

Raising awareness on gender issues: a path through physics, outreach and diversity.

Maria Rosaria Masullo^{a,*}, Giovanni Dionisio^b, Roberta Antolini^c, M. Cristina Antonucci^d, Silvia Arezzini^e, Sveva Avveduto^d, Cristiana Crescimbene^d, Ilaria Di Tullio^d, Sandra Leone^e, Daniela Luzi^d, Nicolò Marchesini^d, Sabina Pellizzoni^f, Lucio Pisacane^d

*a INFN - National Institute for Nuclear Physics, unit Naples
Compl.Univ. MSA, Via Cinthia ed.6, Napoli, Italy*

*b INFN- National Institute for Nuclear Physics, unit Headquarters,
Piazza dei Caprettari 70, Roma, Italy*

*c INFN- National Institute for Nuclear Physics, unit LNGS
Via G. Acitelli, 22, Assergi, L'Aquila, Italy*

*d IRPPS CNR - Institute for Research on Population and Social Policies-National Research Council,
Via Palestro 32, Roma, Italy*

*e INFN- National Institute for Nuclear Physics, unit Pisa
Largo Bruno Pontecorvo, Pisa, Italy*

*f INFN- National Institute for Nuclear Physics, unit Roma1
P.le Aldo Moro, 2, Roma, Italy*

E-mail: masullo@na.infn.it, gianni.dionisio@presid.infn.it

When and where it is convenient to start working on raising awareness on gender issues? Our answer is that high school is definitely a good start, mainly if we think that outreach activities can have a role in the transition to an environment for learning, teaching and researching in physics that is equally attractive and supportive to all genders, at each stage of their education and career path. As researchers of INFN and CNR we promoted a school competition devoted to consider the role of women in science and particularly in Physics. Outreach activities can have the role of raising awareness, knowledge through an active involvement of students for changing the culture and removing stereotypes. In these years we organized 3 contests, with 226 videos, more than 100 high schools and a thousand of students involved. The idea was to try to understand the thinking and knowledge of young people on present and past gender issues connected to women and science, to know how they imagine the society of the future, to understand if they are unaware "carriers" of stereotypes and prejudices and if the cultural change can start from/with them. The students have been asked to produce a video on subjects regarding these questions. The article describes the contests, the evaluation process, the results of first analysis. The work started inside the EU-funded GENERA project, to which both research groups belong, and continues inside the GENERA Network. The collaboration among physicists and sociologists has been, and still is, fundamental in these years.

*41st International Conference on High Energy physics - ICHEP2022
6-13 July, 2022
Bologna, Italy*

*Speaker

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1. Introduction

Even if recent years have seen improvements in woman participation in the fields of science, there is still work to be done to achieve gender equity in all scientific fields. And this is especially true in STEM (Science, Technology, Engineering and Math) disciplines. According to the UNESCO Institute for Statistics, the mean percentage of female students in tertiary education enrolled in engineering, manufacturing and construction programs was between 6% and 7% in the years from 2015 to 2018; in contrast, the percentage of male students choosing these careers was around 20–21% [1]. Improving educational opportunities for girls continues to be of paramount importance if gender equity in and through education is to be achieved. Due to this underrepresentation we miss different points of view in solving problems, questions and ideas which can be beneficial for all the society. Moreover, there are strong economical reasons. Among the other countries, Italy recognizes that the poor presence of women in the study and in the work environments in which STEM subjects are required, and in particular Physics, Information Technology and Engineering, is a significant obstacle to the economic growth of our country¹.

Several researches have tried to explain the reason of this gender-imbalance, focusing not only on “women” and their engagement in STEM disciplines, but, more recently, also on the disciplines itself, its rules, practices and culture [2]. As Evelyn Fox Keller wrote [3] “The relationship between gender and science is a pressing issue not simply because women have been historically excluded from science, but because of the deep interpenetration between our cultural construction of gender, and our naming of science.”

Among STEM disciplines, physics is one of those where the percentage of women, both in universities and in research, is the lowest [4]. The physics culture is full of concepts as the myth of lone genius, the dominance of physics, the neutrality of research, the masculinity of the field; concept and stereotypes related to what physics is and what a physics researcher is [5]. The effects of this culture can be witnessed in the widespread finding that many children, students come to see particularly physics as being for boys. Moreover, researches have underlined that women and girls encounter particular identity issues in relation to participation in physics and engineering [6]. Keeping in mind that identity is not an individual experience, but rather a characteristic of a social environment, where personal interactions, cultural characteristics and structures in various contexts define what kind of people belong to those contexts, it is clear that a cultural and structural change is required to go over the woman under-representation.

Research institutes and universities reply to this issue with Gender Equality Plans usually focused on gender equality among the staff and academic community but not directly related to reducing the gender gap in STEM.

To work in this direction, inside the GENERA project, we decided to propose an outreach activity directed toward students. Schools have an enormous potential to effect changes in culture, in gender relations, to create a gender-sensitive and gender-equal generation of men and women, and at same time outreach activities can be used to work on students, on teachers and on ourselves, as physics researchers. We would like to know how students engage in science and how this is related to who they are and who they want to be, which are, or could be, their career aspirations.

We have been acting since 2017 by promoting a school competition devoted to a consideration of the role of women in science and particularly in Physics. Our idea is that outreach activities can have the role of raising the awareness, the knowledge through the active involvement of students and that this is the way to change the culture, to remove the stereotypes. The aim is that new and more aware generations have the chance to make choices more appropriate and based on their real skills and their aspirations, without being influenced by hidden prejudices and stereotypes still able to obstruct the choice of STEM faculties by the girls.

¹ Directive of the Presidency of the Council 23 May 2007 (G.U. n. 173 of 27 July 2007).

2. GENERA (2015-2018) and GENERA Network (since 2018)

GENERA (acronym for **Gender Equality Network in Physics in the European Research Area**) is an EU-funded three-year project to support the research organisations active in physics and related fields to implement Gender Equality Plans customised to circumstances and needs of the physics research community through the examination of all decision-making processes, to identify any possible sources of gender bias in the research organisations.

It included 13 beneficiaries (Italian National Research Council (CNR) and Italian National Institute for Nuclear Physics (INFN) for Italy), 3 associates and 18 observers. With the signature of the Memorandum of Understanding in August 2018 it was established the GENERA Network², combining physicists and social scientists with the purpose of improving the collaboration among the members in gender equality policies in physics. Today the Network counts 35 members, almost equally distributed between universities and research institutes, and 6 “Friends”, how are called the organisations that support the objectives of the Network.

The mission of the GENERA Network is not only to improve gender balance in research organization, but also to shape and identify new markets for science knowledge where gender can play a role in differentiating the research quality and the innovation outcomes. The research organisations are called to collect in a new way gender data in physics, to share the results and to elaborate the outcomes in order to provide detailed and consolidated data for the use of the policy makers in the European Research Area.

One of the GENERA project achievement is the concept for Gender in Physics Days, that are meant as initiatives with the aim of implementing activities towards gender equality, identifying gaps, barriers and best practices. Starting from the necessity of involving in these initiatives hosted in GENERA institutions a wide spectrum of participants, from researchers to managers, from policy makers to different stakeholders, as INFN and CNR decided to include in the first Italian Gender in Physics Day, a competition reserved to the students of the Italian secondary schools. The idea was, at long term, to improve female participation in science, starting from the higher school educational level, while, at medium and brief term, was to understand the thinking and knowledge of young people on gender issues, to learn what is the student level of awareness on gender stereotypes, to understand if they are unaware "carriers" of stereotypes and prejudices, and finally to know how they imagine the society of the future.

Questions that guided our choice were:

- how students perceive the personality of woman researchers,
- what is their idea about the role of women scientists on scientific progress,
- how students consider cultural and social prejudices and stereotypes on women in science and in which way they could affect the career paths of young women scientists.

3. The school competition

The idea of this kind of competition, born inside the Gender in Physics Day organization, was based on two motivations: education and gender equity are instrumental in the development of the society, and the concept of change is strictly associated to young people and cultural change to students and school system.

With these ideas in mind, the students have been invited to submit a product (in the first contest video, photo, report, story, spot, poster; starting from the second edition, only video) on the topics covered by the announcement. The product could be realized by individuals, groups of students or the entire class, ranging over a wide variety of disciplines and competencies, from the story of woman scientists, to the physics itself, and more.

They have been asked to produce a product on three main subjects: work on stereotypes and prejudices, well established in the social and cultural background, that condition choices of new generations and weigh especially on the role and image of women in the field of STEM subjects and scientific research; encourage young women to undertake a career in the world of science;

² <https://www.genera-network.eu>

know the character of women researchers and deepen aspects of their private and professional life, pointing out the important and often different contribution of women to scientific progress.

The students allowed to participate attend the last three classes of high school, with an age comprised between 16 and 18 years, regardless of the course of studies.

The evaluation of the materials presented is carried out by a special commission, made up of experts in gender. Each product is submitted to the evaluation of at least three referees, followed by a common comparison in accordance with the following criteria: a) originality and creativity, b) communicative effectiveness, c) correspondence to the theme of the contest, e) technical skills. Each evaluator works on a detailed grid that takes into consideration the various technical and thematic aspects of the video and gives a vote. The best videos from each team are reviewed by all referees and rated. The winners are awarded a scientific prize and a plaque with the name of the school that won the prize and they are given the opportunity to visit one of the INFN national laboratories.

The first edition of school competition took place in Rome on May 17th 2017 and was titled “*Women in Physics: stereotypes and gender bias*”.³ In this occasion the students were left free to speak about the female role in scientific career with a medium of their choice. Short videos (58%) were by far preferred to reports, tales, posters and reportages and since the following edition we asked only for videos. Many works reported, in an often didactic way, the experience and life of past and present female scientists, seen as a possible example for girls in choosing a training course in the STEM subjects.

The competition involved 120 high schools and more than 800 students from all over the country, mostly coming from scientific high schools (59%) [7].

The second edition took place one year later, on May 16th 2018, at the INFN Laboratories of Frascati and was titled: “*Stories of women, research and applied physics: the other face of physics*”. The themes of this edition were selected in order not only to deepen the personality of female researchers and aspects of their personal and professional life, but mostly to highlight the important contribution of women in physics and to tell about the innumerable uses of physics, also applied, in the field of research and more generally of society, which have women as protagonists. Candidates were asked to present the project in the form of a not already published video no longer than 5 minutes.

The competition involved 400 students and 40 videos were submitted.

The third edition took place in Rome on May 20th 2022 and was titled “*Women and Research: opportunities, obstacles and challenges in physics*”. The contest was included in the programme of an INFN event devoted to the physics and the role of women, at the presence of the INFN and CNR management and with the welcome address of the Minister for the Equal Opportunities. The focus of this edition was on stereotypes and prejudices, well rooted in the social and cultural context, that influence the choices of the new generations and weigh on the role and image of women in the scientific research and in particular in the study of STEM subjects.

The competition involved 54 high schools, 70 classes and 680 students, especially girls (63%).

An independent expert report by the European Commission recognized our initiative in support for young women and girls to pursue STEM subject⁴.

4. What we learned

First of all, we understood that video is the favourite medium chosen by students, since that nowadays it requires a simple smartphone. This format allows them to perform as actors experimenting with new forms of communication by adopting expressive models typical of television (commercials, documentaries, music videos and more). In most videos the students decided to play actor roles, expressing in this way their strong involvement with their work. In

³ See Genera Italy YouTube channel:

https://www.youtube.com/channel/UCxZx0CFc19g0HQqeQf2gIxg/videos?view=0&sort=dd&shelf_id=0

⁴ *She Figures 2021. Policy briefs*, Rand, ICF, Quantas, Portia and Elsevier, 2021.

some cases, the use of objects like mirror, or lab coat allowed the girls to adopt a process of self-identification, while in other cases (more than 20%) the citation of official gender statistics wanted to give an objective look on the subject of the competition. Furthermore, they really appreciate to work in groups, to create something from the beginning like stories, submit questionnaires, etc.

Girls who are currently attending courses in applied science and scientific high schools have often perceived themselves to be considered “different” and for this reason witnessed external attempts to direct their lives, already in the phase of choosing high school. In several cases they have heard about gender issues, but they never specifically focused on this topic and above all they do not know in practice what does this mean. They asked to be informed and believe that the way schools generally deal with these topics is superficial and often far from the reality. Using questionnaires or interviews, many of them have “discovered stereotypes” and found how they are hidden everywhere. At the same time, they are proactive and enthusiastic, confident that things will change for the better and real parity will be achieved.

Faced with a current topic, such as that of stereotypes and prejudices, in all editions of the competition the students, both boys and girls, have shown a strong determination to react to anachronistic injustices and a desire for improvement. Perhaps it is not coincidence that the first prize winning videos were produced by students attending schools in small towns of central and southern Italy, where society expresses a more marked viscosity to change.

5. Conclusion

First of all, we learned a lot working together as an interdisciplinary research group with people from physics and from social science. The evolution of the different contests comes from the difference among us. For the organizers, all the competitions have been amazing experiences: watching videos and evaluating them allowed us, on the one hand, to breathe the same air of these youngsters who become actors, directors, writers and interviewers sharing their dreams and enthusiasm, and, on the other hand, also to perceive sometimes their fear of disappointing expectations. This experience underlines as young generations can be the real driving force behind a cultural change in which women can always express an interest in science, a confidence in their scientific abilities, and ultimately decide to pursue scientific careers, in the same way as men decide to pursue human science careers. Many of them discovered that science is not a matter of men only and in this occasion learned the names and the hidden lives of many female scientists.

At the same time, we as researchers have to promote this cultural change from ourselves, also using our outreach activities in a different way from the usual conferences for specialists, which are also important, suggesting different role models not only the hero or heroine one.

Physics today offers the possibility of pursuing fascinating jobs in very different fields and frontier professions. Starting from this point, in the next edition of the contest, we agree to ask the students to focus on professions of the future related to the women in physics, with an insight to the technological evolution and the climate emergency, which make it necessary to have specialized figures with scientific, technological, IT, digital and interdisciplinary skills for Big Data analysis, artificial intelligence, IT security (i.e. coding and cyber security), quantum technologies, market analysis. We are curious to find out how gender stereotypes are changing in relation of new professions and new skills of scientists in the coming decades.

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