

Science Education and Research for Women Empowerment

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ABSTRACT

Maximum exploitation of existing human resources is possible by immediate engagement of women in science. But, historically, scientific field is found to be male-dominated. Women empowerment embraces the good quality education. Sensitizing and encouraging the women towards education embracement enables them to set free from ignorance, poverty and starvation. Hence, education is continuing as the most practicable avenue for women empowerment. Imparting science education to the entire population expedites the accomplishment of scientific and technological progression. The present article enlightens the efforts of Indian government and United Nations towards empowerment of women through science education and research.

Keywords: Gender discrimination, Science education and research, STEM, Women Success

INTRODUCTION

Women are underrepresented in Science. Attrition rate of women in science area of academic field can be explained taking into consideration of a number of reasons. Gender based discrimination and bias, hostile working environment, Poor professional / financial support and amplified work-family conflict are some of those most frequently faced issues. At present, women are underrepresented in enrolment, graduation and employment in the fields of Science, Technology, Engineering and Mathematics (STEM). Out of more than 600 awarded Noble prizes till 2019, only 20 were bagged by women [1] (Table 1)

Women encountered a relentless tussle to participate in science. It may be permission to study the science, to become full-fledged researchers, to secure appropriate cadre, to overwhelm favouritism, to get the acceptance for publications, and to get funding for research proposals, to get entry into professional bodies, and to acquire appreciation, awards and honours [2]. Rosalind Franklin (1920–1958) provided proof to the double helix theory based on which Nobel Prize was jointly won in Physiology or Medicine in 1962 by Crick, Watson and Wilkins for unearthing the DNA structure. Posthumous nominees are prohibited for Nobel prizes, hence, Rosalind Franklin was not recommended for noble prize [3].

Reports reveal that female doctoral students experience more stress compared to males. In addition to family responsibilities, female research scholars are affected by the general stress factors like difficulty in management of time & family, financial restrictions, own expectations and recurrent appraisal of research progress. Women undertake manifold roles in their regular life. Balancing the private life with that of professional is a courageous task, which makes them to expose to an internal conflict. Physical as well as psychological health issues arise for women due to stress caused by multiple responsibilities and a scarcity of time and vitality [4]. Relocation issue is one of the prime reasons for discontinuation of PhD program by women, which leads to gender gap in R&D. Enacting policies related to flexible leave policies for maternity and to take care of the infants will assure the improvement of women scientists.

Table-1: Women Noble Prize Winners

Name	Field/ Subject	Year of Award	Contribution
Marie Curie	Physics	1903	Radiation phenomena.
Maria Goeppert Mayer	Physics	1963	Nuclear shell structure.
Donna Strickland	Physics	2018	Laser physics - method of generating high-intensity, ultra-short optical pulses.
Marie Curie	Chemistry	1911	Discovery of the elements radium and polonium.
Irene Joliot-Curie	Chemistry	1935	Synthesis of new radioactive elements.
Dorothy Crowfoot Hodgkin	Chemistry	1964	Structures of important biochemical substances by X-ray techniques.
Ada E. Yonath	Chemistry	2009	Structure and function of the ribosome.
Frances H. Arnold	Chemistry	2018	Evolution of enzymes.
Gerty Theresa Cori, née Radnitz	Physiology or Medicine	1947	Catalytic conversion of glycogen.
Rosalyn Yalow	Physiology or Medicine	1977	Radioimmunoassay of peptide hormones.
Barbara McClintock	Physiology or Medicine	1983	Mobile genetic elements.
Rita Levi-Montalcini	Physiology or Medicine	1986	For their discoveries of growth factors.
Gertrude B. Elion	Physiology or Medicine	1988	Important principles for drug treatment.
Christiane Nüsslein- Volhard	Physiology or Medicine	1995	Genetic control of early embryonic development
Linda B. Buck	Physiology or Medicine	2004	Odorant receptors and the organization of the olfactory system.
Francoise Barre- Sinoussi	Physiology or Medicine	2008	Human immunodeficiency virus.
Carol W. Greider	Physiology or Medicine	2009	How chromosomes are protected by telomeres and the enzyme telomerase.
Elizabeth H. Blackburn	Physiology or Medicine	2009	How chromosomes are protected by telomeres and the enzyme telomerase.
May-Britt Moser	Physiology or Medicine	2014	For their discoveries of cells that constitute a positioning system in the brain.
Tu You you	Physiology or Medicine	2015	Novel therapy against Malaria.

NEED FOR GENDER EQUALITY

Discussing issues related to 'Gender Equality' is an embarrassing issue for the both genders in view of the involvement of emotive topics. Hence, a constructive deliberation is required, which provides real material regarding the issues involved and specifics of organizations as well as their programs which back the women to pursue a scientific career [5]. Scientific aptitude is the essential requirement in the technology dependent world [6]. Substantive gains can be obtained by improving the women's contribution in scientific movement.

Providing the men and women with correct knowledge, valuable aptitudes and good technical abilities is possible through science education which develops self-reliance and generates employment. "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" was the goal stated at the UN climate change conference-

2016 held in Paris. It clearly indicates the UN has recognized the fact that economies are benefited by achieving gender parity and empowering all women and girls [7].

ACADEMIC FIELD ISSUES

A stretched history of gender difference was recorded. Either downplaying or ignoring the contributions of female scientists was reported in scientific communities of western and eastern countries. Science education was not permitted for female students during a great part of history. Marie Curie was able to prove that women can do science of worthy. In the history of science, milestone is receiving her 2nd Nobel Prize against her work in chemistry. She inspired female category to opt science programs and pursue professions in science [8]. Comparable enthusiasm and interests were shown by female and male science students of both elementary and secondary schools of US. But, science interested male and female students preferred physical and biological sciences respectively. Gender differences are clear at the university level from the higher orientation of men towards engineering and physical sciences [9].

PRESENT STATUS - GLOBAL

Globally, at the levels of bachelor's (45–55%) and master's (53%), equality was achieved by women. But, slipped down the parity at PhD level (43%) and further the gap widened at researcher level (28.4%). In order to foster gender equality, a specified quota (30%) was introduced at company board of director's w.e.f. 2013 in countries like Germany [10]. The numbers of women choosing careers in the scientific professions have risen dramatically over the past 20 years. Yet, the corresponding rise in middle and senior levels of all career paths has not materialized. An overview of the current demographics of women in the professions and potential shows the presence of discrepancy [11].

Women researchers' number is under minority in the world. Almost in all nations, there is a rising plea for higher statistics on women in science. But, mostly, usage of available data in policymaking is limited. UNESCO Institute for Statistics compiles the data and releases the fact sheet regarding profiles at global and regional levels and areas of their under-representation. As per the fact sheet of June 2019, worldwide percentage of female researchers is 29.3%, whereas, statistical data in different countries about participation of female researchers is 75.6% (Myanmar), 53.2% (Thailand), 48.2% (Malaysia), 46.6% (Srilanka), 40.6% (Indonesia), 30.1% (China), 38.4% (Pakistan), 30.1% (Singapore), 20.2% (Israel) and 13.9% (India) [12]. 1.740, 1.371, 0.290 and 0.283 million researchers are present in China, US, UK and India respectively [13].

PRESENT STATUS - INDIAN

As per 2011 Census, the literacy rates for women and men in India are 65.46% and 82.14% respectively. As per 2012-13 statistics from AISHE (All India Survey on Higher Education), percentages of female enrolment at bachelor's / master's level are 37.84 / 5.42 (Arts), 11.30 / 2.60 (Commerce/Business), 12.09 / 2.31 (Science), 4.46 / 0.39 (Technology), 4.06 / 0.22 (Engineering), 9.32 / 15.47 (Law/ Education / Computer / Other). % of women enrolment in Universities has grown from 29.2 (1990-91) to 39.4 (200-01). Low fraction of women in prestigious institutions can be attributed to the fact that inertness of parents to spend the amount for girl child [14]. The female Ph.D. awardees increased at a faster rate (9.35 per cent per annum) than male Ph.D. awardees (5.86 per cent per annum) during the period 2012-2017. This has reduced the gender gap in research at Ph.D. level. Number of PhD Degrees awarded to female are 8775 in 2012; 9638 in 2013; 8578 in 2014; 9284 in 2015; 12505 in 2016 and 14121 in 2017 [15].

Breakdown of researcher's data on sector of employment (% of researchers) in India is Business enterprise (26%), Government (31%), Higher Education (39%) and Private-non-profit (4%) [16]. As per the statistics of 2008, % Women scientists in various institutions are 16.05 (CSIR), 20.8 (DST), 15.0 (DAE), 27.4 (DBT), 29.0 (ICMR), 14.0 (DRDO) and 14.3 (ICAR). Similarly, percentages of women faculty in prestigious Universities are 7.7 (IISc, Bangalore), 20 (University of Hyderabad) and 20 (JNU, Delhi). Women percentages in fellowships are 7% (IASc), 5% (INSA) and 8% (NASI). % of Women in Shanti Swarup Bhatnagar Awardees (1958-2014) 3.75 % (Chemical Sciences) and 3.38 (Total) [14]. In India, women at PhD level are 20-25%, but it falls to 10-12% while reaching professors or heads of divisions [14].

Social conditioning (like gender – bias) can be changed by ‘Role Models’. The Indian Academy of Sciences (IASc) compiled the biographies of Indian women scientists in the form of a book entitled “Lilavati’s Daughters: The Women Scientists of India”. Some of the prominent Indian women scientists are listed in Table 2.

Table-2.Prominent Indian Women Scientists

Name	Field / Subject	Contribution
Asima Chatterjee	Organic chemistry and phytochemistry	Developed anti-epileptic drug, Ayush-56 and anti-malarial drugs.
Dr. Indira Hinduja	Medicine (Gynecologist, obstetrician and infertility specialist)	Introduced GIFT (Gamete Intra fallopian Transfer).
Shubha Tole	Neuroscience	Developed master regulator gene which controls the development of the brain's cortex hippocampus and amygdale.
Darshan Ranganathan	Bio-organic chemistry	Supramolecular assemblies, molecular design, chemical simulation of key biological processes, synthesis of functional hybrid peptides and synthesis of nanotubes.
Paramjit Khurana	Plant Biotechnology, Genomics, and Molecular Biology	'All Weather Seeds'.
Dr.Aditi Pant	Oceanography	Oceanography and geology (Antarctica).
Tessy Thomas	Technology	Project Director for the Agni-IV and Agni-V missile in Defence Research and Development Organisation.
Usha Barwale Zehr	Biotechnology	Produced India's first genetically modified food, the Bt brinjal.
Charusita Chakravarty	Chemistry	Classical and Quantum Monte Carlo, Molecular Dynamics and Structure and Dynamics of Liquids.
Anandibai Gopalrao Joshi	Western Medicine	First Indian women doctors to learn and practice western medicine at the age of 21.
Mangala Narlikar	Mathematics	Simple Arithmetic and Advanced Mathematics.
Aditi Pant	Oceanography	Geology and oceanography (Antarctica).
Sunetra Gupta	Theoretical Epidemiology	Infectious agents that cause diseases such as influenza and malaria, among others
Nandini Harinath	Scientist at the Indian Space Research Organisation	Worked on 14 missions, deputy operations director for the Mangalyaan mission.
Rohini Godbole	Physics	Particle Phenomenology.
Janaki Ammal	Botany	Cytogenetics and phytogeography.
Kamala Sohonie	Biochemistry	Discovered ‘cytochrome C’.
Rajeshwari Chatterjee	Electrical Engineering	Microwave engineering and Antennae Engineering.
Kalpana Chawla	Aerospace Engineering	Space Shuttle.
Kadambini (Basu) Ganguly	Western medicine	First female physicians of South Asia to be trained in western medicine.
Anna Mani	Physics	Meteorological instrumentation

Dr.Suman Sahai	Genetics	Founder of the Gene Campaign in India, an organization working on food, nutrition and livelihoods.
Sunita Sarawagi	Data mining, machine learning	Works on extracting structured info from unstructured data & how to maximise the reuse of deep neural network models used in translation.
Vidita Vaidya	Neuroscience	Works on how experiences, stress affect the circuitry of the brain.
Gagandeep Kang	Gastrointestinal sciences	India's first indigenous rotavirus vaccines.
Farah Ishtiaq	Evolutionary ecology	Spread of malaria in birds.
Devapriya Chattopadhyay	Paleoecology	Works on fossil records of molluscs from Kutch to study the effects of ocean circulation millions of years ago.
AditiSen De	Quantum computation, information, cryptography	Works on finding the right quantum mechanical system for a quantum computer.
Muthayya Vanitha	Data interpretation, mission design	Telemetry and data interpretation, including creating data handling systems for remote sensing satellites
RituKaridhal	Data interpretation, mission design	Mars Orbiter Mission.

NEED FOR ENHANCEMENT OF WOMEN'S RESEARCH CAPACITY

Augmentation the involvement of women in STEM fields is above the social-justice issue. Relatively, the number of women academic researchers in STEM (science, technology, engineering, and mathematical) fields is less. Research capacity of academic women in STEM includes rewarding research productivity, recognition and merit evaluation for awards) and enhanced grant funding [17]. Considering the fact the women are also the part of the university community, augmented participation of women in STEM has to be ensured by Universities.

GLOBAL INITIATIVES

The number and involvement of women in the scientific field can be improved by three strategies. One of it is ensuring educational awareness i.e., safeguarding encouraging gender balance in faculty, popularizing the triumph of women scientists, educating on unconscious gender bias. Second strategy is nominating women for scientific boards, scientific awards, selection committees and speaker lists of conferences. Third one is data analytics to quantify women regression, followed by publishing the data trends [18]. Other measures are conception of special events / casual get-togethers, giving the deserved credit and release of dedicated special issues in journals with research articles from women.

Gender gap details in STEM were collected as a part of D&B survey by UN in order to provide knowledge on the drivers and the barriers in Science and Engineering, which facilitates the end users like policy-makers & other crucial patrons, academic wings, active groups working on gender equality in STEM etc. STI GOL (SAGA Science, Technology and Innovation Gender Objectives List) is embedded in D&B survey. The underlying objectives or policy impacts for STI GOL are: changing perceptions, assertiveness, manners, social customs and stereotypes in order to reroute the women towards STEM; engaging girls and young women in primary to technical education; Inviting, providing entree to and safeguarding women retention in higher education of STEM; promoting gender equality in (a) STEM-associated policy-making (b) innovation and entrepreneurship undertakings and (c) career development for scientists and engineers, promoting the gender element in content, plans and practices related to research [19].

In higher education of STEM, only around 30% of female students are interested, as per the data of UNESCO (2014-16), whereas, women researchers are less than 30% in the world. In recognizable

posts of STEM, women strength is 12%. Hence, 11th February is declared as “International Day of Women and Girls in Science” by UN General Assembly in order to facilitate complete as well as equal access to women for involvement in Science. One of the development goals in “2030 Agenda for Sustainable Development” is science and gender equality. Hence, theme of 2019 is "Investment in Women and Girls in Science for Inclusive Green Growth" [20].

INDIA GOVERNMENT INITIATIVES

In India, women are sensitized by NGO's and Government Departments. Three Science Academies in India (The Indian Academy of Sciences, Bangalore; The Indian National Science Academy, Delhi; The National Academy of Sciences, India, Allahabad) have given many recommendations regarding Women in Science based on their documented information in this area. To coordinate different programs of Women in Science, “Inter-Academy Panel” was established under the chairmanship of Prof. Manju Sharma, former Secretary to the Government of India. A vision document was proposed by it which mainly focussed on summarizing the recommendations and to give implementation strategy [14].

Numerous hurdles are faced by women faculty to receive research funding. In India, prior to 2001, less number of research fellowships, postdoctoral positions, start-up grants and other research grants were received by women. Moreover, they receive less credit for their contributions in a team work [21]. Disproportionate share of household and caregiving duties to women are the additional factors under the deficiency of social support which distress women's grant-writing productivity and grant success.

By 2010, principal investigators of funded research projects reached to 23% due to launching of special funding schemes launched for women. To encourage participation of women in Science and Technology fields, funding agencies are offering the special awards and funding schemes to encourage the re-entry of women scientists having mid-career break. DST, Ministry of Science & Technology, Government of India has constituted a Standing Committee for Promoting Women in Science in March 2016 which tries to create gender empowering atmosphere in science and technology institutions, recommends different measures to safeguard women progression in science and also recommends tailor made programmes to foster utilization and support of women in science [22]. KIRAN (Knowledge Involvement in Research Advancement through Nurturing) embraces women-exclusive schemes of DST like **Women Scientist Scheme-A (WOS-A/B/C)**, **Indo-U.S. Fellowship for Women in STEMM**, **Women Entrepreneur Quest (WEQ)**, **S&T for Women**, **Women Technology Parks** and **Consolidation of University Research for Innovation and Excellence in Women (CURIE)**. DST gives a national award for “Women's Development through application of Science and Technology”.

DBT (Department of Biotechnology), India is helping to build capacities for women scientists who are interested to resume after a career break by offering special schemes like Women Scientist Scheme (Career Re-orientation) and Biotechnology Career Advancement and Re-orientation programme for women scientists (Bio-CARE) [23]. Age relaxation in young scientist programs like Start Up Grants offered by UGC and DST. As per recent regulations of UGC, maximum duration permitted for women candidates to complete Ph.D. / MPhil program is relaxed by two / one year(s) and permitted the maternity / child-care leave up to 240 days. In addition, research data transfer is allowed in case of relocation of woman researcher [24].

WOMEN ENTREPRENEURSHIP

Acquirement of entrepreneurial skills by women profiles them to grow into entrepreneurs, which aids to relieve from poverty. Some of the suggested recommendations are amalgamation of entrepreneurial skills with science education curricular, making compulsory the gaining these skills to accolade the certificate, and, providing the amenities and resources by government to impart entrepreneurial skills [25].

CONCLUSION

Counselling the women helps them to believe in themselves and also improves confidence in them that their scientific work materials for society. Confronting the discrimination and defying the gender bias

by women is required. Healthy gender equality can be maintained through equalized temperament, attitude and style which facilitate the advancement of women. Gender disparities can be eliminated by effective implementation of government laws in order to achieve the parity of women in researcher population.

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