

Research Article

Transition of Indian Women in Engineering Domains: Opportunities & Challenges

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Abstract

India has grown economically in leaps and bounds in the last decade. Today, it is recognized as a major IT giant. The middle class has been redefined in India today. A major contribution to this has come from the women, who have stepped out of their houses and chosen professional degrees. These women, have now entered the portals of engineering domain, contributing to the growth, with their perceptions and styles. India, is one country, where the number of women in professional courses and careers, is amongst the highest in the world. However, there are still a number of challenges faced by women in engineering. This paper addresses the challenges, opportunities and policy shifts necessary to enable women to grow and reach great heights in their career, so as to play a bigger role in the growth of the nation.

Keywords: Engineering, faculty, mentor, family, scientist, recognition, balance, shop-floor, gender-bias

1. Introduction

Moving into the 21st century, many dramatic shifts have been seen in technology, society and politics. The emergence of Southeast Asia and India as major economic engines, has created not only a new marketplace for goods and services, but has also seen their emergence as new competitors in all areas, with their major strength being their vast resources of human capital. It is vital for such a growing economy, to have a vibrant, creative, and diverse engineering and scientific workforce. A major contribution to this workforce has been from women, especially in India. It is not uncommon, to find representation of women, in some typical IT companies to be of the order of almost 50%. Another area, where there is tremendous growth in women workforce is in technical education. Even in late 1990's, it was not common to find women teaching in technical institutions. The majority of the technical institutions hardly had a handful of women teachers. With private participation in higher education in India, enrollment of women, both as students and teachers, in the engineering field, has seen an unprecedented increase, and is probably the highest in the world. It is no longer surprising in a technical institution, to find, 50% or more teachers to be women.

In the US, the Bureau of Labor Statistics (BLS) projects have a strong demand for engineers through 2012 especially in computer/information science professions. It is projected to grow by 36 per cent. To meet this figure, the role of women workforce cannot be ignored. In India the enrolment of women engineers was barely 910 in the

year 1970, which increased to 26,470 in 1995. The share of women in the engineering enrolments increased from 16% in 1995 to 22% in 2001. In 2001, 22% of the students admitted to B.Tech / B.E. programmes in India were women. The corresponding percentage for M.Tech / M.E. was 16% and PhD was about 17% (P.P.Parikh et al, 2003). In the US the percentage of bachelor's degrees in engineering awarded to women in 2006 was 19.3% of the total, masters degrees were 22.5% of the total and doctoral degrees were 20.2% of the total. In the UK in 2003-4 about 14% of the full time undergraduates in Engineering were women while 20% of the postgraduates were women (Rangan Bannerjee et al, 2008). The percentages of women engineers at the IITs and the NITs are significantly lower than the national average (Vivek wadhwa, 2006)]. In 2005 at IIT Bombay the percentage of women graduates to the total is about 8% at the Bachelors (B.Tech) level, 9% at the masters (M.Tech) level and about 17% at the Doctoral level (including science, humanities and management (Naresh Kumar 2004).

In spite of this increased participation of women in Engineering, gender disparities in engineering still exist around the world and special efforts are being made by institutions, governments and professional organizations to rectify these (F.A. Kulachi et al 1998). In this paper, we address some of the issues of women in engineering, especially in India, the opportunities they have, the challenges faced and discuss some policy changes which can help women to contribute more than they are doing at present. The paper addresses the above issues, in general to women in technical fields and focuses on special issues related to women in teaching, in engineering colleges and technical institutes.

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2. Enrollment of women in technical institutions

In mid 80's, the number of girl students in an engineering programme in India, was hardly worth mentioning. Gradually, the urban middle class Indian families, saw the need for educating girls and the enrollment of female students in higher education saw a rapid growth. Girls in India, were no longer closeted inside the house, and spending on a girl child's education was no longer seen as a burden. This transition was more visible in the urban and semi-urban cities of India. However, the number of girls opting for engineering courses was not much. The preferences were mostly for pure science, arts and to some extent medicine. However, early 90's saw the IT sector growing in India, at an exponential rate. This suddenly created a huge vacuum in qualified man power. As a result of this, private participation in engineering education saw a sudden spurt. The demand also threw open opportunities for the enrollment of girls in engineering institutions. This actually, prompted the Telugu Desam Party in Andhra Pradesh, to reserve 33% of seats in engineering colleges in the state, for women. The latter half of 90's onwards, there has been tremendous increase in the entry of girl students in engineering colleges.

In spite of the increased growth in the number of girls entering engineering courses, there are still many issues which prevent girls from opting for technical education. This is obvious by the comparison of the performance of girls with that of the boys at class 12. In most of the states, the girls out beat the boys and the pass percentage is significantly higher amongst them. However, the numbers drastically reduce when it comes to engineering degree. There are a number of interesting reasons for this, as inferred from the teaching experience of the authors, who have been teachers in engineering colleges for over 20 years. The reasons are briefly discussed here.

- Fundamentally, women are not prepared for engineering studies. The mind set of people (men and women) have to change, before women can compete on an equal footing with men. Even today, people cannot comprehend a woman mechanic or electrician or engineer doing the work as efficiently as her male counterpart. While working in a cool AC room in a IT sector is perfectly acceptable for a woman, most people would raise an eyebrow, if a woman were to roll up her shirt sleeve and work on a machine or slide under a lorry to repair it!!
- Another interesting reason, is the lack of very qualified and efficient lady faculties in engineering. Faculty mentorship has been known to be very important. Since, we are still in the transition stage, Indian universities and engineering colleges do not have many women in positions of deans, principals, or directors. There is still a bias in the minds of the administrators, about women heading technical institutions. It would easily take another decade for women to rise to top positions in technical institutions on par with men. The lack of same-gender or same-ethnic group role models may discourage students

from continuing their education in the engineering domain.

- Technical education is definitely more expensive, than other degrees. In India, there is still a large percentage of population, which views heavy investment in a girl's education as a wasteful expenditure. This lack of solid financial support is another reason why, girls are not able to join engineering degrees.
- Beyond the above issues, there is another reason, why technical education is not very attractive to women. Nearly all engineering courses seem to be devoid of any social relevance. This does not appeal to women, who are by nature and genetic disposition, more inclined towards activities which have a human touch. Therefore, women tend to choose majors that they perceive as having high levels of interactions with other people.
- It is clear that engineering is vital to any economy and has important benefits to society. However, most often, engineering has emphasized on technology rather than its benefits to society. It is now recognized that this perspective has limited the attractiveness of engineering as a career to many, especially women.

Serious attempts to restructure the engineering culture and pedagogy need to be examined and propagated so that in the 21st century, we can prepare women students for leadership in engineering domains, tap their innate qualities and channelize it to benefit society through innovation and also enable a more diversified workforce.

3. Statistics of women in the area of science/engineering

Distribution of Women Enrolment by Faculty

The faculty-wise distribution of women enrolment in higher education during 2010-2011 is as shown in Table 1.

Table 1: Women Enrolment Faculty-wise: 2010-2011 (Source: UGC report)

Faculty/Year	2010-11
	% Women
Arts	41.21
Science	19.14
Medicine	4.68
Agriculture	0.36
Veterinary Science	0.10
Engineering & Technology	11.36
Commerce/management	16.12
Law	1.19
Education	4.60
Others	1.24
Total	100

Table 1 shows that the women enrolment in the faculty of Arts had been 41.21% of total women enrolment, followed by the faculty of Science (19.14%), the faculty of

Table 2: Presence of women in Government R&D institutions, and some universities: 2004

Organisation	Grade of the scientist	Scientists total	% women	Technical total	% women
CSIR	-----	5030	13.0	3250	14.0
DBT	-----	179	31.8	277	23.1
ICMR	-----	615	27.3	1939	20.1
DAE	-----	436	16.5	----	----
DOD	----	127	8.7	-----	----
ICAR	Assistant Professor	12750	10.4		
ICAR	Associate Professor	4750	6.2		
ICAR	Professor	2500	3.5		
IISc	Academic	316	6.6	34	14.7
IISc	Scientific	113	9.7		
Hyderabad University (Science departments)		101	15.8 (Only one professor)		

Commerce/Management (16.12%), etc., constituting 76.47% in these three non-professional faculties. There is a slight change in the percentage of women enrolled in all faculties as compared to the percentages in 2009-10. The faculty of Education where the percentage is 4.60 % in 2010-2011 as compared to 2009-2010 (3.70%), Engineering Technology in 2010-11 is 11.36% as compared to 7.69% in 2009-10. Highest percentage of women enrolment is recorded only in non-professional faculties of Arts, Science and Commerce/Management.

Relative presence of women as scientific and technical staff in Government R&D institutions, and some universities.

Perusal of the annual reports from a few institutions showed that in most cases the presence of women in advisory committees was less than 15%. One very prestigious biological science institute where 30% of faculty members were women, did not have a single woman in the advisory committee. The number of women faculty in the IITs is not worth mentioning! The reason could be the remote locations of the IITs, due to which it may not be possible for the husbands to move to the locations.

4. Challenges of women professionals

All modern societies recognize that education and a career are not only the right of a woman, but a key factor that contributes to the economic and social development of a nation. In spite of this recognition, the participation and contribution of women in many professions is insignificant, especially at the higher levels. This is most evident in the field of engineering, where women represent a large untapped source of talent. In India, the participation of women in engineering was negligible till the early 1980s. It is only in the past 15 years that their enrolment has shown an increasing trend. This movement began first in the southern states and has gradually spread to other parts of the country. However, with the increase in numbers, women engineers are facing many problems in

their careers. These problems need to be understood and analyzed. Some of the problems associated with women are discussed below:

Balancing work with family responsibilities

Women generally struggle more with the daily pull of raising a family or caring for elderly parents and this obviously puts additional demands on their time. In India most of the women get married after their graduation. These women find it difficult to go for higher education as they struggle to meet their family demands of having and raising children. If ever a break is necessary to raise children, without question, it is invariably the woman, who takes a break and is forced to sacrifice her growth in her career.

Managing dual career families

In India males are considered to be bread winner and thus independent of the woman's qualification she is forced to take the lesser position. Women are expected to contribute to the family income, but definitely not so much that the family can run on her income alone, which carries the threat of making the man redundant!! This often causes the women to sacrifice their career to balance with that of their spouse.

Lack of guidance and mentorship

There are very few women engineers and scientists working at the top level. Thus, there are few models to emulate and few to get advice from. Although men can also be mentors, there are certain unique experiences of women that can only be discussed and shared by other women working in the same area. To quote some typical examples,

- Different treatment by undergraduate and graduate students meted to female faculty, in technical institutions. A strict male teacher, is often respected, whereas a strict female teacher is often disliked immensely, by the boys. (again this is quoted by

number of experiences of the authors, while heading engineering departments)

- Difficulties in dealing with agencies outside of the university who are used to dealing with male professors.
- A disconnect between women faculty and the upper administration which is mostly male dominated. The natural tendency to pass on the information in casual networks only to male colleagues, often leads to exclusion of women from important information not necessarily due to malicious intent.

Not being taken seriously

The biggest challenge women face in their career is not being taken seriously. Often they have to go farther, work harder and accomplish more in order to be recognized and prove their worth. They are often subjected to jibes, questioning their capabilities and ability to work on par with the men, when they are infact probably doing much better than their male counterparts.

Discrimination and/or Harassment

Most of the women in India are subjected to discrimination at their workplace. Women's research is often marginalized. Women's approaches are not recognized. When there is a scope for promotion, most of the women feel that they are sidelined and the higher post is given to a man, inspite of them having a better performance index. Increasingly men and women are working for long hours together, closeted in small areas. This has led to an increase in the sexual harassment of women, often at very high levels within the organization. Fearing ridicule and disbelief, women either put up with it or as an extreme step, even quit the job. Women are often ridiculed even at the time of interviews, where male interviewers ask unwarranted questions on her relationships, her duties to family, her capabilities etc. Another point of ridicule, especially with young women, is the need to take maternity leave, which is viewed as a loss to the organization. In today's scenario, it should be seen that every interview committee has atleast, one female in it, to prevent such events. Infact, it would not be farfetched to say that it should be made mandatory, especially when recruiting is done in large numbers.

Laboratory climate impact upon the careers of women scientist

Researchers are expected to spend personal time in the lab doing research work. Most of the women find it difficult as they are expected to spend their personal time for family obligations. Thus the laboratory climate in engineering and research, negatively impacts the careers of women scientists and engineers.

Hypocritical view points

Indian society is still to come out of conditioned hypocrisy

about the role of women in nation building. A man who is fanatical about his work and career is looked upon in awe and with respect, while a career oriented woman is seen as someone failing towards her role as a wife and a mother. While many working women, willingly or forcefully, change their careers to suit the career choices their husbands make, rarely would a man change a job or his location, to help a wife make a better career choice. A paradigm shift is necessary to bring about an attitudinal change.

5. Achievements and Recognition of Indian Women Scientists

Recognition in science can be judged on the basis of variety of factors such as ability to secure permanent faculty position, attract research grants, and research scholars, publications and patents, invitations to speak in conferences, travel fellowships, invitations to be on various policy making, and review committees, awards, academy fellowships etc. Some of the criteria such as publications are objective but others depend on the scientists' visibility and recognition by peers. In 2004 Vineeta Bal has tried to assess the performance of Indian women biological scientists on the basis of publications in 38 high impact journals (Impact factor 5 and above). According to that limited analysis, 85.7% of the papers from India had men as the corresponding/senior authors and only 14.3% had women.

Very few women are elected as fellows of science academies (Table 4). Women seldom receive awards open to both the sexes. For instance, National Biosciences award, instituted by the DBT in 1999, has given 24 awards between 1999 and 2003. Only 2 awards (8%) have gone to women. Bhatnagar prize for young scientists was instituted in 1958, by CSIR. It is one of the most prestigious awards in natural sciences. Out of 333 awards given between 1958 to 1998, women received only 8 awards (2.4%). Maximum recognition for women was in medicine (7.5% awards), whereas in physics, earth science and engineering not a single woman got the Bhatnagar award.

Table 4: Science Academy fellowships for women

Academy	Total fellowship	% Women
Indian National Science Academy	744	3.2
Indian Academy of Sciences-Bangalore	841	4.6
National Academy of Agricultural Sciences	395	4

Not a single woman has become fellow of INSA. In biological sciences also women fail to get recognized though they are present in reasonably large numbers. Out of the 502 awards and medals given by INSA over the years, only 14 (2.8%) have gone to women. No woman

has become INSA president, and out of 41 recent past office bearers, only one was a woman (Prof. Indira Nath). In contrast, India has seen a tremendous growth of women in managerial positions. To name a few, Preetha Reddy (MD Apollo hospitals), Kalpana Morparia (CEO JP Morgan, India), Shobana Bartia (Chairperson and editorial director, Hindustan Times Group), Renu Sud Karnad (Managing director HDFC) and Debjani Ghosh (Intel South Asia managing director).

6. Recommendations for Action

Based on the above discussions following recommendations are suggested to allow women to select and work in the area of their interest, with focus on engineering jobs, and contribute in their own way to the society.

Flexible hours

Most of the western countries have flexible working hours, and part-time jobs. This concept, is almost totally absent in India. The IT industry, works in time synchronization with the US and Europe. This has led to many companies working till late hours. Though, initially women get a job in these companies, the family responsibilities will not permit the woman to continue, beyond say 5-6 years. Flexible working hours and part-time jobs and working from home option will help women to cope with the dual responsibility of a home and the profession. This facility is more relevant at the time of child bearing and rearing.

Shop floor and field jobs

Such jobs are very important in the area of engineering. Women should not be completely debarred from such jobs assuming that they are not fit for it. Women in fact have tremendous physical stamina and can cope up with situations, at times even better than their male counterparts. Women engineers who opt for such jobs must be considered and offered the same, subject to their merits.

Equal opportunities

All the organizations should have directive that there will not be any gender bias in the process of selection and promotion of their staff. No job should be denied to an employee, just because the employee happens to be a woman.

Accommodation

Major cities in India, are heavily populated and traffic snarls are common. With most production units, factories and IT hubs, located on the outskirts of the cities, many young women from small towns hesitate to take up the jobs due to lack of safe and suitable accommodation near their work place. Setting up a chain of working women's hostels is an essential requirement in this regard.

Child care facilities and crèches:

Another major problem often faced by married women engineers, is the lack of professional child care facilities. Further, women often suffer from guilt, if they perceive that the child has not received the best. The rearing of children is a concern for both parents. Yet, women end up taking up a major share of the responsibility, often at the cost of their career. Providing for healthy and affordable day-care at the working place, would go a long way in improving the productivity of women.

Awareness program

- *For Employer:* Employers should be made to understand the capabilities of women engineers and their utility for the organization. This can be done by promoting and publishing success stories of women engineers. The employers need to recognize the balance women can bring to a workplace and the increase in performance of the employees as a whole, due to this.
- *For parents and society:* Most of the parents in India educate their daughters to get a good match. They are very reluctant to send them to far distant places for job and just force them to take up a sub-standard job near their homes. This lowers the morale of the qualified women. On getting married the women are forced to leave their job and join their husbands even if their job is better than that of their husband's. A midway solution is rarely sought. By default, the woman's career takes a backseat.
- *For women engineers:* In India most of the young married women are made to think that the family is their responsibility and that they should be ready to make sacrifices as and when required. These women suffer from the guilt in case they have to devote more time at their work place and thus cannot give their best at their workplace. Such women continue to work at lower positions and do not aspire for senior positions. They must be educated to see that they have an equal right to make a choice in their lives and strike a balance.

Conclusion

India has seen tremendous growth in participation of women in engineering and science, especially after 80's. It has been recognized without doubt, that women engineers have made a significant impact on Indian economy, with a large number of them working in the IT sector. However, society as a whole, women including, has to undergo a paradigm shift in thinking, if women have to reach higher positions in the technical field. Nature has endowed certain responsibilities on the women with respect to child rearing and bearing. This need not be a hindrance for the woman have aspirations and ambitions. It is definitely possible, to strike a balance for a woman, with certain policy changes and cooperation from people around.

Women with their patience, forbearance and inherent managerial capabilities, can contribute immensely to any organization.

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