

Women & Science: past, present and future over a struggling and challenging way of communication



Alessandra Fino¹, Daniela Guglietta², Daniela Caschera³, Anna De Meo⁴ & Serena Santoro¹

¹National Research Council—Institute of Atmospheric Pollution Research (CNR-IAA), Strada Provinciale 35d, 9 – 00010, Montelibretti (RM), Italy.

²National Research Council—Institute of Environmental Geology and Geoengineering (CNR-IGAG), Strada Provinciale 35d, 9 – 00010, Montelibretti (RM), Italy.

³National Research Council—Institute for the Study of Nanostructured Materials (CNR-ISMN), Strada Provinciale 35d, 9 – 00010, Montelibretti (RM), Italy.

⁴National Research Council—Institute of Heritage Science (CNR-ISPC) Strada Provinciale 35d, 9 – 00010, Montelibretti (RM), Italy.

id AF, 0000-0002-2051-5533; DG, 0000-0002-6177-2258; DC, 0000-0002-0587-0238; AD, 0009-0001-0303-2433; SS, 0009-0001-1160-899X.

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Short Note

Corresponding author e-mail: alessandra.fino@cnr.it

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ABSTRACT

The under-representation of women in science is still a problem all over the world due to the existence of societal, cultural, and structural barriers that prevent them from participating to scientific research and communication. This work provides an overview of these barriers in the past and in the present in science. Then, a brief analysis of the current state of gender inequality in science and scientific communication, using evidence from the world, European Union and Italy, is reported and discussed. Furthermore, specific measures that can be taken to reduce and overcome gender inequalities, considering science communication practices, are outlined stressing the necessity of ensuring equal opportunities for all within the scientific community and its communication processes.

KEYWORDS: women in science, STEM, science and scientific communication, gender gap, gender equality.

INTRODUCTION

Science plays an essential role in evidence-based decision-making but in recent years, there have been challenges to the authority of science, raising worries about the public's lack of faith in scientists (Nichols et al., 2021). Despite that, in most nations a significant portion of the population trusts scientists and advocates for their increased involvement in social and policy-making activities, according to a recent study published in 2025 by Nature.

This paper acknowledges, however, the presence of disparities in trust levels both across and within nations, influenced by individual and national factors, including political inclination (Cologna et al., 2025). The same study highlights that a large majority of the countries polled (83%) agree that scientists should inform the people about science. An additional factor that can influence trust in science is an imbalance in gender representation (Hubner, 2024). Indeed, if women are underrepresented in the scientific field, this influences the public perception of science, making it appear as a male-dominated sector. On the contrary, gender equality can increase trust in science by demonstrating that it is an inclusive field, representative of all people. Women have given relevant contribution to science, but due to the prevailing gender biases in society, they have often been barred from taking part to many scientific sectors (UNESCO, 2025). According to UNESCO SCIENCE REPORT in 2018 only 33.3%, one in three, of researchers worldwide are women (UNESCO, 2021). Women researchers are less likely than men to work in engineering and technology-related professions (UNSD, 2020). Furthermore, they are more likely to work in academia and government while men researchers primarily work in the private sector and women make up only 22% of professionals in the Artificial Intelligence industry (UNESCO, 2021).

Historically, there have been various barriers to women's engagement in science, and many are still present today. In the

past women have traditionally been assigned to household duties because of stereotypes and their contributions to science were often ignored in favor of male counterparts. Moreover, women's presence in science, in some world regions, has been limited for a long time by their limited access to education, especially in STEM (science, technology, engineering, and mathematics) fields professions (Fussy et al., 2023).

Nowadays women continue to experience gender biases and men, still outweigh women in many STEM jobs and leadership roles (Dasgupta et al., 2014). Furthermore, women are less likely to obtain research tutoring, have fewer first-author publications and many disciplines have significantly fewer than 45% women authors than their counterparts (Keller, 2021; Holman, 2018; Murphy et al., 2022). Women continue experiencing prejudice in funding, employing, and advancement prospects (Carrero et al., 2024). Compared to men, women researchers are less likely to be promoted or earn grant chances (European Commission, 2025).

Despite progress, personal, societal/cultural and organizational factors continue to be the major causes of gender gap (Vergara et al., 2025). Even though there have been notable advancements in the field of gender equality in science, the persistent existence of these obstacles emphasizes the necessity of ongoing initiatives to promote inclusivity. According to a study recently published in *Nature*, people rely on communication about science with the public to better understand scientific discoveries and their impact on daily life. Effective science communication helps to promote awareness and understanding of scientific issues, fostering informed decision-making and greater participation in public discussion (Cologna et al., 2025). But women are still often under-represented in the media science communication (Eom et al., 2025; Macdonald, 2021). Several interrelated biases contribute to this unbalanced women presence in science communication: a systemic bias, considering that historically men have been overrepresented in research samples (Bailey et al., 2024) a media representation bias, considering that image of a scientist is typically a white man (Eom, 2025) or on TV, the typical scientist is a highly intelligent white man who doesn't have any kids, isn't married and is holding a high-status scientific position (Macdonald, 2021); and some individual and social factors, such as the possible role of cognitive biases in perpetuating gender bias (Shanks et al., 2024). Furthermore, women may find it difficult to imagine themselves in scientific professions due to the absence of female role models in many media, which reinforce gender biases (Macdonald, 2021). Today, things have changed significantly, and an increasing number of initiatives devoted to women in science have led to a very different representation and to wider possibilities for women.

The international community has worked extensively to encourage women to look at careers in science over the years, making a lot of efforts. Among these are the 1995 Beijing Declaration and Platform for Action one of the reference frameworks built for analyzing the global status of women and evaluating state initiatives to promote women's empowerment. By adopting the Resolution A/RES/70/212 on December 22, 2015, the United Nations General Assembly established the annual International Day of Women and Girls in Science that celebrates the vital contribution that women and girls play in science and technology (UNGA, 2015).

Its tenth anniversary was celebrated on February 11, 2025. The aim of this work is to provide a brief overview of the gender gap issue in science and scientific communication, highlighting global strategies to overcome gender inequality. Furthermore, some practicable proposals and practices to better apply the policy recommendations will be evaluated and discussed, considering various communication models and their possible contributions.

METHODOLOGY

In the present work, we conducted an analysis on the gender gap issue in science and scientific communication, based on published data in international scientific literature and up-to-date documents produced by national, European and international Institutions on these topics. In particular, the data exploitation is based on: The World's Women 2020 "Trends and Statistics, Statistics Division of the UN Department for Economic and Social Affairs" (UNSD, 2020); the Science Report: "The Race Against Time for Smarter Development" (UNESCO, 2021); "She Figures 2021 – Gender in Research and Innovation – Statistics and Indicators" (European Commission, 2021) and "She figures 2024 - Gender in Research and Innovation: Statistics and Indicators" (European Commission, 2025). Regarding the Italian situation, we chose to focus on the National Research Council of Italy (CNR) data. In consideration of the wide situations in different Italian research entities and universities, the National Research Council of Italy (CNR) reality has been chosen as reference for the data analysis for several reasons. Firstly, CNR is the biggest public research entity in Italy, with multiples locations in every Italian region. Furthermore, each Italian university has different management and rules, while CNR applies the same rules in every institute, regardless of its geographical location or number of personnel involved. Hence the gender situation in the whole CNR institutes could be considered representative of the Italian situation, more effectively than single Universities.

Based on all data analysed, we made, where possible, a comparison among the national, European and international, data for some parameters we considered remarkable. The main findings are presented in the following section.

ANALYSIS OF DATA AND DISCUSSION

Analysis of Present gender inequality in science and scientific communication

At international level, according to the 2021 UNESCO Science Report (UNESCO, 2021), women attending universities are increasing in almost every nation. Currently, the percentage of women among university graduates slightly exceeds that of men globally, both at the bachelor's (53%) and master's (55%) levels. Furthermore, women recently represent 44% of PhDs, the threshold level required for a career in research showing some progress from 43% in 2013. Moreover in 2018, women made up 33% of researchers, showing progress compared to 28% in 2013 (UNESCO, 2021). Women account for 44% of PhDs but only for

33% of researchers, showing therefore that many female graduates are choosing not to pursue a career in research or decide to leave the research field entirely (UNESCO, 2021). Women researchers in the life sciences have attained parity or even dominance in many nations. However, women continue to be underrepresented in subjects that are driving the Fourth Industrial Revolution and, consequently, may be unbalanced in many of the professions of the future, such as digital information technology, computing, physics, mathematics, and engineering (UNESCO, 2021).

At European and national level, concerning the tertiary level of education (PhDs), women are under-represented among doctoral graduates in many fields of studies. In 2021 at both levels women graduates were over-represented in the field of Education and still under-represented in the broad fields of Information and Communications Technology (ICT) and Engineering, Manufacturing & Construction (Fig. 1).

Looking at the science and technology occupation, in 2018 women represented around one-third of the total population of researchers at all levels: worldwide, in the European Union and in Italy (Fig. 2.).

Considering scientific publications as the main way of communicating science, we have evaluated world and European data provided in 2025 by European Commission for various Research & Development fields on active authors (defined as authors who published 10 or more papers in the last 20 years and at least one paper in the last 5 years or those who published four or more papers in the last five years) and on corresponding authors (considered as the only person who has main responsibility for communicating with the journal, throughout the publication process) (European Commission, 2025). Among the pool of authors which publish actively and based on three different Seniority levels, women are under-represented especially in the fields of Natural Sciences and Engineering and Technology (Fig. 3a). European Commission estimated Seniority levels via the time elapsed since

an author's first publication in a journal indexed in Scopus as three different categories: <5 years or 'early-stage', 5 to 10 years or 'middle-stage' and >10 years or 'senior' stage. Furthermore, among early-stage active authors, the gender gap was generally smaller, but as the seniority level increases the gap gets worse. In addition, data on corresponding authors in publications with international collaborations (Fig. 3b) are even worst showing that women are deeply under-represented especially in the fields of Natural Sciences and Engineering and Technology. However, on average in several fields, the percentages of women corresponding authors have slightly risen over time relative to men, in the periods 2013-2017 and 2018-2022 (European Commission, 2024). When considering the average proportion of women authors on publications resulting from international collaboration in all fields of Research & Development (R&D), for the period 2018-2022, at EU level, the average proportion of women on international authorship teams was only 31 % (European Commission, 2025).

An additional key challenge at European level is the gender gap in access to research funding. As reported in "She Figures 2024", an unconscious gender bias can occur in the evaluation of research proposals for funding allocation. For instance, even when qualifications are the same, men are often perceived as more outstanding, independent, innovative, and leadership-oriented (Moss-Racusin et al., 2012; Van der Lee & Ellemers, 2015). In 2022, women had a slightly lower success rate (29%) compared to men (32%). This gender gap in favour of men is visible in most Member States, including Italy. However, in a few countries, women had a marginally higher success rate than men, such as Bulgaria (53% vs. 42%), Denmark (19% vs. 16%), Portugal (16% vs. 15%) and Norway (29% vs. 24%). The report also highlights that in 2022 at EU level women were more successful in obtaining funding than men in Engineering and Technology (33% vs 30%) and in Humanities and the Arts (23% vs 22%). It is worth noting that funding bodies have implemented measures to improve grant procedures and

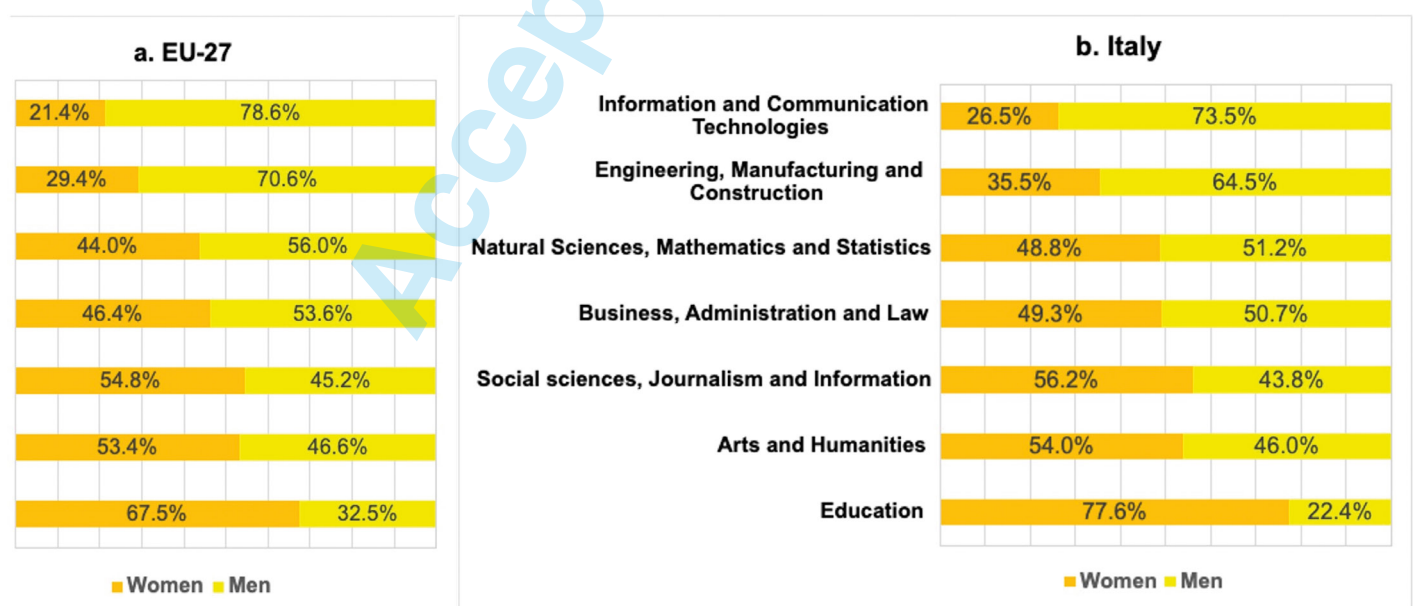


Fig. 1 - Distribution of doctoral graduates in percentage across broad fields of study by sex in 2021: a. in EU-27; b. in Italy (Data Source: European Commission, 2025).

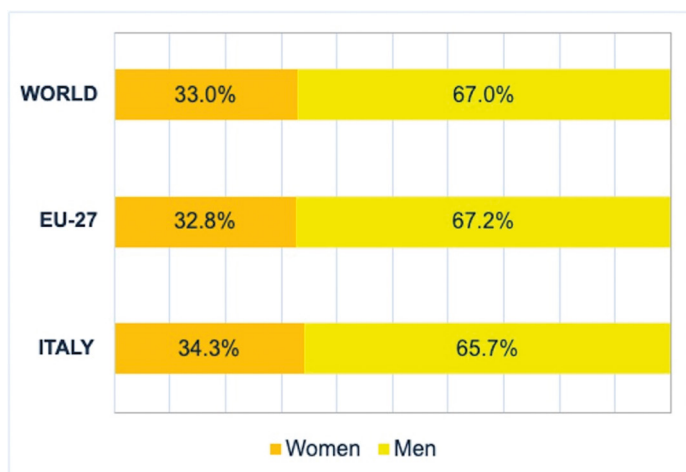


Fig. 2 - Women researchers in percentage in the world, EU-27 and Italy in 2018. (Data Sources: UNESCO, 2021; European Commission, 2021).

promote gender balance among recipients. A recent example is the GENDERACTIONplus project <https://genderaction.eu/>, funded under the Horizon Europe programme. This project, running from 2022 to 2025, aims to strengthen European cooperation and coordinate gender equality objectives within the European Research Area (ERA). In April 2025 the GENDERACTIONplus consortium published a guideline “Inclusive Funding: A Co-Created Guideline for Mitigating Bias Throughout the Research Funding Cycle” which provides Research Funding Organisations (RFOs) with practical guidance to design and implement funding programmes that actively reduce gender bias (Greithanner et al., 2025).

Finally, the barriers preventing women from advancing to higher-level positions in their careers, the so-called glass ceiling phenomenon, persist at international, European and national level (UNESCO, 2021). This phenomenon can also be observed at Italian level in the context of CNR. Fig. 4 illustrates the proportion of CNR women and men researchers across the different research career levels in 2023. For CNR data on women and men at different professional levels, it is evident that both manager and research director levels are mainly occupied by men, with a women presence in higher level employment less than 30% (Fig.4). According to the

reported data, women percentage is higher than men value when research fellowship positions are considered.

Different reasons could certainly concur to this unbalance situation, in which women seem to have more difficult than men in reaching higher-level positions. At the first steps in carrier, the personal ambition could be a good stimulus for young women to start a scientific path. Then, diffuse social perceptions on women’s professional roles, especially in particular closed social contexts, can negatively impact on the women possibility to improve their careers. Moreover, the approaching of family responsibilities, i.e. children birth, and a difficult of the modern family in balancing these situations, often without any (or poor) support by institutions and tax benefits, compels women to fall back on secondary roles or, in extreme situations, give up their careers (Galsanjigmed et al., 2023).

How gender inequality in science and scientific communication can be addressed and mitigated?

As shown by the previous analysis, gender inequality in scientific careers is a persistent problem entailing women’s underrepresentation in senior and decision-making positions. Even though the growth in the share of female PhD graduates in scientific matters (Fig. 1), proactive policies are essential to decrease the gender gap in women representation in science and scientific roles. As proposed by Isaksson (Isaksson, 2024), different pathways for mitigating this bias could be adopted. Onepathway regards inclusivity and diversity, including interdisciplinary collaboration and integrating gender perspectives in STEM and scientific communication development. These recommendations assume no knowledge hierarchies or potential conflicts in interdisciplinary work, overlooking differences in terminology, methods, and goals between social science and technology perspectives. This aim could be achieved through the development of shared social and political strategies, addressed to the gender inequality mitigation not only in science and scientific roles, but in a wider social context. Another pathway highlights the importance of enhancing knowledge and awareness raising activities. This pathway includes mutual exchange among scientists and the promotion of educational activities (Schmidt et al., 2017; Isaksson, 2024). In this context,

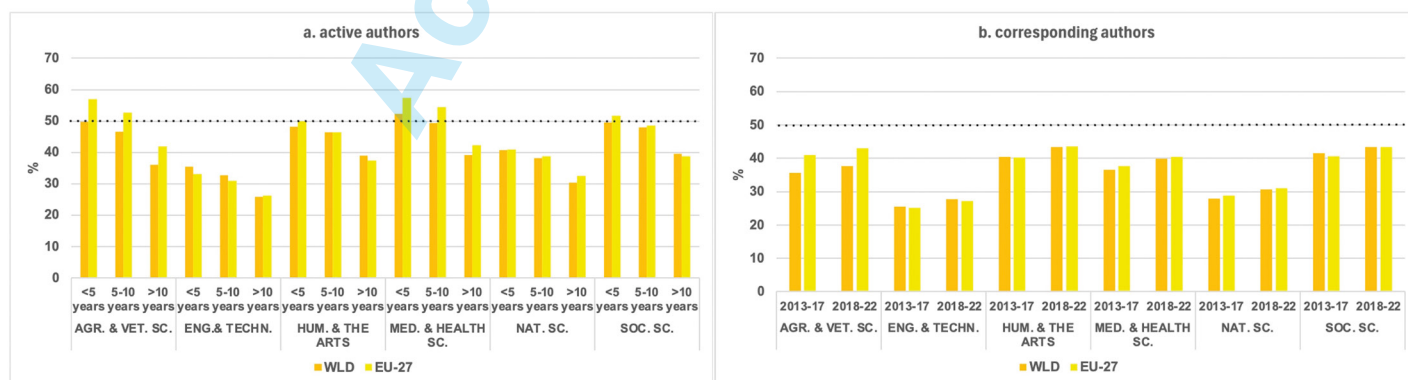


Fig. 3 - a. Proportion (%) of women among active authors, by field of R&D and seniority level in 2018-2022. b. Proportion (%) of publications resulting from international collaboration for which a woman is corresponding author to those for which a man is corresponding author, by field of R&D, in 2013-2017 and 2018-2022 (Source: European Commission, 2025).

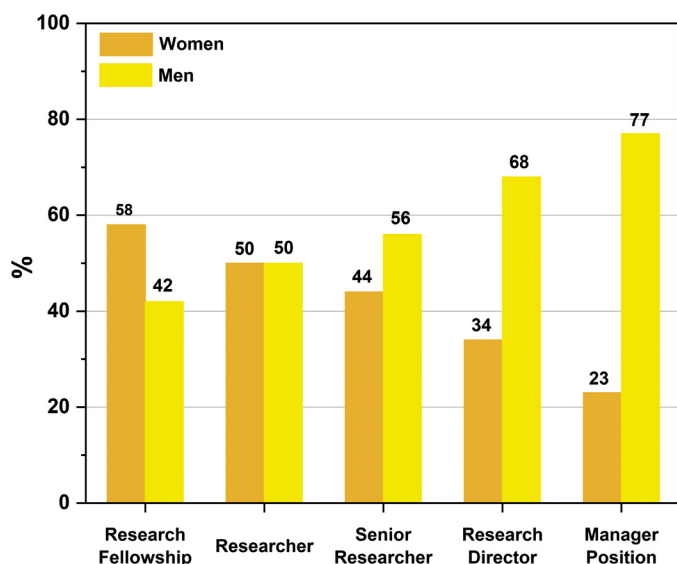


Fig. 4 - Differences (%) in CNR research career levels by sex in 2023 (Data source: CNR, 2024 a).

implementation of different communication strategies and social paths is of great importance, especially for the younger generation.

The European and Italian gender social and scientific policies

According to the social and political paths, several strategies have been pursued, in Europe and in Italy for mitigating the gender gap, in all social, educational and political fields and, consequently in the scientific context. The European Commission has actively worked to shift societal attitudes and set out clear goals to make tangible progress. In March 2023, EU launched the #EndGenderStereotypes campaign, encouraging discussions on how gender norms affect career choices and decision-making. Recognizing these challenges, the EU has intensified its efforts to realign with the UN's Sustainable Development Goal 5: achieving gender equality and empowering all women and girls (<https://sdgs.un.org/goals/goal5>). By strengthening gender mainstreaming in international partnerships, allocating sufficient resources, and promoting gender-transformative approaches, the EU aims to drive meaningful and lasting changes. Furthermore, in 2020 EU elaborated the *Union of Equality*, - a Gender Equality Strategy (European Commission, 2020) in which EU sets out key actions for the next 5 years and commits to ensure that the Commission will include an equality perspective in all EU policy areas. The aim of this strategy is that women and men, in all their diversity, could be ensuring to have the freedom to pursue their aspirations, enjoy equal opportunities, and fully participate in society. While primarily focused on EU policies, the Strategy aligns with broader global efforts to advance gender equality, since its approach promotes gender balance in different fields, including research and innovation, combining gender mainstreaming with targeted actions. Thanks to the Strategy approaches, the Gender Equality Index, developed by the Institute for Gender equality (EIGE) for measuring the progress of gender equality in the EU, in 2024 <https://eige.europa.eu/gender-equality-index/2024> was 71/100,

the highest measured since now, with an increase of 7.9 points since 2010 (<https://eige.europa.eu/gender-equality-index/2024>).

Regarding the actions in the scientific and innovation field, in particular, the commitment of education and R&I stakeholders, as well as national authorities in EU Member States and Associated Countries, is needed to strengthen women's participation in STEM. The European Strategy for Universities (European Commission, 2022), adopted by the Commission in January 2022, sets the objective to address the underrepresentation of women in STEM, through a roadmap of activities spanning across education and research policies. This Strategy includes the implementation of flagship initiatives for favouring student mobility across EU University, schools and research entities (i.e. Erasmus + programmes), and for supporting University for the development of high quality and relevant future-proof skills, taking into consideration the question of diversity and inclusion. Furthermore, with the Digital Education Action Plan (2021-2027) (European Commission, 2020b), the Commission supports initiatives to tackle the gender digital skills gap in education and training (Action 13), as *Girls Go Circular* project, a free online learning programme, trained over 26.000 14-19 year old girls in 15 countries across Europe since 2020 and the 'ESTEAM Fests' (Entrepreneurship, Science, Technology, Engineering, Arts and Mathematics) that offer hybrid workshops, where girls and women of all ages come together to improve their digital and entrepreneurial competences. By 2024, 11 ESTEAM Fests were organised in 19 Member States.

In July 2021, the Italian government presented its National Strategy for Gender Equality (Dipartimento per le Pari opportunità, 2021), in which, in full agreement with the European guidelines, it is intended to offer a clear perspective and a concrete path towards gender equality and equal opportunities, to clearly outline a system of integrated political actions bringing to life concrete, defined and measurable initiatives. In this document, which serves as a strategic framework for the implementation of the National Recovery and Resilience Plan (NRRP) and the reform of the Family Act, the Italian Department for Equal Opportunities started a wide-ranging and inclusive process, whereby the contributions from central Administrations, Regional and Local Authorities, as well as social partners and the main associations active in promoting gender equality were collected, integrated and duly exploited. This joint effort makes this Strategy a shared asset: the path that was designed and mapped out together to move the country forward and see it finally reinvigorated by women's energy, ideas and freedom.

Concerning the research entities, even Italian Universities and Research Centres have been worked on strategies to mitigate the gender gap, declined in strategic and operational documents, specific Gender Equality Plan (GEP), based on gender mainstreaming. This approach introduces a gender perspective in policies to combat the inequalities between women and men in society. In 2022, CNR developed and adopted its triennial (2022-2024) Gender Equality Plan (GEP), which aims to support and promote the full and balanced participation of all CNR staff in scientific, technical-administrative, institutional and research activities (CNR, 2024b). The GEP is the response to the European Commission's request for a gender plan to be eligible for the Research Framework Programme. Considering the relevance of this issue, CNR has been active for years in research, design, and

analysis of gender-related issues and specific EU projects have been submitted and funded in the last years (e.g. H2020- MINDtheGEP project, GETA Observatory, Gender and Talent - <https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/home>), with the aim to propose a series of concrete actions to achieve the principle of equal opportunities (CNR, 2024b).

Furthermore, several actions have also been promoted and adopted in the last years by public schools, local entities and private associations. As a recent example, STEM Women Congress (<https://www.womenatbusiness.it/stem.php>), held in Milan in May 2024, represented an important occasion with a rich agenda of interventions, moments of discussion, concrete opportunities to help bridge the gender gap in STEM disciplines, to stimulate women's careers in science, technology and scientific communication and to eliminate the prejudices still surrounding these fields.

The science communication models as tool to improve scientific gender balance

Communication can also contribute significantly to achieve gender equity, through various practices and principles (UNDP, 2025) including:

i) the use of a correct gender-sensitive language, by removing any form of biases and gender-based discrimination and promoting equality and inclusion;

Models and behaviors are shaped by language, and social inequalities are perpetuated by discourse. In addition to contributing to the affirmation of individual and collective identities, words are a very powerful means of hiding or revealing a whole realm, of denying or affirming rights. Despite the great changes that have taken place in the social representations of gender and sexual orientation, there is still androcentric language, both at the individual and institutional level, which must be changed to give visibility to the roles and functions of women and avoid discriminatory use of language.

ii) the promotion of proper visual communication through images representing equal number of men and women in visual media and the strengthening of an inclusive communication that includes and represent both genders;

iii) the encouragement of balanced educational programmes, mentorship, and role models.

Science communication can represent a strategic tool for addressing the gender gap by enhancing the visibility, representation, and influence of women in scientific and societal contexts (Barata et al., 2023). It contributes to the promotion of more inclusive and equitable practices concerning gender and race, providing women scientists with a platform to act as role models for future generations.

In this context, in the last years several examples of women, strongly involved in scientific matters, can be represented by:

Samantha Cristoforetti, an astronaut at the European Space Agency (ESA), who uses social media to share her experiences aboard the International Space Station (ISS). She engaged a broad audience, making space explorations more relatable engaging and she has led, through her example, to a spike in enrolment of young female students in astrophysics.

Antonella Viola, an immunologist and professor at the University of Padua, who is renowned for her commitment to science communication. She has effectively communicated complex immunological concepts to the public during COVID-19 pandemic period, fostering a deeper understanding of science and encouraging greater female participation in the field.

Ilaria Capua, a veterinary virologist and former member of the Italian Parliament, who has been a vocal advocate for open science and gender equity in research. Her efforts to promote data sharing and her resilience in the face of adversity have made her a prominent role model for women in science inspiring young women to pursue careers in STEM disciplines.

There are three main models of expert-public interactions in science and technology communication: the dissemination model (often called the deficit model), the dialogue model, and the participation model, which, together, form a multi-model framework that can coexist (Trench, 2008; Bucchi, 2009; Hetland, 2014). The examples of women scientist abovementioned represent new valid approaches in the development of the science communication models, that, in over the last century, have shifted from the initial simple dissemination to more complex and participatory approaches. These include the recent Public Engagement with Science and Technology (PEST) model, which advocates for active dialogue between scientists, policymakers and the public.

The development of science journalism is also an important factor in delivering scientific findings to the public via the mass media and has developed based on the public's interest, scientific developments, and current issues such as climate change. The shift from print media to digital media has greatly affected the dissemination of science, improving the speed and extent of scientific information dissemination.

The dialogue and participation models with the extensive use of digital media can significantly contribute to the achievement of gender balance with the application of correct practices and languages.

CONCLUSIONS

The analysis of the general situation on gender inequality in science and scientific communication provides evidence that a joint effort is necessary to achieve a positive cultural change. This milestone can be reached through improvement of awareness and the involvement of institutions, government organizations and civil society to promote and enhance girls' and women's access to all STEM education fields and career levels.

While significant progress has been made in increasing women's participation in science and research in the past decades, disparities still persist. Systemic adjustments and efforts towards gender equity in scientific research, education and access to STEM are necessary to address these problems.

As highlighted by the Council of the European Union, gender equality is also a crucial factor for sustainable economic growth and embracing diversity is a key element of good science (Council of the EU, 2020). Scientists must follow practices and principles expressed above taking into consideration that the responsibility

of scientists is not limited to the mere production of knowledge but also extends to how that knowledge is communicated. Effective, inclusive, and accessible scientific communication is, in fact, a fundamental tool for making science more understandable and appealing to a broader audience. This is particularly important for engaging women and girls, who often do not see themselves represented in traditional STEM role models.

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