Female Researchers in Science in Brazil: the Scissors Effect

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Abstract. We present percentages of female scientists in Brazil, in different fields of science, at different levels of the academic career. Our results are introduced within a historical perspective and some affirmative actions implemented recently are discussed.

INTRODUCTION

The participation of women in the formal economic life in Brazil has been increasing. Today within the 20 most competitive careers, women are the majority in graduation in 15 of them. Women are also the majority of undergraduate students in most courses and half of the professors in the universities (MEC, 2010). Notwithstanding, this situation is still far from representing gender equality. Women are underrepresented in the science, technology, engineering and mathematics (STEM) fields at all levels of the career. Moreover, the percentage of women in all fields decreases drastically at higher positions and increased seniority (Barbosa y Lima, 2013; Caldas y Barbosa, 2002; Cotta y Caldas y Barbosa, 2009; Arenzon y Duarte y Cavalcanti y Barbosa, 2013). Furthermore, this situation has remained the same for the last ten years (Barbosa y Lima, 2013) and is very similar in other countries of Latin America (Cavalcanti y dos Santos y Barbosa y Saitovich, 2005)). These findings suggest that either no change is happening in this field or the change is so slow that a ten year analysis is not enough to perceive it (Barbosa y Lima, 2013; Saitovitch y Barbosa y Funchal y Pinho y Santana, 2015). Naturally, this raises the question of the origins of the absence of females in the exact and physical sciences. Part of the answer to this question involves understanding women participation in the educational system. In this paper first we show how late the education in Brazil started and that the participation of women in Brazil in high education is recent. Then we show show that today women are still under represented in all levels in science, technology, engineer and mathematics but in the health sciences are already half of young scientists. The reasons of both phenomena are discussed and a few programs aimed to increase the participation of women in exact sciences and technology are described.

WOMEN AND FORMAL EDUCATION IN BRAZIL

Formal education in Brazil started in the sixteenth century, by catholic priests, when the Portuguese administrators established themselves with their families in the new continent. In addition to the education of the elite, the Jesuits, whose mission was to evangelize, also provided basic education for "Indians" and workers under the agenda of getting them under the supervision of the church. Girls were kept illiterate, with the exception of daughters of the wealthy families, who were educated by nuns: they were taught to read, write and to perform domestic work. Teaching lasted only three years and reading was restricted to religious texts. In the eighteenth century, Marques do Pombal, the prime minister of Portugal, created the public school system and expelled the Jesuits from the colonies. The new school system reorganized subjects in accordance to the illuminism framework, including science and modern languages and removing religion as the center of education. In Brazil the implementation faced the problem of not having enough people to replace priests in their teaching responsibilities (Maciel y Shigunov Neto, 2006; Oliveira, 2009). Since the schools were separated by gender the lack of properly trained people affected more the girls than the boys. For example, schools for girls did not have science.

After the period in which Marques do Pombal was in power, Catholic schools returned and Brazil developed a dual system in which private and public schools operated in parallel (Maciel y Shigunov Neto, 2006; Oliveira, 2009). The middle schools were divided into schools with focus on Humanities, Schools of Classical Studies, Schools of Scientific Studies and those dedicated to training teachers for the fundamental levels, the so-called "Normal" Schools. In 1808 with the self inflicted exile of the royal family, the education in Brazil received a more formal structure with girls allowed to study, albeit only until the 5th grade (Bruschini y Amado, 1988). The first college was created in 1808. Women, however, were not allowed to attend college until 1879, and, initially only in medicine and law schools. The first female engineer graduated in 1919 and the first physicist in 1937. This late arrival of women in exact sciences has its roots in the division of the middle school into Classical and Scientific studies. Since Classical studies were considered more suitable for girls, more girls schools were devoted to Classical than Scientific specialization. This division of the high school system in Brazil persisted until the 1970's, when three complementary changes were made: (i) the schools for girls only and boys only were abolished, (ii) the Classical and Scientific schools were combined into a single system of high school, and the public school system was expanded to cover the entire population. Then the mixed schools, where all subjects were taught, gave rise to an expansion in women participation at universities. Unfortunately the new regulation for the high school system is implementing again the same structure by dividing the students in Classical and Scientific studies, which can affect the progress of the women participation in exact sciences.

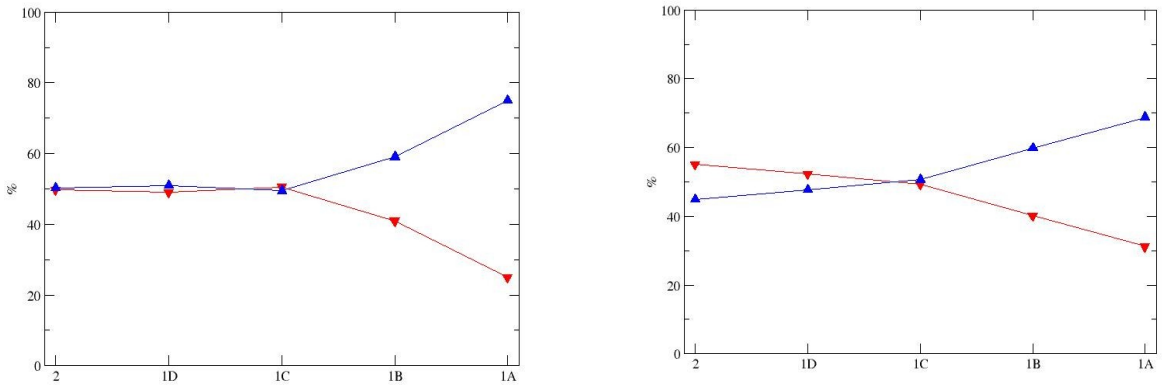
The history of the increase in participation of women in academic life parallels the history of higher education, post-graduation and research in Brazil. In 1951 the two major funding agencies for science, technology and education were created: CNPq and Capes. While the first focuses on the accreditation of researchers, the second evaluates the institutions and grant masters and doctoral degrees.

WOMEN IN RESEARCH

CNPq, one of the national grant agencies in Brazil, offers research-productivity fellowships for professors affiliated to Brazilian institutions. This fellowship gives these professors, known as "CNPq-researchers" a modest salary supplement. CNPq-researchers are rewarded at one of five levels on the basis of productivity, measured by the number of papers published in indexed journals, by the number of graduate student supervisions, by how often their work has been cited by other researchers, and by their h-index, a number which attempts to describe the scientific productivity and impact of a researcher using the scientist's most cited papers and the number of times they have been cited in other publications. The highest CNPq research-productivity level is 1A (after 1D, 1C, and 1B) and the lowest is 2, for junior researchers.

The comparison between Figures 1- 5 shows that, in all fields of knowledge, the presence of women in that particular area decreases as the career progresses. As we can see, the situation is alarming in the exact sciences, where the percentage of women at all levels is much lower than men, in most cases lower than 50%. If a comparison between the percentage of female scientists with CNPq fellowship and the members of the Brazilian Academy of Sciences (ABC) is made, the percentage of the women in the ABC which is 13,3% is even lower (Okido y Romanzini y Ferrari y Martell y Magna y Barbosa y Brito, 2018). This situation does not reflect the participation of women in the academic life, nowadays, roughly half of the professors at universities in Brazil are female (MEC, 2010). It also does not reflect the participation of women in the production of science. The comprehensive Elsevier study shows that almost half of the publications by Brazilian authors have the participation of women ( ). The question is why these women are not granted with the CNPq fellowship. While the decrease of women participation as we go up in the

career is seen in all fields of science, the low number of the researchers at the entrance is more clear in exact sciences than for health and biological sciences. A probable explanation for this phenomena might be at least partially related to the history of the Brazilian educational system. Until the , the70's students at high school level have to select be between Classical, Scientific and to study to be a teacher. Traditionally women either chose to be a teacher or to follow Classical studies . In this case, if at the university they could study either social or biological or health fields. Since the Classical studies were more traditionally the choice of the female students at the high school, it is natural their massive presence in the biological fields. One evidence of this preference is that the first women graduated in physics more than 50 years after the first female student graduated in medicine.



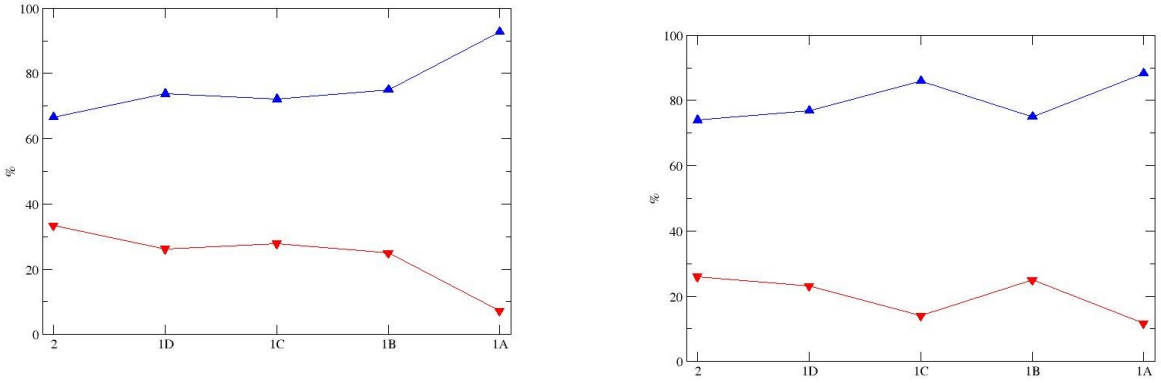
(a) (b)

FIGURE 1. Percentage of men (blue up triangles) and women (red down triangles) at the different levels at the CNPq research in (a) the biological sciences and (b) the health sciences [source:CNPq]

An interesting case is the field of astronomy, illustrated in Figure 5, which shows a clear increase in the percentage of women at the higher levels, in particular CNPq researcher 1A. The first point to mention here is that care must be taken since we are dealing with small numbers compared, for example, to physics (Silva, 2007). A second one is that these numbers are worrisome: they might indicate a better situation 20 years ago than nowadays! Considering that, with few exceptions, to go from the lowest to the highest degree it takes about 15 to 20 years of career, and that all the researchers presently in the lowest level will attain the highest, then, in the future we will have a situation worse than the current one. A possible explanation for the present different trend in astronomy and physics should be searched among the common belief (more than 20-30 years ago) that astronomy was a "romantic" field, similar to poetry or art, and, as such, is suitable for women (see, for example, Veigas, 2013). On the other hand, the current small percentage of young female researchers compared to male, has, much probably, economic reasons as well as the fact of being purely academic career, with few available positions. Another interesting view of the gender issue in astronomy can be obtained from the analysis of Brazilian Astronomy Olympics competition (OBA, http://www.oba.org.br/site/). This is an annual competition which involves more than 650,000 students, from the first grade up to secondary school, from all regions in Brazil. When comparing the gender distribution between the first level (first grade) and the last lever (secondary school) the percentage of girls participating in the competition decreases from 52% to about 48%. Therefore, we believe that the starting point of the gender gap in the astronomy, and, probably in other STEM careers is in the secondary school, just before entering college.

Our results suggest that the low participation of women in STEM fields in Brazil require actions at the beginning of the education, changing the view that those are male only fields. It also indicate that actions are also needed to

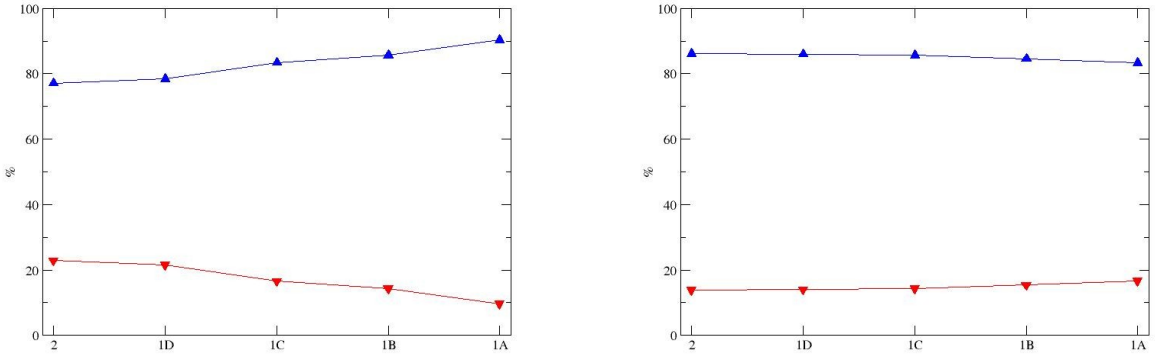
guarantee that talented women can reach high levels of the research career. Next a few initiatives on these two points are discribed.



https://matematicasf.wordpress.com/

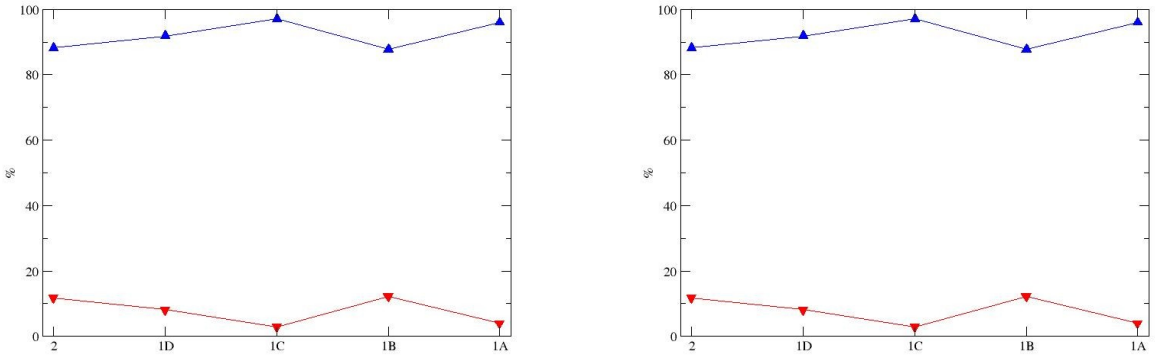
(a) (b)

FIGURE 2. Percentage of men (blue up triangles) and women (red down triangles) at the different levels at the CNPq research at (a) chemistry and (b) geology fields [source:CNPq]



(a) (b)

FIGURE 3. Percentage of men (blue up triangles) and women (red down triangles) at the different levels at the CNPq research at (a) engineer and (b) economy fields [source:CNPq]



(a) (b)

FIGURE 4. Percentage of men (blue up triangles) and women (red down triangles) at the different levels at the CNPq research at (a) mathematics and (b) physics fields[source:CNPq]

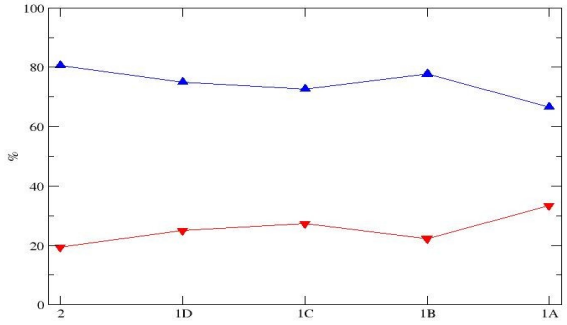


FIGURE 5. Percentage of men (blue up triangles) and women (red down triangles) at the different levels at the CNPq research at astronomy [source:CNPq]

INITIATIVES

With the purpose of promoting the participation of women in STEM fields and to increase the presence of women in top levels of the career, a few transversal affirmative action policies have been implemented in Brazil.

The first transversal plan was the Women and Science Program, launched in 2005, based on the work of an inter ministerial group composed of the Special Secretariat for Policies for Women (SPM), the Ministry of Science and Technology (MCT), the National Council for Scientific and Technological Development (CNPq), Ministry of Education (MEC), among other participants. The main tasks of this program were to stimulate scientific production, to reflect on gender relations, women and feminism in the country, and to promote the participation of women in the field of sciences and academic careers. One of the initiatives of this program was the "Promoting the Equality of Genders" (http://cnpq.br/apresentacao-mulher-e-ciencia), a combination of efforts and a successful partnership between the ministry of Science and Technology, Education and the Special Secretariat for Policies for Women and UN (Lima, 2008). The program has over the successive editions stimulated the production of textual and scientific

content, as well as critical reflection on gender issues, inequality between women and men, feminism and the various manifestations of discrimination, race and sexual orientation. Its purpose was to award, at each edition, the essays of the high school students, the scientific articles of undergraduate students, graduates, specialists, master's students, master's and doctoral students, who stood out in the approach these themes (http://www.igualdadedegenero.cnpq.br/igualdade.html). From the 5th edition (2009) on, with the inclusion of the category Promoting School of Gender Equality, it started to award prizes to pedagogical projects and innovative actions in this area, proposed by public or private secondary schools, per unit of the federation. For this edition, the category State and Municipal Secretariats of Education was included, which will award prizes to projects and actions aimed at the promotion of gender equality. In 2013 this program offered fellowships to female high school students to develop projects under the supervision of a male or female professor at the Universities. One possible impact of this initiative is that the schools and the agencies started to look to the gender balance something was not even considered in the past. Many male and female researchers motivated by possibility of having a grant if they involved high school girls in their research, started to think about the gender balance.

In parallel thanks to the constant pressure of women's movement and by theg Promoting School and Gender Equality program, the agencies created the policy of one year maternity leave for females holding a CNPq fellowship, and a four months leave for the graduate students (http://cnpq.br/noticiasviews/-/journal_content/56_INSTANCE_a6MO/10157/909274). This policy started as an internal rule of the CNPq in 2013 and is now a Congress law. Since this law has been approved recently, its impact will need more time until it could be analyzed.

Lamentably the initiatives to promote women in science lost their prestige in the current government. In 2016 the Special Secretariat for Policies for Women lost the status of ministry and the program is lacking funding. In addition the Science and Technology ministry has been merged to the ministry of Communication, with funds that correspond to half of the funds in 2013.

Recognizing the importance of diversity in science, non governamental organizations are creating their own action plans to promote women.Some scientific societies have programs to support female students. One of the first societies to promote women in science was the SBF (Brazilian Physical Society) which has a group with focus in gender (http://www1.fisica.org.br/gt-genero/index.php/historico) since 2003. The activities of this group includes organizing events, a book and the Carolina Nemes prize for young female scientists (http://www.sbfisica.org.br/v1/home/index.php/pt/premio-carolina-nemes). The Brazilian Academy of Sciences in partnership with the Loreal and Unesco provide since xxxx an annual prize for seven young female researchers in the fields of physics, chemistry, mathematics, biological and health sciences. The SBPC (Brazilian Society for the Progress of Science) developed the site Ciência & Mulher (Science & Women http://www.cienciaemulher.org.br/), with content made for women and about research and work developed by women. The SBC (Brazilian Society of Computing) has the program “Meninas Digitais” (Digital Girls http://meninas.sbc.org.br/), this program has the goal to promote the area of Computing to develop the interest of female students to pursue a career in Computing. The actions of the Program are diversified: offer of minicourses and workshops; realization of dynamics; lectures with students and professionals who already act in the area sharing their experiences. More recently the Women in the Mathematics Community is promoting the agenda through “Matemática Substantivo Feminino" (Mathematics a Female Noun) which brings the debate about the lack of participation of women in the math field and lack of interest of girls in math (https://matematicasf.wordpress.com/). The Brazilian Chemical Society (SBQ) is starting to promote and organizing thematic events for women in science. The 41st annual meeting of SBQ had one thematic session for discussing about experiences and lessons learned from different generation women scientists from different regions of Brazil and Chile (http://www.sbq.org.br/noticia/41ª-ra-mulheres-debatem-suas-conquistas-e-obstáculos-na-carreira-cient%C3%ADfica).

There have been also international initiatives to support women that count with Brazilian researches in the organization. The ACM (Association for Computing Machinery) has the council ACM-W (Association for Computing Machinery Council on Women in Computing https://women.acm.org/) has a Brazilian research as a council member. Some conferences from ACM have round tables and sessions about women in computing. The SIGGRAPH Conference has the Women in CG as a regular round table since 2015, this started with the Brazilian research Aruquia Peixoto in the organization with Diana Arellano (Peru) and Dolly Omisore (UK), and is now organized by Aruquia Peixoto, and Jessica Sommerville (Australia). The editions 2016 and 2017 of SIGGRAPH Asia Conference had the round table Girls in STEM also with the Brazilian researcher Aruquia Peixoto in the organization, with Barbara Mones (USA) and June Kim (Australia) as co-organizer in the last edition, (Peixoto 2016; Mones and Kim 2018).

In Engineering, the IEEE EDUCON is the flagship conference of the IEEE Education Society. In 2017 a round table about Women in Engineering was realized by the first time in this conference, the organizer and moderator was the Brazilian researcher Aruquia Peixoto, and the panelists were Maria Teresa Restivo (Portugal), Tiia Rüütmann

(Estônia) and Cleo Sgouropoulou (Greece). As a result of this round table, the IEEE EDUCON 2018 had two round tables about Women in Engineering, one with focus in academy and another in industry, with the organization of Rebecca Strachan (UK), Itoro Charles Emembolu (UK), Maria Teresa Restivo (Portugal), María de los Angeles Martinez (Spain), Carina González (Argentina) and Aruquia Peixoto (Brazil) (Strachan, Emembolu, Peixoto, and Restivo 2018).

Also, with the development of the discussion about gender in Engineering, a Workshop and a Special Session about Inclusion and Diversity in Engineering Education (IDEE) was developed in IEEE EDUCON 2018 conference, with Aruquia Peixoto as Chair and Pedro Plaza (Spain) as co-Chair of the Workshop (Peixoto, Strachan, de los Angeles Martinez, Soledad González González, Plaza, Blazquez, and Castro 2018; Peixoto, Plaza, Castro, Blazquez, Martin, Sancristobal, and Carro, 2018).

The international community in physics has been promoting this discussion since 2002 when the First International Union in Pure and Applied Physics Conference (http://iupap.org/working-groups/wg5-women-in-physics/) was organized. This event was the origin of the creation of gender groups in the physical societies, including the Brazilian group. Since 2003, also the International Astronomical Union has established a Working Group of the Executive Committee (http://iau.org./science/scientific_bodies/working_groups/122/) in order to collect information, propose measures, and initiate actions in support of, or to advance equality of opportunity for achievement between women and men in astronomy, in the IAU and in the world at large.

CONCLUSIONS

In summary, despite all advances achieved by the Special Secretariat for Policies for Women, supported by the nongovernmental organizations for promoting the participation of women at all levels of the economic life, the situation of gender equality in exact sciences is far from a desirable level; in some cases, it has been unchanged for a time scale of more than one decade (Lima y Barbosa, 2013). Since women started to participate in exact sciences about 50 years later than in social and health sciences and understanding that the change in the culture is a slow process, we expect that the government policies initiated in 2005 to promote women and particularly to attract girls to exact sciences and technology will result in the attraction of enough women to generate a critical mass necessary for the movement to grow and be empowered. There are reasons for hope. The recent initiativies of some Scientific Societies and private sector show that issue is on their agenda . We expect higher commitment of policy maker to embrace the cause and help to trim the scissors effect on women in science.

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