy, but equality between men and women is it. Concerning this topic, many studies, debates and events have been carried out, from which it is possible to conclude that little by little a more global vision of the subject is being built, which is not as easy as the affirmation of the roundness of the Earth, since it involves social, human and structural areas, which are very sensitive and in which there is a risk of creating ambiguities and falling into ideologies because although machismo has done a lot of damage, feminism can also

cause it. Analyzing reality in depth helps to form a criterion and see the issues -even the subjective ones- with greater objectivity and amplitude. Surely, the aspiration of many is that one day this topic will not generate wounds, grudges, or resentments, but the certainty that we all need each other and that it is healthy for men and women to share in our scientific task the best of ourselves: contributing creativity, rigor, curiosity, pragmatism, flexibility, creativity, originality, generosity, sensitivity, etc. to our work, so that we enrich ourselves as a research team or group, and make our institutions, our countries and our society grow, leaving a rich legacy of scientific and human knowledge, because researchers -men and women- have the responsibility to direct their knowledge towards a greater good.

2 A look at the past

It is difficult to analyze the proportion of men and women dedicated to the field of knowledge, due to the complexity of obtaining data and analyzing it mathematically. Each country and region has its own characteristics and its figures in this regard are very different. The current publications on the disparity between men and women in the scientific field mention psychological, social and cultural factors to explain the differences; since the biological aspect has been completely overcome since in the past it was thought that women did not have the capacity or character necessary for the study of science and engineering, as Voltaire wrote in his Philosophical Dictionary "there have been wise women, as well as warriors; but there have never been women inventors" [2]. Studies of brain structure and function, as well as hormone regulation, human cognitive development and human evolution have not found significant biological differences in the ability of men and women to perform in any science [3]. On the contrary, psychological, social and cultural factors are widely discussed, from many fields, such as prejudices, stereotypes and customs.

In publications on the role of women in science [4-8], some of the contributions of many women scientists are mentioned, who were either not given due recognition to their work or were banned from universities, research institutes and scientific associations. These women have left behind brilliant contributions to the sciences through their intelligence, systematic approach, curiosity, perseverance and even the ability to sacrifice themselves for knowledge, as they had to hide their names or use pseudonyms to achieve their goals [4].

While several patrician women were able to share the intellectual sphere in the same way as men in Roman times, this was not the case in medieval times. During these centuries, because of the continuous wars and conflicts, the European kingdoms did not promote education, but weapons. Young men of the nobility were encouraged to climb positions in the military career, and young commoners to take up arms and work in the fields or as craftsmen, women took care of children and home; while culture was preserved in the monasteries, where monks studied, deepening mainly philosophy and theology, repeating Greek and Roman knowledge and developing incipiently science (for example, alchemy and taxonomy). In the 13th century, the first universities started as centers of knowledge; since then and up to the 20th century, the entrance to them was restricted to a small group of the population, which was constituted by men. The

few women who studied sciences during this period were private, many of them had to overcome adverse conditions, mockery or rejection. However, this did not bend their character or their love for the search of knowledge, becoming an example of honor, even though their work did not receive the deserved consideration.

To rescue the evidence of women's contributions to Science it has been necessary to remove old pages, forgotten books, notes, logs, letters, etc. This valuable contribution influenced the heritage of our current science, and it has not been sporadic, casual or unheard of, but determined, systematic and important, that in the absence of institutional support from universities, associations and families; numerous women scientific researchers have invested efforts, illusion and enthusiasm to overcome the adversities that threatened to prevent them from fulfilling their desire to investigate and discover the laws of nature; their brilliant minds penetrated reality, and analyzed it; thus, they achieved important advances, regardless of the recognition and support received. Because to know, to learn, to discover, to develop knowledge is enough for a researching mind, regardless of being a man or a woman.

In the 19th century, the first women entered the universities, although with difficulty, the faculties of Medicine and Law in Europe and America. Gay [9] emphasizes that the entry of women into the medical field was natural, because they had always been dedicated to caring for the sick in their homes. In fact, perhaps the sensitivity of women themselves has inclined them to this field and continues to do so, since today the health sciences share with the social sciences the highest proportion of university women. The first university career that women entered was Medicine; at the end of the 19th century also Philosophy and Letters was accessible and later, Law. In this century, women began to enter the university in Latin America [10].

The 20th century was the scene of numerous social changes, some of them driven by demands for greater rights for traditionally relegated social groups. Among these changes, a very significant one was universities' massification, which opened their doors to receive not only thousands but millions of young students. This fact was partly due to the change of orientation of the University, which until the 19th century was dedicated to classical studies. In contrast, at the beginning of the 20th century, professionalization gained ground, making university studies the space to prepare young people for their entry into the labor field. In this context, the entry of women into the field of knowledge also increased significantly,[10] which can be contextualized within a change of paradigm: While it was not socially acceptable for women to work outside the home until the 20th century, in the 20th-century women were encouraged to enter all fields of work, many of which had previously been reserved for men, Many women see the labor field as the only space for self-realization, relegating to second place their dedication to the home, when it should be a choice of women the most appropriate space to develop their capabilities and skills to the maximum and not consider as valuable only their progress in the labor field, but by the deployment of their full potential in the personal, intellectual, family, social and professional.

3 Our present

It is difficult to measure equity in men and women's participation in science, technology, engineering, and mathematics [11-15]. The current reality is that in universities, colleges, institutes and research laboratories there is a large proportion of women working independently and autonomously on highly specialized projects. Many women researchers are authorities in their field, chair scientific associations (as is the case of the AAAS, American Association for the Advancement of Science), direct groups and lead research lines. Although not in the same proportion as their male counterparts, women's achievements in previous decades have allowed their scientific work and in the field of technology, engineering, and mathematics to be recognized, although not yet to the full extent. Besides, in this 21st century, it is increasingly common for women to enter all knowledge fields. Although it is still striking that a woman stands out in them, amazement is no longer a cause for discouragement, but rather a cause for satisfaction, since these achievements are the fruit of her capacity and attitude in the face of challenges.

Women's scientific and engineering publications have increased over the past 30 years, but the number is still below their male counterparts. This is reasonable because of the lower proportion of women dedicated to science. However, other factors also play a role such as the fact that an article may receive less favorable reviews when it is identified as being written by a woman author [16], the lower proportion of women as editors and reviewers [17], not being part of highly interfering committees, receiving less funding, having less support from administrative staff, not having access to networks to obtain information, and lack of mentors or tutors to ask for advice or support [6]. To promote gender equity in scientific publications, reviews need to be objective and unbiased, scientists need to be accepted on review committees, and they need to have sufficient financial resources for their research, which is being achieved, although more work needs to be done.

Some of the causes of the disparity between the number of male and female researchers are education, customs, and culture. On the one hand, in developed countries or the large cities of developing countries, it is probably still common in large regions of the planet for prejudices, cultural stereotypes, and false perceptions regarding careers to influence women's decisions not to pursue these fields of knowledge [11, 12, 18, 19]. To encourage women to become involved in the scientific field, many institutions dedicated to supporting science and technology have implemented information and promotion programs to make society more aware of these areas of knowledge and to encourage more girls to consider science, technology, engineering, and mathematics as an option for study and future employment. Since it is difficult for a young person or adolescent to overcome the social pressure that tries to induce them into a certain field, presenting them with a false conception of what their reality should be, it is necessary that young people in general, and women in particular, receive adequate vocational orientation, so that they can study and later dedicate themselves to that profession for which they feel inclined and have natural abilities, which without being decisive, does contribute to a better development within a discipline or profession.

Prejudices about conditions such as sex and age can influence entry to research groups when the most significant should be the professional merits, the quality of the person, their previous experience, and their qualifications. To not make a biased decision, it is necessary to rely on the skills and experience of the team that receives them, as well as on the candidate's decision to contribute significantly to the group, and on his or her commitment and responsibility [20].

The dedication of men and women to their research work throughout their lives is different; in women, maternity and childcare do not allow them to have the same continuity as the career of male researchers [12]. The efforts made by women to work in fields as competitive as science reveal their dedication and commitment to their academic careers, even though they cannot devote all their time during their first years of career to caring for their families; subsequently, their dedication is very similar to that of men [18]. For this reason, scientific careers must be evaluated objectively and without prejudice.

According to Elsevier's 2018 report [14], which collects data over 20 years, it concludes that over this period: the proportion of women researchers and inventors has increased in 11 countries (United Kingdom, United States, Canada, Australia, France, Brazil, Japan, Denmark, Portugal, Mexico, and Chile) and in 28 countries of the European Community or EC28; women publish less research work on average than men; and it is not possible to determine whether or not their work is cited or read more. The Elsevier report shows that most women in science focus on health and life science fields, such as medicine, biochemistry, genetics and molecular biology; in these fields, the proportion between men and women is very similar, while women scientists have less presence in the physical sciences [13, 21, 22]. An interesting conclusion is that although overall women appear to be significantly less productive, some women are more productive than their male colleagues and the proportion of peer-reviewed scientific publications by female authors is growing. This report states that women publish predominantly in health fields and even exceed the number of men's publications. The second field in which women researchers publish is in Psychology, Education and Social Sciences.

The UNESCO report "Towards 2030", includes a contribution by Huyer [23] entitled "Is the gender gap in science narrowing? "which indicates that the proportion of women and men devoted to science, technology, engineering and mathematics between countries is very different, since in some countries such as Bolivia and Venezuela the proportion is 63% and 56%, while in Korea and Japan it is 18% and 15%, respectively, and in France, Germany and the Netherlands 25% of researchers are women.

Finally, UNESCO's Women in Science program[1] published data in 2018 [19] on the proportion of women and men in university studies, their dedication to scientific areas, and their professional employment, in several countries. Among the conclusions of UNESCO in this regard, it can be mentioned that although there is a higher proportion of women enrolled in university studies, the opposite is true for graduate studies. Another conclusion is that, on average at the world level, 29% of scientific researchers are women, although it varies among different regions; these data are interesting, since

[1] Source: UNESCO Institute for Statistics.

countries that have traditionally contributed significantly to the field of science, such as Europe and the United States, have a lower proportion of women dedicated to science than other regions, such as Latin America, whose gender parity is higher.

Currently, calls for research projects prioritize women who lead a project. Several universities and research centers encourage girls and young women to take an interest in science, and there are competitions exclusively for women scientists. This effort by organizations to support women's research will surely encourage more women to engage in scientific research. However, all these efforts would not be useful without the real interest that women have in devoting themselves to the development of Science, Technology, Engineering and Mathematics, which must always be supported by society and institutions. It is important not to lose sight of the fact that women's promotion is the promotion of Humanity in general.

The positioning of women in the scientific and technological field is good, they have a recognition that they have not had at any time and this is due to their continuous effort, their dedication and their passion for knowledge. The support of Institutions and Associations must continue to promote women's inclusion in these fields and take care to eliminate everything that hinders their initiative to dedicate themselves to Science, Technology, Engineering and Mathematics. The diffusion of these fields in elementary education levels has allowed more women to be interested in them, but it is necessary to continue with this promotion so that ignorance do not be a cause for a woman not to choose to dedicate herself to a career of this nature.

4 A look into the future

After this brief overview of the situation of women in Science and Technology, it is easy to agree with Richard Zare, Chairman of the Department of Chemistry at Stanford University "Achieving gender equity is a profound problem, one that most scientists would like to see overcome, but it is likely to persist unless active measures are taken to change the culture in which we live" [15], since it is precisely a social and cultural change that is necessary so that women have the possibilities to assume the role they choose in society and not the one that is conditioned externally, it is the responsibility of public and private institutions to achieve this.

It is evident that women can develop in Science, Technology, Engineering and Mathematics, as in other fields, wonderfully, the trap is that they never develop the same as men, because we are not equal. The differences between the two sexes are not only biological and psychological, other more subtle differences influence the way of approaching problems to solve them. It would not be fair to make a list of the conditions and particularities of each sex, because comparisons do not help. It is enough to say that sensitivity and aggressiveness well-directed are useful, creativity and systematization, rigor and flexibility complement each other, it is not necessary to make fight the extremes, it is enough to make them grow rhythmically, without rivalry or confrontation, rather with the greatness of spirit and humility to recognize the skills and abilities that have to be promoted and the mistakes that have to be corrected. Comparisons prevent us from having a clear and broad vision of the challenges we have as Humanity; Science and Technology are a sign of our time and have transformed

human reality, but there is still a long way to go before contributing to the whole society acquiring better living conditions. This is possible, but it is necessary not to lose energy in useless and fruitless discussions about men and women's superiority or inferiority; this discussion is vain and only wears us out. Rather, we require the commitment of all to use the knowledge acquired and the progress of Science and Technology to build a better world than that inherited from previous generations. Men and women are not equal, nor inferior or superior; women have a particular way of being, thinking and feeling, they have different conditions and expectations, you cannot judge the development of a man and a woman in the same way, not in the field of science, as it is not done in sports, and that is beneficious, because these differences enrich the development of science and technology. Women should not be required, nor can they aspire, —nor —should they have to develop a scientific career in the same way as men, because they have their own conditions and with them, they have the right and the duty to perform as scientists. Those who study the issue of equity agree that prejudices are those that have often relegated women to scientific fields, so the construction of new prejudices does not help. However, the content is different, but with the same sense of separating and dividing, because they can cause harmful effects and prevent society from progressing towards new horizons of brotherhood and mutual support.

Analysts [11, 15] on this topic agree that it is necessary to combine several strategies for support girls and young women who wish to pursue a career in science or engineering or mathematics, among them are

(a) Changes within institutions: The staff of the departments or centers can analyze policies, practices, and customs to distinguish those that may favor discrimination in any area and propose the measures they consider most appropriate and effective to eradicate it and build quality labor relations [15]. The work climate in academic environments is an important factor in supporting women when they begin a scientific career, which is why it is important that all those who are part of Universities, Centers and Institutes linked to Science, Technology, Engineering and Mathematics make an effort to eliminate prejudices and stereotypes, create healthy coexistence relationships based on respect and generosity, with fraternal ties that are free of envy, selfishness, comparisons, and gossip, among others, and foster an appropriate work atmosphere so that everyone can fully develop their multiple capacities [24].

(b) Continuing education: Staff training provides a space for coexistence, an opportunity to assume the policies of the institution, allows people to cover operational deficiencies, and strengthens the sense of teamwork and the need to move forward together towards a common goal [15].

(c) Creation of new paradigms. Transforming academic norms and scales to allow young researchers, regardless of gender, to initiate and develop their scientific careers, with the necessary flexibility so that they can integrate their family,

work, and community responsibilities. It is desirable to have policies in place so that graduate students, postdoctoral scholars, and teachers with children or other family responsibilities can maintain productivity in their careers [15, 25].

(d) *Changes in evaluation methods.* Academic institutions need to work together with scientific and professional societies and with agencies that promote science and technology for a lasting change to occur. These sectors should provide guidelines for the promotion of equity, and help to improve indicators and standards, to promote and guarantee equity, increase the pool of talented scientists and engineers, and increase their integration into society. One possibility for equity is not to measure the scientific career between men and women with the same scale due to each gender's particularities.

These are just a few ideas, each institution must analyze the measures that can favor the promotion of the entry, permanence and natural development of women in Science, Technology, Engineering and Mathematics, so that they are the most appropriate in their context, because exaggerated measures could cause a harmful effect and cause imbalances and injustices in academic environments.

5 Conclusions

Women have the skills and abilities to become scientists, if they want to; otherwise, any extrinsic drive and motivation would not be enough to make their way in such difficult and sacrificial terrain, let alone in developing countries. But it is necessary to give them the means to make their careers concrete and to remove the obstacles that may prevent them from dedicating themselves to Science, Technology, Engineering and Mathematics, in addition to the fields in which women have traditionally worked, such as Health and Social Sciences and Humanities.

We are in a privileged moment so that everything we have received and what we are discovering and generating is transformed into a good for society. It is necessary to build new paradigms, in which differences are appreciated as valuable, and in which we understand that these differences enrich research teams and that there are various ways to measure progress in scientific careers, all of which will contribute to the development of Science, Technology, Engineering and Mathematics without discrimination of any kind.

True equity (more than equality) will be achieved when no one is surprised because a woman is a director of a research center, a university rector, a research group leader, or a company director. When the achievements of women are seen naturally, then it can be said that we are reaching where, as a society, we expect, a world in which men and women, each with their conditions and particular characteristics, work together, without comparison or prejudice, in the development of Science and Technology to offer this wealth to Humanity.

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