REVIEW ARTICLE

The malaise of under-representation of women in science: the Indian story

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Under-representation of women in science is a global phenomenon and affects India as well. It deprives women of opportunities in science and is also a great loss to society and science itself. The scientific community can be an important pressure group for building greater focus on the issue and pushing for concrete measures to address the problem. This article reviews the discussions amongst the Indian scientific community on the subject since the early twentieth century and examines the suggestions made by it, based on research and personal experiences. There is a strong case for mandating women's presence in leadership and decision-making positions to address the issue. There is also a case for greater involvement of male colleagues in addressing this issue. Important suggestions have been put forth to make our scientific institutions women-friendly, but not many have been implemented. The resolution of the issue requires stronger will and deeper commitment from policy-makers and the scientific community itself.

Keywords: Bias, gender, STEM, under-representation, women in science.

WOMEN have been participating in science and making contributions since ancient times. However, their acceptance amongst the male-dominated scientific community has always been a challenge. In modern science this is best exemplified by the experiences of one of the most celebrated women scientists, Marie Curie. Marie Curie, the only person to have won the Nobel Prize in Physics and Chemistry, and the first woman to receive the Nobel Prize, and the first woman professor at the University of Paris, was not granted membership to the French Academy of Sciences. While rejecting her membership in 1911, a spokesman for the Academy held it 'eminently wise to respect the immutable tradition against the election of women'[1].

Women constitute about half the global population and therefore half the potential human resource. However, their proportion in science is much lower than their proportion in the population. The phenomenon is global and affects even the most developed countries. Metaphors such as 'glass ceiling', 'sticky floor', or 'leaky pipeline' are used to describe the reducing presence of women as they move up on the science career graph[2].

The proportion of male students opting for science and engineering is much higher than that of females. Globally, one in five men graduates in engineering and one in nine graduates in science. The corresponding figures for women are one in twenty and one in fourteen[3]. In India, almost 40% of undergraduate science students are women and 30% are in engineering[4]. For science, the figures are comparable with some of the most developed countries and for engineering, the proportions are higher for Indian women. In UK, women account for 40% of undergraduate students in physical sciences and mathematical sciences and 14% in engineering and technology[5]. The proportions in the USA are 40% for physical sciences, 43% for mathematical sciences and 18.7% for engineering[6].

Thirty-seven per cent of Ph D awardees in science in India are women, indicating that not many women are lost to science till the Ph D level. The gender gap widens in the practice of science with women occupying 15% of science faculty positions. Only about 14% of government scientists are women[7]. Recognition of the contributions of women scientists remains poor. Women comprise only 7% of the fellows of the Indian Academy of Sciences (IASc) and 5% of the Indian National Science Academy (INSA)[4]. The number of women recipients of prestigious science awards like the Shanti Swarup Bhatnagar, has been increasing over the decades[8], but the absolute number remains minuscule with 15 women awardees out of 461 (ref. 4) as of 2014.

It is important to address this issue. Having more women in science is not only about gender equality and equity but is also in the larger interest of scientific progress and society. Studies indicate that male domination of research can lead to gender differences being overlooked, making research output male-centric. For example, there is not much data on female crash dummies, even though the anatomies of men and women are different[9]. Another example is that of aspirin which was developed in 1899 (ref. 10), but it was only in 1993 that its differing effects on men and women were discovered[11]. Loss of educated women in the science workforce is a loss of national and private resource spent on their education. It is an opportunity loss in terms of their possible contributions to science and society.

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Table 1. Summary details of articles from Boolean search

Time period	Number of articles, section wise	Total number of articles	Number of articles with women as sole authors/first author
Pre-independence	NA (no sections in the journal)	1	Not determinable
Post-independence to 1989	No articles	No articles	NA
1990–1999	Correspondence – 1 Editorial – 1 General article – 1 Meeting report – 1 Opinion – 1	5	4
2000–2009	Commentary – 2 Research communications – 1 Correspondence – 4 Editorial – 1 General article – 1 Meeting report – 4 News – 3	16	11, 2 not determinable
2010–7 October 2016	Commentary – 3 Correspondence – 9 General articles – 4 Guest editorial – 1 Meeting report – 5 Opinion – 1	23	15

The scientific community is a key stakeholder in this important issue, and it is relevant to examine its perspectives on the subject. This review examines the discussions amongst the Indian scientific community on the subject since the early twentieth century, along with the suggestions made by Indian scientists based on research and personal experiences. The aim is to draw out important lessons for addressing the problem.

Methods

Source of data

The review is primarily based on a study of articles on the subject published in the journal *Current Science*. The reasons for confining the study to this journal are: It is an open access journal; articles are available in a searchable format making identification of relevant articles amongst thousands of articles feasible; journal issues since inception in 1932 are available online, making it possible to observe trends over a long period of time; the journal captures contemporary research and discussions amongst the scientific community on issues impacting science and therefore, what is published in the journal can be taken as reflecting the contemporary discussions at any point in time, including that on the subject of under-representation of women in science; the journal is interdisciplinary capturing the perspectives of scientists from multiple streams.

Boolean search using the keywords women, gender, ceiling, bias, scientist, woman, girl, female and STEM was applied on volumes starting from 1932–33 (Volume 1) to 2016 (Volume 111, Issue 7), the last issue available at the time of this study. Book reviews and advertisements were excluded from the study.

Summary details of the articles are given in Table 1.

Trend analysis

The searches threw up 45 articles on the subject. For the study of trends, time periods have been divided into pre-independence, post-independence to 1989 and thereafter, decadal time frames have been considered 1990–1999; 2000–2009; 2010 till present. Articles in each decade have been analysed for general trends: these include overall observations and trends on the analysis of the problem by various authors; problem definition: this section covers how various authors define the problem based on their personal and professional experiences as well as research; underlying causes: this captures various underlying causes as expressed by the authors; solutions suggested in the articles: this section details various remedial measures discussed in the articles.

Results

Pre-independence period

Only one article was found during this period. The article was on the issue of girls' education in India[12] and does not specifically address the subject of popularizing science amongst girls. The reason for this was probably

because less than 3% of women in British India were literate[12], and therefore the focus was on improving overall education of girls.

Post-independence to 1989

During this time, substantial progress was made in science education for women. In 1950–51, 14 women per 100 men were enrolled in higher education. By 1970–71 women comprised 18.5% of science students at the Universities. The proportion for engineering was minuscule at 1%. Two decades later, by 1990–91, these percentages increased to 36.8% and 10.9%, respectively, bridging the divide significantly in science[13].

However, there is no article on the subject in this period! This shows that the issue did not receive much attention in the discourse amongst the scientific community. This could be due to very few women researchers at prestigious universities. As we see later in the review, the discussion on the subject is primarily led by women scientists, until the current decade. Therefore, few women in science and research could have translated into lack of discussion on the subject.

1990–1999

General trends: During this decade, limited deliberations occurred on women in science issues and these are mostly based on personal experiences and opinions and not on research. Only one article argues progress based on data analysis[14].

An interesting feature evidenced is that the fora deliberating such issues are largely women. Out of five articles in this decade, four are authored by women, depicting that the problem is considered to be a women's issue.

During this period, views of male counterparts on participation of women in science were at variance. Some of them believe that women do not have the same scientific capabilities as men and that only few women have the motivation to excel[15]. However, there are others, who espouse the benefits of gender diversity in science. These scientists believe that gender diversity could lead to 'many more new discoveries' due to the less 'dogmatic' nature of women scientists[16] and bring in 'new and potentially beneficial attitudes'[17] to the practice of science.

Problem definition: There are two schools of thought. One is that women are at a disadvantage at all stages of education and careers in science starting from primary school[16]. The other more optimistic and more prevalent view is that good progress is being made at all levels of science education[14,17] and entry level research positions[18]. However, subsequently women's presence declines due to various reasons and the representation at the top levels is very low[15].

Underlying causes: Social and cultural biases in society are considered to be the key causes for a major part of this decade. Rao[16] extensively dwells upon these biases. Girls are expected not to question, 'killing' their spirit of enquiry, a must have to do well in science. They are assumed to be incapable of purusing science and therefore encouraged to study humanities. Marriage is seen as another important cause for women dropping out of science. It is argued that managing the demands of family and profession, simultaneously, can be difficult[16,17] and women prioritize family over work because of which their careers take a back seat.

Towards the end of the decade, scientists begin to deliberate on gender biases at the workplace and their impact on women scientists. Scientists perceive that women's problems are 'poorly appreciated' or 'deliberately ignored'[17] and they are seen as women's personal problems, and not that of society[15]. Women scientists are often not taken seriously. For example, women nominees on committees are considered 'token representation'. When women apply for postdoctoral work or permanent jobs, the social bias that women are required to give preference to family over work, sometimes becomes a consideration in hiring. This affects the opportunities available to them post-Ph D[18].

Solutions suggested in the articles: One of the key suggestions made is to bring about mindset changes to address the social and cultural biases as well as the workplace gender biases. Many ideas are put forth at the level of family, schools and workplace. These include educating families to treat boys and girls equally, counselling parents to encourage girls into science and sensitizing teachers to gender problems and encouraging them to be role models for girl students. At the work place, gender sensitization of male colleagues is recommended for creating a 'women friendly' and 'less alienating' atmosphere for women scientists[16]. It is also felt that women themselves need to be more assertive to perform better at the workplace[15].

Scientists suggest creating appropriate infrastructure like crèches[17] to help women balance child rearing and professional responsibilities. In addition, special schemes and relaxations that allow women to manage the dual responsibilities are widely recommended. These include unpaid leave, special fellowships and relaxed age limits for fellowships[16] and flexible age limits for temporary research projects along with provisions for extending the duration and fellowship enhancements[17]. The positive experience of CSIR in implementing some of these measures[14], builds a strong case for their wider implementation. Relaxation in selection and promotion criteria, to compensate for the dual responsibilities, is also suggested[15].

Another important subject of deliberation is the issue of quota versus affirmative action with scientists expressing

preference for affirmative action. The quota system is seen as not being in the interest of women[16] as it could be perceived as 'patronizing'[17] and could also lead to a 'feeling of disgust' amongst women and 'resentment' amongst men[18].

To spread awareness on Indian women scientists, a proposal to create a website on the contributions of women scientists is also put forth[18].

2000–2009

General trends: Serious deliberations on the issue started in this decade, around 2001 (ref. 19). Women scientists continue to lead the discussions. Here again main discussants are predominantly women[20–22] and most of the articles (11 out of the 14) are authored by women or have women as first authors.

Scientists observe the trend of greater number of men opting for the more lucrative engineering[23], management or information technology[24] careers compared to science. This aspect, although not much deliberated, is important and needs to be researched further. Is it that more women are finding a place in science because fewer men are opting for it? or is engineering the first choice for women as well, but because of intense competition in engineering, are they settling for science careers? or is it because of gender biases being genuinely overcome in science education? If any of the first two reasons are found to be true, it would imply that increasing proportion of women in science education is not entirely because of overcoming of gender bias.

Science Academies play an active role in addressing the challenge. IASc and INSA constitute special committees[25] to work on the issue. The INSA study of 2004 is a first comprehensive study on the subject[26] and makes many important recommendations. The study confirms the prevalence of 'gender insensitive organizational practices and workplace discrimination' affecting career growth of women scientists. Platforms like the National Women's Science Congress which provide opportunities to women scientists to showcase their work are created in this decade[27].

In addition, many Government initiatives are also seen. Government policy enumerates encouraging women to take up careers in scientific research as one of its objectives[28]. A Task Force on Women in Science is created by the Department of Science and Technology (DST), Government of India, to examine various aspects of the problem and make recommendations. Special schemes for women scientists, voiced in the previous decade, are initiated in this decade. DST launches 'Women Scientist Scheme' to facilitate women's come back in scientific careers after a break[29], by offering short-term research projects. The University Grants Commission announces 100 part-time research fellowships for unemployed women with Ph Ds[25].

The dimension of pay parity amongst the male and female scientists in the Indian context is discussed in this decade for the first time. The conclusion is that women in the age group of 30–40 years have a small positive edge but lose it after 40 years[30]. The reason for this could be higher proportion of women taking career breaks, or postponing research during the child bearing and rearing years[27,23], which affects their career progression at a later stage.

An important observation made by scientists is the possibility of greater marginalization of girls in science education, as education becomes more privatized[26] and hence more expensive. This is even more relevant in today's context, with increasing share of private sector education. Therefore, it is important to research and examine this aspect in depth.

Scientists also express the lack of easy availability of appropriately disaggregated data[21], making research difficult.

Problem definition: Scientists mostly agree that the number of women in science starts reducing post-Ph D, with the drop becoming more pronounced in senior positions. There is a virtual absence of women in leadership and decision making positions.

Underlying causes: There is a major shift in key causes ascribed to the problem, based on new insights from research studies. From cultural and social causes being considered as the primary reasons previously, the opinion in this decade is that the organizational factors arising out of the male dominance of scientific institutions and workplace gender biases are also important.

Research in this decade demonstrates that 'women-specific environmental issues' at the workplace negatively impact the productivity of women scientists as measured by the quantum of high quality published research. Two plausible explanations are put forth. The first one is the possibility of lack of necessary equipment and lack of support staff, as discovered in the case study of women from the Massachusetts Institute of Technology. The second one is gender biases in peer reviews as demonstrated by a Swedish study that concludes that 'peer-reviewers cannot judge scientific merit independent of gender'[24]. These results call for similar research in the Indian context, to assess the true extent and impact of workplace gender bias.

Gupta *et al.*[23] study the impact of societal and workplace factors and their role in creating workplace stress, or 'burdens' for women scientists. The first burden is the workplace gender bias and a 'hostile' work environment for women arising from the male domination of academic and research institutions. The second burden comes from gender stereotyping, leading to women having dual responsibilities of family and profession. The third burden comes from lack of informal networks which are

important for accessing project funding, publishing peer-reviewed research and securing nominations for awards and science academies. Out of the three burdens, only the second one is rooted in social causes, the other two fall in the domain of women unfriendly organizational practices.

Scientists also deliberate on how the societal and workplace factors interact with each other to affect women in science. Scientific institutions do not have a 'critical mass'[28] of 10–15% in research and faculty. Fewer women mean few women colleagues. Gender stereotyping keeps them out of male groups. These two factors – lack of critical mass and gender stereotyping – together translate into less support from peers and lack of 'social capital' or 'informal networks' for women, all of which are critical for progress in scientific careers. Similarly, the three burdens as described in the Gupta *et al.*[23] study, work in tandem to create a triple burden on women, responsible for 'low position' of women in science. These interactions make the issue complex.

The policy of institutions not hiring couples is also seen as negatively impacting the careers of women scientists[24,26,28].

Solutions suggested in the articles: Scientists lay great emphasis on addressing organizational issues in this decade. There is an emphasis on 'shedding the cloak of prejudice'[31] and creating a supportive and encouraging[32,33] environment for women. This is in consonance with the conclusion of the INSA study that women do not want special privileges, but want more gender friendly organizational practices[26].

Many scientists recommend bringing in transparency in decision-making. These include gender–unbiased transparent criteria for evaluating project proposals, hiring and nominations to decision making positions[24]; mandating universities and project funding agencies to have written policies for recruitment and promotions and reporting of the decisions[21]; allowing self-nomination for awards and appointing more than one independent committee to evaluate the applications, as borne out by the success of these practices in USA[28].

Another interesting suggestion is to incentivize institutions to be gender friendly. Scientists suggest various ways of implementing this including linking government funding to institutions incorporating gender equity into their policies[21]; incorporating performance on gender equality into the rankings of the academic institutions and reviewing and ranking departments based on their performance on issues related to recruitment, hiring and retention of women[23].

The scientific community also stresses on the importance of including women in institutional governance, national planning[21] as well as in selection committees and policy making[26]. It is felt that these measures are necessary to incorporate women's perspective into planning and governance of scientific institutions, without which it would be difficult to address the problems faced by women scientists.

Surprisingly not many scientists discuss the issue of sexual harassment, the prevalence of which is reported by the INSA study[26]. There is only one suggestion to strengthen the implementation of the sexual harassment legislation at scientific institutions[21].

Some of the other suggestions to help women balance work and family responsibilities include providing child care facilities at institutions[21,28], campus housing[26], option of working from home[34], flexible working hours[21,23,26,33], University wide policies on child care, parental leave and slowing of tenure clock[23] and reconsideration of age limits, grant structure and duration for research funding for women opting for family leave[21].

For the first time in the discussion, the scientific community calls for a need for 'pressure for change from within', including both men and women[35], thereby acknowledging the key role that it could itself play in addressing the issue as well as the important role that men need to play.

2010 – October 2016

General trends: Discussions gain further momentum in this decade with about half the articles belonging to this decade! The most promising trend of this decade is the fact that more men are participating in the discussion as shown by a significant increase in the proportion of articles authored by men.

Research gains further momentum and disproves some commonly held notions *vis-à-vis* women in science. Greater acceptance of these could have a profound positive impact in addressing the problem. The perception that women are unable to devote adequate time to research due to the dual burden of household and workplace, leads to preference for men in hiring. Similar preferences come into play while deciding on nominations to institute committees affecting women's candidature for leadership positions[36]. However, research proves that more women (47%) than men (34%) devote 40–60 hours per week and that, 86% of the women can manage both family and work[37].

Two other commonly held notions, which act as road blocks to women's progress are that women are less productive in terms of quality and quantity of published research and that they have limited mobility. However, Hasan *et al.*[38] study disproves both these notions. Their study concludes that the quality of research by female research scholars is as good as that of their male counterparts and the quantum of quality research is commensurate with their numerical strength. These results corroborate Bal's proposition[24] that the lower productivity of employed women scientists as observed in her study in the previous decade, is not because of lack of competence

but is because of women specific environmental issues. The study also finds that women have the same propensity to relocate to new locations and to other institutions for higher education and research as men.

The research studies in this decade are more geographically distributed, including the north east[7]. Many show positive trends in women's participation in science. Desai *et al.*[39] study on women scientists at Indian Council of Medical Research (ICMR) institutions across the country concludes that there is no glass ceiling at ICMR institutes. Khandka *et al.*[40] examine the performance of women scientists at the Uttarakhand State Science and Technology Congress and conclude that women perform better than men, winning more awards on an average, proving the existence of a conducive environment for female researchers in the state. Higher success rate for women scientists from Universities, than men, in a study of CSIR extramural research projects[41] indicates absence of discrimination.

Another positive trend is that the State Councils for Science and Technology are beginning to engage in the discussions, with Uttarakhand State Council for Science and Technology taking the lead and contributing three articles[40,42,43] on the subject, in this decade.

In spite of greater collective discussion on the issue, women continue to be reluctant to discuss workplace gender biases openly. Scientists suggest that this could be because of fear of being targeted within the small scientific community[37] or because women think that the capability to manage dual burden is a personal ability or inability[7]. It could also be because of the male dominated 'hierarchical culture'[36] at the scientific institutions, which does not leave much room for expression of such issues. This is an important factor that needs to be addressed because if women do not voice the issue, it will not get due attention and could remain unresolved.

Women scientists feel that they have to work harder than their male colleagues for successful careers. Internationally some of the organizations quantify this. For example, at France's National Center for Scientific Research the male advantage for promotion is 1.32 (ref. 44).

While gender bias in science education seems to have been largely addressed, with women constituting about 40% of undergraduate science students, research highlights that fewer girls compared to boys take the highly competitive exams like the IIT-JEE or the INOs and even fewer girls get through[45,46]. This again brings us back to the question whether the increase in the proportion of girls in science education is because science is providing equal opportunities to girls and boys. If this were true, then the proportion of girls in highly competitive exams would also have been proportionately higher.

Problem definition: The problem definition remains the same as in the last decade. There is consensus that the number of women starts decreasing post-Ph D. More than 50% of women who pursue a doctorate in science do not pursue a career in scientific research[47]. The numbers decline at every stage of career progression with very few women in leadership positions.

Underlying causes: Research in this decade demonstrates that men and women perceive the underlying causes differently. In women's opinion the cause is a combination of family responsibilities and lack of organizational support. Men on the other hand perceive 'family and social norms' as the major obstacle for women[37]. Male domination of scientific institutions with mostly men in decision making positions, coupled with their perception that qualified women drop out of science primarily because of family and social norms, which are beyond their purview, is a plausible explanation for the very slow pace of progress on this issue.

Another important cause identified for women dropping out of science is the informal policy of the institutions of not employing both spouses[37,47,48]. The 'sons of the soil'[49] policy is seen as another contributing factor, as women often have to move out of their home states after marriage.

Scientists also express concern on the lack of proactive role played by the Government. The sole paper on government policy on science and technology[50], argues that the science and technology policies of the Indian government have not been favourable to women in science and technology. Scientists express dissatisfaction at the lack of policy changes and lack of implementation of the recommendations of the DST Task Force on Women[44].

Solutions suggested in the articles: Scientists continue to focus on solutions for making the workplace environment better for women and tackling gender biases at scientific institutions.

There is a very strong opinion in support of strengthening women's position in policy making and leadership positions at scientific institutions through regulations and quotas[48]. The suggestions made by scientists include mandating one third women representation on committees related to selection, hiring, promotion, and policy formulation[37], targeting 30% women directors and Board of Governors or equivalent at premier academic and research institutions over a period of five years[51]; mandating 30% women in scientific evaluation committees[44] and improving women's presence at premier research institutions through time bound target recruiting[37]. The recommendation gains critical importance in view of the fact that men and women perceive the underlying causes of the problem differently. Therefore, it is necessary to have a female perspective in policy and planning. In fact Sinha *et al.*[7] note that the policies for promoting women in science would have been framed sooner if women were better represented in policy making.

Scientists also offer solutions to the problem of women falling behind in research due to maternity leave or career breaks, which affects their promotions. The suggestions include – applying an appropriate 'multiplicative factor' to the number of research papers published, for promotion considerations[51] and modifying the re-entry schemes to make them more effective – extending the projects to five years, mandating government scientific institutions to allow women scientists to undertake such research at their facilities and ensuring that that such projects are given due weightage when women apply for tenured positions[37].

In view of the greater acknowledgement of the role of men, scientists suggest 'counselling' men[52] in policy making and leadership roles and educating the scientific community on the importance of gender sensitive campuses[47].

Some of the other important suggestions from scientists include – encouraging strong women networks[27] to address the third 'triple bias'; mandating/encouraging institutions to accommodate both spouses[37,48] based on their respective qualifications and merit; greater recognition to women through awards[36,42] and transparent procedures to deal with sexual harassment[44]. Another important recommendation is to create fora where women can express themselves freely[53]. One of the ways of achieving this could be to replace hierarchical structures with collegium[36] with an open and collaborative culture. An open environment would go a long way in encouraging women to voice their concerns more freely.

Many suggestions from the last decade have been put forth during the current decade as well – showing that not much has been done to implement them. These include 'family friendly' facilities like day care for children, work from home facility, campus housing, transport facilities[7,27,36,44,47,48] flexible timings[27,36,37], transparency in selection procedures[37,47], and encouraging workplace gender sensitivity through a system of incentives for those who practice gender parity[52], gender audits[47], mentoring programmes[37,47] regular interaction with eminent scientists[54] and promoting female role models[47,48].

In addition to measures related to policies and institutional structures, an important recent suggestion is for social scientists and scientists to work together to create a better understanding of workplace gender bias, its causes and solutions[55].

Summary and recommendations

The acceptance and understanding of the issue have evolved significantly, specially over the last two decades, as captured in the summary in Table 2.

There has been progress on the resolution as reflected in positive trends reported in some articles[39–41]. However, the problem still persists, especially beyond the entry level positions[7,15,18,47].

Two important research findings, the widespread acceptance of which could help mitigate the problem, seem to have not got due attention. The first is the research that proves that men and women perceive the problem differently[37]. According to women scientists the problem is caused by a combination of factors related to family responsibilities and lack of organizational support. Male scientists, on the other hand, consider social and family norms to be the primary cause[37]. With mostly men in decision-making positions, the problem and solution identification is done from a male perspective. With the women perspective missing, it is only logical to infer that the identified solutions do not fully address the issues faced by women scientists. This underscores the importance of mandating women representation in leadership positions and in policy and planning, both at the national and institutional levels, for the desired change to transpire. This has been proposed by scientists[21,26,37,44,48,51] themselves. In fact scientists note[7] that if women were involved in policy making, the policies required to enhance women's participation in science would have been formulated sooner. The second set of research results are studies that disprove the commonly held perception that women are not able to devote adequate time to research due to family responsibilities[37] and the doubts raised on the capabilities of women scientists as measured by the quality and quantity of their research output[24,38]. These findings challenge the very basis of gender bias against women, but the perceptions continue. Therefore to lend more credence to these important results, widespread studies on these themes across STEM fields, geographies, institutions and hierarchical levels should be carried out.

The above discussion underscores the importance of sensitizing male scientists to the problems faced by their female colleagues and their equal professional capabilities. Scientists themselves have suggested 'counselling' men[52] in policy-making and leadership roles, gender sensitization of scientists for a 'less alienating' environment for women scientists[16], and educating members of the scientific institutions on the importance of a gender sensitive campus[47]. In this context the biggest positive change of this decade is the greater participation of male scientists in the discussions on this issue, as reflected in the greater proportion of articles authored by men, in the current decade. This should be strengthened further. Work place gender sensitization could be a good tool for catalysing this.

The trend analysis on problem definition, shows that the scientific community in India believes that the problem of under-representation of women in science in India persists largely beyond the entry level positions. However certain observations raise doubts on this perception. Fewer girls as compared to boys take the highly competitive exams like the IIT-JEE or the INOs and even fewer girls get through[45,46]. If the gender bias in science education was truly overcome, it should have translated into a

Table 2. Summary results of the trend analysis of articles from pre-independence to October 2016 in *Current Science*

Time period	Trends (focus on)	Underlying causes	Suggested solutions
Pre-independence	Girls education	Illiteracy in British India	Improving girls education
Post-independence to 1989	No article on women's participation in science, indicating that the issue did not receive much attention amongst the scientific discourse		
1990–1999	• Problem seen as a women's issue. • Discussions based primarily on personal experiences and opinions. • Deliberations led by women scientists.	• Social and cultural biases. • Marriage and family demands. • Workplace gender biases discussed, towards the end of the decade.	• Mindset changes. • Educating boys and girls equally. • Gender sensitization of male colleagues. • Assertive female scientists. • Creating appropriate infrastructure to help women balance family & professional responsibilities. • Special Schemes and affirmative action for women scientists. • Creating website repository of women scientists & their work.
2000–2009	• Discussions gather momentum, continue to be led primarily by women. • Trend of men opting for lucrative careers such as engineering and management, making place for women in science noticed, but not adequately researched and deliberated. • Active involvement of Science Academies in researching the issue and finding solutions. • Government schemes to support women scientists. • Greater research.	• Organizational factors arising out of male dominance and work place gender biases, along with social biases.	• Focus of the solutions shifts to workplace interventions. • Creating a friendly and encouraging workplace environment. • Incentivizing institutions to be gender friendly. • Increasing number of women in leadership and policy making positions. • Involvement of the entire scientific community and not just women, emphasized. • Last decade's solutions related to infrastructure and special policies, re-iterated.
2010–10 October 2016	• Significant increase in the participation of male scientists in the deliberations. • Research disproves some commonly held notions about productivity and mobility of women scientists.	• Male domination of scientific institutions coupled with differing perceptions of male and female scientists on the root cause of the problem. • Lack of pro-active role of Government.	• Continued emphasis on addressing workplace gender issues. • Strong support for increasing women's presence in leadership and policy making roles through regulations and quotas. • Open and collaborative work culture. • Collaboration between scientists and social scientists for a better understanding of the problem.

larger proportion of girls taking these examinations successfully. Another trend is that of greater number of men opting for the more financially rewarding careers in engineering[23], management or information technology[24]. So is the improvement in gender ratio in science because of fewer interested men? These aspects should be studied in detail, to get a true picture of our progress on addressing the issue under discussion.

Further, most of the research studies are limited to institutions and universities of national importance. The scope should be expanded to state universities and private educational and research institutions across the country for a better understanding of the regional variations and variations across various types and levels of institutions. Easy availability of appropriately disaggregated data needs to be ensured to enable good quality research. This will also help in monitoring improvements and progress on the issue.

The little flexible hierarchical structure of the science organizations aggravates the gender biases and prevents women from freely expressing themselves. More co-operative work environments like the collegium[36] system that encourage women to achieve their full potential, need to be explored.

Scientists have made many useful suggestions to address various aspects of the problem, specially over the last two decades. These include creation of supporting infrastructure[7,27,36,44,47,48]; transparency in decision making at scientific institutions[21,24,37,47]; incentivizing institutions to promote gender balance[21,23]; special provisions like flexible timings[27,36,37], special schemes and relaxations[15–17,37,51], all of which have been discussed in detail in the results section. However, many of these remain unimplemented, as is reflected in the same recommendations being made repeatedly. All the recommendations made by scientists and various panels and task forces should be

comprehensively documented and critically examined in the present context, post which the scientific community should pursue their implementation vigorously.

Scientists are of the view that the Government has not been very pro-active in addressing this issue[50]. The community should act as a strong pressure group on the government for making the required policy changes and implementing the existing suggestions. The Science Academies and the State Councils of Science and Technology could play a key role here.

In conclusion, the problem needs to be addressed at two levels – mindset issues at the individual level and the policy and institutional level changes. The former may be more difficult to address and would require sustained efforts over a longer period of time, but the policy and institutional level changes can be brought about more quickly. The scientific community should work towards addressing both the aspects of the issue.

Ramaswamy[47] very succinctly sums up the crux of the problem and the approach required to address the problem 'A real commitment to gender sensibilities is needed, and not just a patronizing attitude that facilitates women's careers'.

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