

Are we all ready to get rid of gender inequality?

A global approach to the gender gap in mathematical, computing, and natural sciences: how to measure it, how to reduce it?

re you surprised to see few women's names on the list of Nobel Laureates? Are you surprised to see so few female scientists on the periodic table of chemical elements? Are you surprised to know there are still relatively low percentages female students in STEM (Science, Technology, Engineering and Mathematics) education programs? The answer to these questions might raise gender gap issues that have existed for a long time. The low representation of female scientists appears not only historically, but also currently in STEM education programs. While in most countries, women represent a majority of all graduates from tertiary education, fewer women than men complete STEM university degrees. Women account for less than 20% of entrants into tertiary level computer science programs in OECD countries and only around 18% of engineering entrants [1]. However, it seems that gender gap issues do not receive the attention they should. The United Nations proclaimed in its Sustainable Development Goals (SDGs): "Providing women and girls with equal access to education, health care, decent work, and representation in political and economic decision-making processes will fuel sustainable economies and benefit societies and humanity at large." However, much work remains to be done before such benefits can be reaped.

The Gender Gap Project

This project, titled "A Global Approach to the Gender Gap in Mathematical, Computing, and Natural Sciences: How to Measure It, How to Reduce It?", aims to ensure women's full and effective participation and promote gender equality and the empowerment of all women and girls at all levels in mathematics and sciences. To achieve this aim, eleven international interdisciplinary unions have been collaborating on various tasks over three years (2017-2019): International Mathematical Union (IMU), International Union of Pure and Applied Chemistry (IUPAC), International Union of Pure and Applied Physics (IUPAP), International Astronomical Union (IAU), International Union of Biological Sciences (IUBS), International Council for Industrial and Applied Mathematics (ICIAM), International Union of History and Philosophy of Science and Technology (IUHPST), United Nations Educational, Scientific and Cultural Organization (UNESCO), Gender in Science, Innovation, Technology and Engineering (GenderInSITE), Organization of Women in Science for the Developing World (OWSD), and Association for Computing Machinery (ACM).

The tasks of the project include the following initiatives:

- To develop a robust and sustainable methodology to clarify the meaning of gender gap. Identify appropriate data and develop reliable instruments to collect this data so as to measure and analyze the gender gap in mathematics and natural science disciplines in various parts of the world. The instruments used include a survey of scientists and a study of gender differences in publication patterns.

- To create a database of good practices aimed at girls and young women, and disseminate them, particularly in developing countries.

- To formulate recommendations to reduce gender gap for unions, institutions, and individual women students and scientists, teachers, and parents. One of the unique features of this project is to collaborate with social scientists on formulating research questions and developing implementation strategies on gender in science.

Task 1: the survey

To facilitate dissemination of the survey, the project hosted three workshops in different regions across the world, including Asia, Latin America, and Africa. The three workshops were held in Taiwan (National Taiwan Normal University, 7-8 November 2017), Columbia (Universidad de los Andes, 22-24 November 2017), and South Africa (African Institute of Mathematical Sciences, 1-2 December 2017). The aim of the workshops was to inform the purposes of the major tasks of the project, to review the contents of the survey in order to reflect local needs, and to build up a network for disseminating the survey across different disciplines and countries.

The survey was developed in collaboration with social scientists and used a snowball sampling method. It collected answers from May 1 to December 31 2018. During these eight months, 32,000 responses were collected *via* the project website [2]. Both men and women were encouraged to respond. The survey was available in seven languages: Arabic, Chinese, English, French, Japanese, Russian, and Spanish. The numbers of respondents to the global survey of scientists per country are shown in *figure 1*. Nearly two thirds of the responses were in English, but it became clear at the workshops that the use of multiple languages encouraged inclusivity. We aim to analyze similarities and differences across regions and cultures, developing and highly developed countries, and across different disciplines.

The total number of respondents in chemistry field was 2,724 worldwide (8.9% of total). The data analysis will be carried out by American Institute of Physics (AIP) Statistical Research Center. Analyses will be conducted for countries in which there are enough respondents to maintain confidentiality.

Task 2: the publication patterns

The purpose of the second task was to design a methodology that allows analysis of publication patterns for different disciplines and extends the current research to longitudinal studies in the future. This work was based upon a comprehensive study carried out by Mihaljević-Brandt, Santamaria, and Tullney



Figure 1 - Number of respondents to the global survey of scientists per country, 02/01/2019 (retrieved from [3]).

[4] on analyzing publication patterns of scholarly output of ~150,000 men and women mathematicians in the zbMATH database from the past four decades (1970-2013), in which significant differences between genders were found. The publication gap puts women at a disadvantage when they pursue careers in mathematics academia. The study revealed that the number of women mathematicians tripled since 1970, but that women published less than men at the beginning of their careers and leave academia at a higher rate. They also found that men publish far more single-authored papers than women, in particular, women regularly collaborate with the same researchers. Similar methodology will be used to study publication patterns in different disciplines (such as chemistry) and across countries and regions. In short, a key objective is to create a sustainable and dynamic methodology to provide a continuous data processing flow, and hence allow for easy updates and longitudinal data analyses.

Task 3: the database of good practice

The third goal of this project is to establish a database of good practices that have been proved to be successful programs for promoting females and girls at different levels to work and study in science and mathematics fields. This collection of the practices will be made available to all countries who are interested in changing the situations of gender inequity and reforming the opportunities of working in educational and industrial sectors. Currently, fifty gender initiatives from thirtynine countries were identified [5]. To extend the services and power of this database, we welcome more initiatives to be recommended across the global so more appropriate models could be researched for local needs and then adopted into local situations.

How to reduce the gender gap?

This global gender gap project has four objectives, namely: - to provide an evidence-based report and recommendations to stakeholders *via* a joint global survey and a study of publication patterns; - to collaborate with social scientists working in gender and science, obtaining similarities and differences of outcomes across different geographical fields, age, degrees, genders, fields of science, and cultures, developing and highly developed countries, and across different disciplines;

- to provide easy access to materials to encourage young women to work in science and mathematics fields, including information and resources about careers and salaries directed at parents, schools, and others who can influence the careers of girls, in particular in the developing world;

- to identify and propose interventions to make improvements and to recommend good practices for girls and females in science, and further to recommend practical policies and actions that will reduce the gender gap across the globe.

So far, the project reinforced evidence that the global gender gap still exists. Preliminary results of the survey for chemistry and mathematics show that women report lower salaries, more career interruptions, and more instances of discrimination. A final project conference will be held at the International Centre for Theoretical Physics (ICTP) in Trieste (Italy) on 4-8 November 2019. Methodology, tools produced, survey results of the project, data analysis of publications, and compilation of good practices will be reported. Information about the use of resources and data from this project will also be shared.

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[3] https://gender-gap-in-science.org/2019/01/04/answers-to-the-global-survey-of-scientists

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