WOMEN IN ENGINEERING – A STATISTICAL OVERVIEW

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ABSTRACT

Women are often under-represented in the academic and professional fields of engineering; however, many females have contributed to the diverse fields of engineering historically and currently.

A number of organizations and programs have been created to understand and overcome this tradition of gender disparity. Some have decried this gender gap, saying that it indicates the absence of potential talent.

Though the gender gap as a whole is narrowing, there is still a growing gap with minority women compared to their male counterparts. Gender stereotypes, low rates of female engineering students, and engineering culture are factors that contribute to the current situation where men are dominated in the engineering field.

In this paper, we aim to provide a statistical overview on various aspects and information related to the involvement of women in engineering and STEM fields (Science, technology, engineering and mathematics). At the end, we also provide an overview onto female employment and education in India pertaining to engineering as well as other fields.

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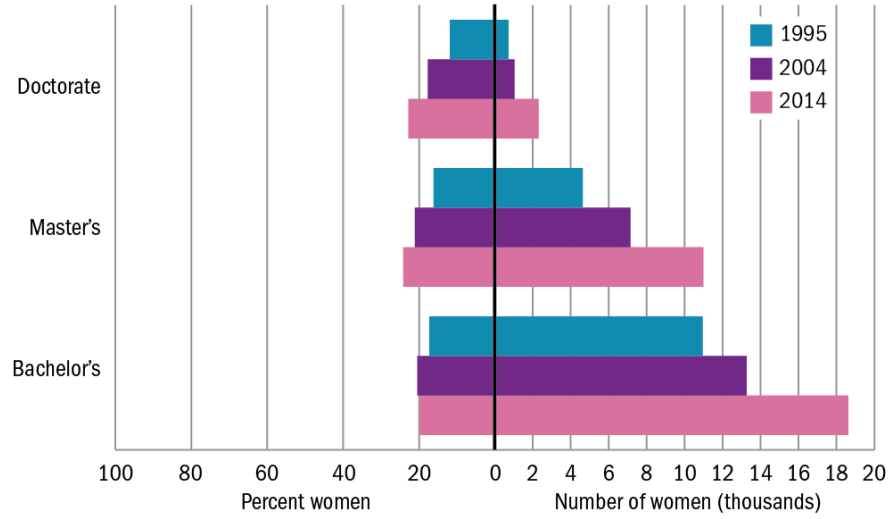
STATISTICAL DATA AND OVERVIEWS

I. Women in Engineering Degrees

Women have earned 57% of all bachelor's degrees and about half of all science and engineering (S&E) bachelor's degree since the late 1990s. In most fields, the proportion of degrees awarded to women has risen since 1995.

Low participation field for women: Engineering, 1995, 2004, 2014



Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017

Image 1 : Chart view representing the percentage of women (Left hand side) and the Number of women in thousands (Right hand side) acquiring Doctorate, Master's degree and Bachelor's degree (Vertical Axis) in three separate decades (1995, 2004, 2014).
Source : National Science Foundation, National Center for Science and Engineering Statistics 2017based on the total number of citizens in U.S [2]

Number of women			
Year	Bachelor's	Master's	Doctorate
1995	10,950	4,632	727
2004	13,263	7,148	1,047
2014	18,626	10,988	2,311

Percent women			
Year	Bachelor's	Master's	Doctorate
1995	17.3	16.2	11.9
2004	20.5	21.1	17.7
2014	19.8	24.2	22.8

Table 1 : Data corresponding to Image 1. [2]

Although the number of women earning degrees in engineering has increased in the past 20 years, women's participation remains well below that of men at all degree levels and in all fine field of engineering.

Since 1995, the proportion of women earning degrees in engineering has increased at all levels, mostly at the master's and doctorate levels. In general, women earn larger proportions of degrees in chemical, materials, industrials, and civil engineering than in aerospace, electrical, and mechanical engineering.

From the '*Img 1'* and '*Table 1'* we can infer that,

- Number of women obtaining Bachelor's degree, Master's degree, and Doctorate in their respective fields of engineering has risen by **70.10%**, **137.68%**, & **217.88%** respectively in the past two decades.

- Percentage of women obtaining Bachelor's degree, Master's degree, and Doctorate in their respective fields of engineering has risen by **14.45%**, **49%**, & **91%** respectively in the past two decades.

- The percentage of women pursuing master's after bachelor's and Doctorate after master's amount to **58%** & **21.10%** respectively as of 2014, in contrast to **53.89%** & **14.64%** respectively in 2004.

- Women obtaining degrees are roughly **22.26%** of that of Men.

From the inferences gathered, we can conclude that the number of Women adopting engineering as a field of career, has measured a significant increase in the past two decades. Greater proportions of women now are pursuing higher studies in the field of engineering.

II. Women in Computer Sciences

In the past 20 years, the number of women in computer sciences has risen at all degree levels. The proportion of women with degrees in computer sciences has increased slightly at the master's and doctorate level but has declined at the bachelor's level. In the past 10 years, both the number and proportion of computer sciences bachelor's degrees earned by women has declined. The proportion of women in computer sciences is highest at master's level.

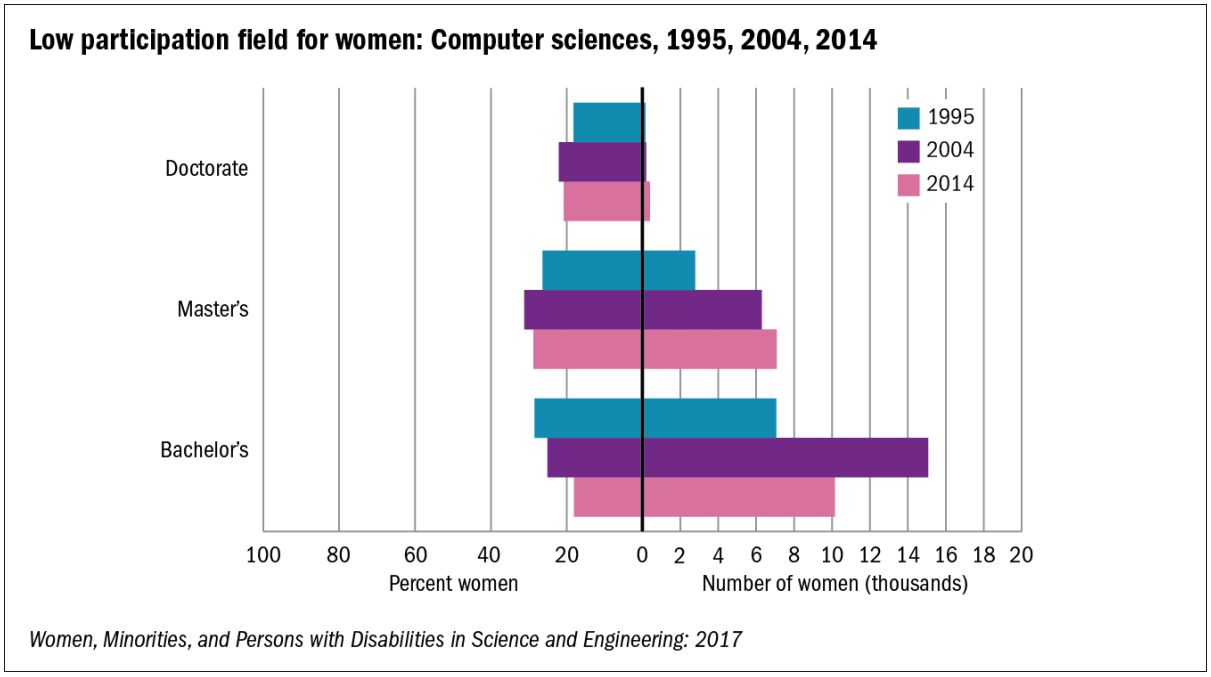


Image 2 : Chart view representing the percentage of women (Left hand side) and the Number of women in thousands (Right hand side) acquiring Doctorate, Master's degree and Bachelor's degree (Vertical Axis) in three separate decades in the field of computer science(1995, 2004, 2014).
Source : National Science Foundation, National Center for Science and Engineering Statistics 2017based on the total number of citizens in U.S [2]

Number of women			
Year	Bachelor's	Master's	Doctorate
1995	7,063	2,786	161
2004	15,066	6,298	201
2014	10,144	7,088	403

Percent women			
Year	Bachelor's	Master's	Doctorate
1995	28.5	26.4	18.2
2004	25.1	31.2	22.1
2014	18.1	28.8	20.8

Table 2 : Data corresponding to Image 2 [2]

From the '*Img 2'* & *'Table 2'* we can infer that,

- Number of women obtaining Bachelor's degree, Master's degree, and Doctorate in the field of computer science has risen by **43.62%**, **154.41%**, & **150.31%** respectively in the past two decades.

- Percentage of women obtaining Bachelor's degree, Master's degree, and Doctorate in the of computer science has risen by **-36.49%**, **9.09%**, & **14.28%** respectively in the past two decades.

- The percentage of women pursuing master's after bachelor's and Doctorate after master's in the field of Computer Science amount to **69.87%** & **5.68%** respectively as of 2014, in contrast to **41.80%** & **3.19%** respectively in 2004.

- Women in the field of computer science are roughly **22.56%** of that of Men.

- As of 2014, **54.46%** of women pursuing engineering are in the field of computer science as compared to **64.50%** in 1995.

From the inferences gathered we can conclude that computer science is one of the most opted fields in engineering opted by women. However, the percentage of women as compared to that of men has experienced low growth.

III. Women in Technology as compared to other Industries

Full industry breakdown shows the percentage of females as compared to males in various industries.

'*Chart 1'* represents the percentage of females among the talent hired in the year of 2013. We can infer that the technology sector is behind several non-tech industries when it comes to female representation in their most recent hiring class.

It depicts that roughly **13.5%** of females are hired for technical roles. It is safe to say, none of the percentages in '*Chart 1'* signal significant advances towards gender parity.

Bringing gender parity starts with addressing the gap in education, but recruiters and hiring managers can also make a significant impact by creating and empowering more female role models.

From '*Chart 2'* it's worth noting that even the field that can boast the highest

number of female software engineers, Financial Services and Insurance, a sobering 23% of them are female. Also, the numbers for high tech software and hardware companies are especially troubling – only **16%** and **9%** respectively, of their software engineers are female. The two fast-growing, dynamic and arguable egalitarian sectors seem to have a hard time welcoming female software engineers into their fold.

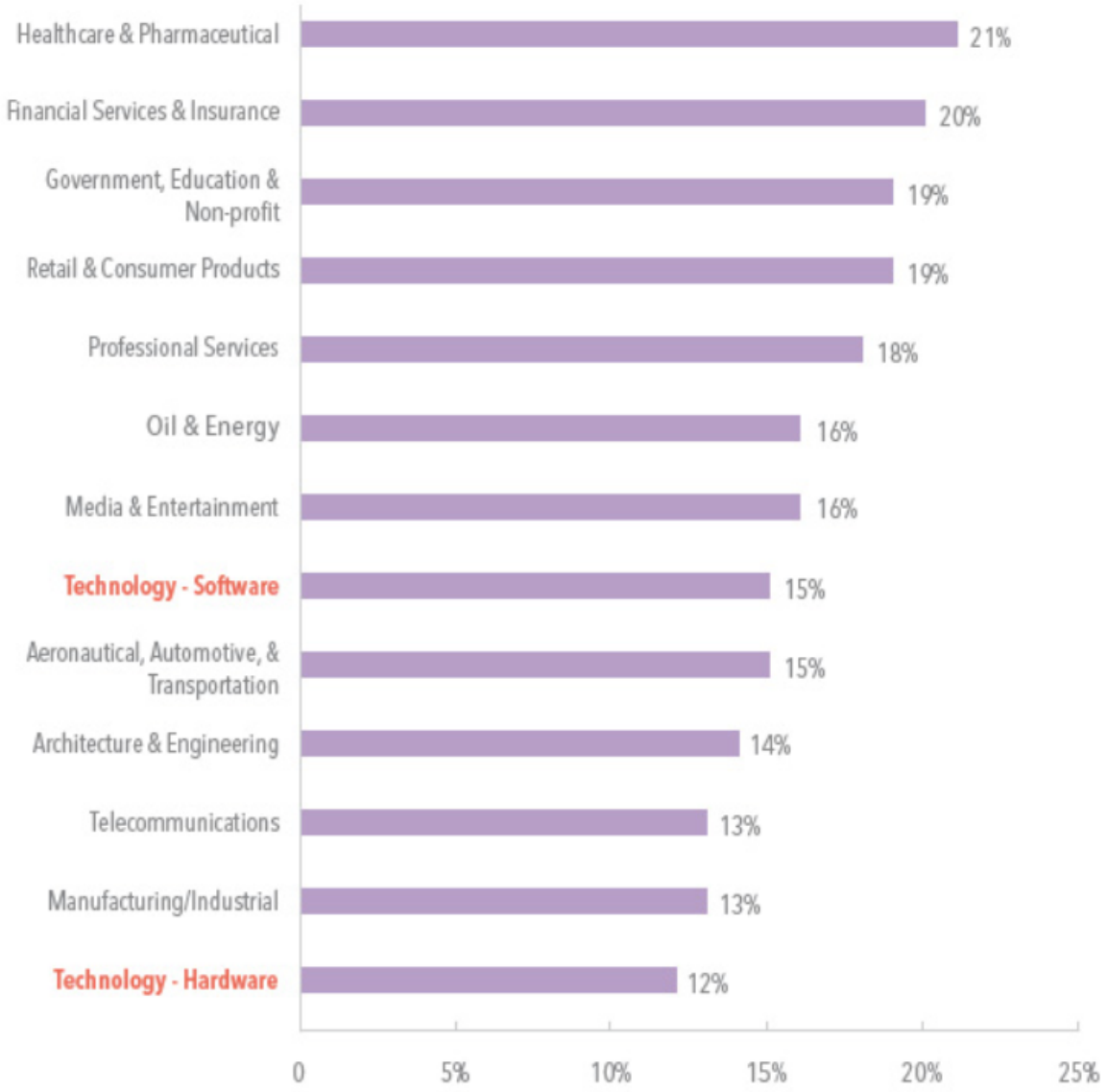


Chart 1 : Depicts female representation among members with software engineering skills, who were hired in 2013 by Industry groups.
Source : LinkedIn Analysis over its women user-base in 2013. [3]

Thus, we can concur that though the percentage of women acquiring degree in the field of engineering roughly **60%** of them are hired for their respective job roles as of 2014.

Also, in the field of computer science, the percentage of females as compared to males amounts roughly to **15.53%** as compared to the percentage of females as compared to males pursuing degree in computer science amounting to **22.56%.**

Both the above points depict gender parity and address gap. This may be due to the absence of high-quality mentoring provided to women in their respective fields along with other discriminative factors influenced by the corporates.

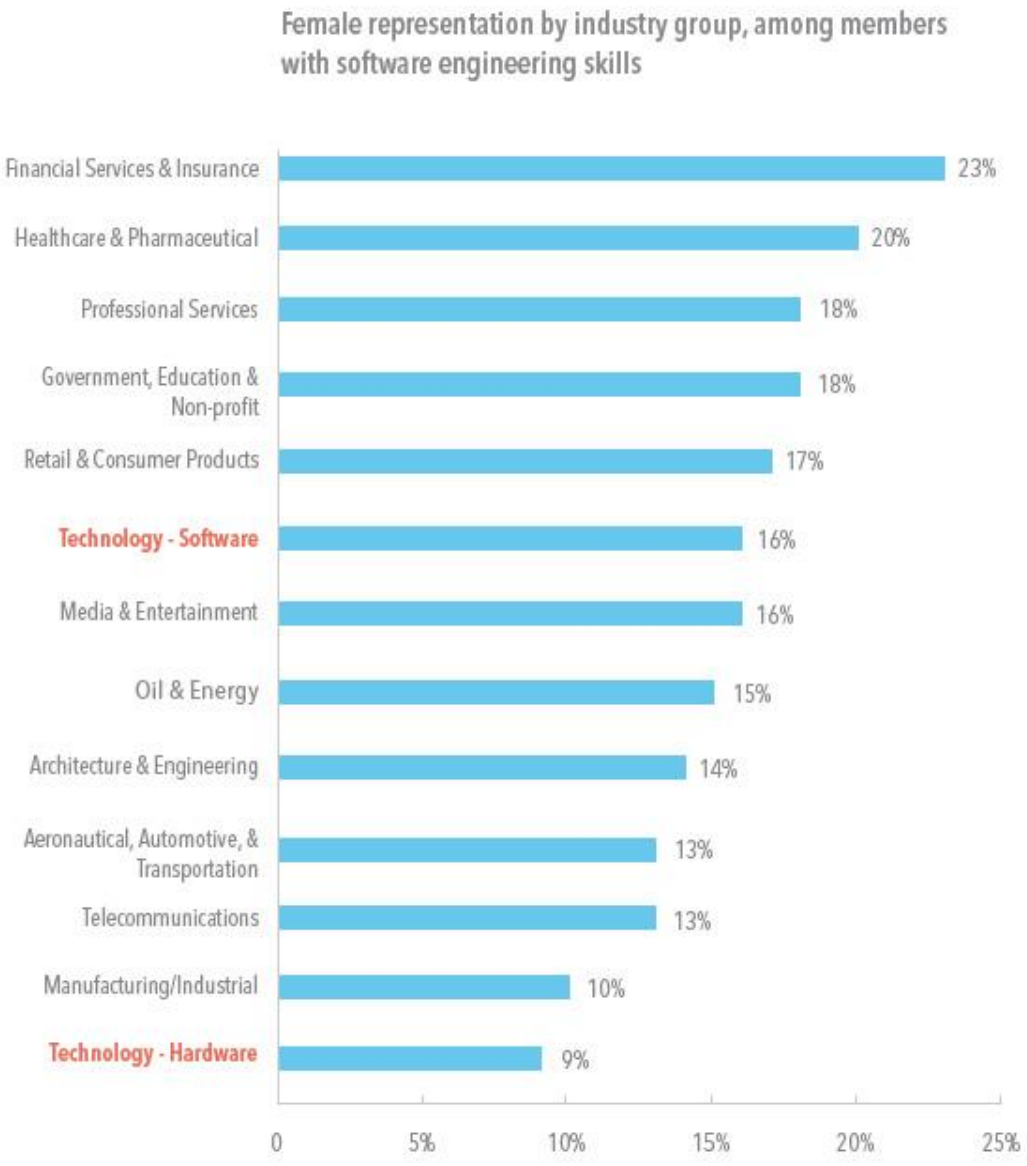


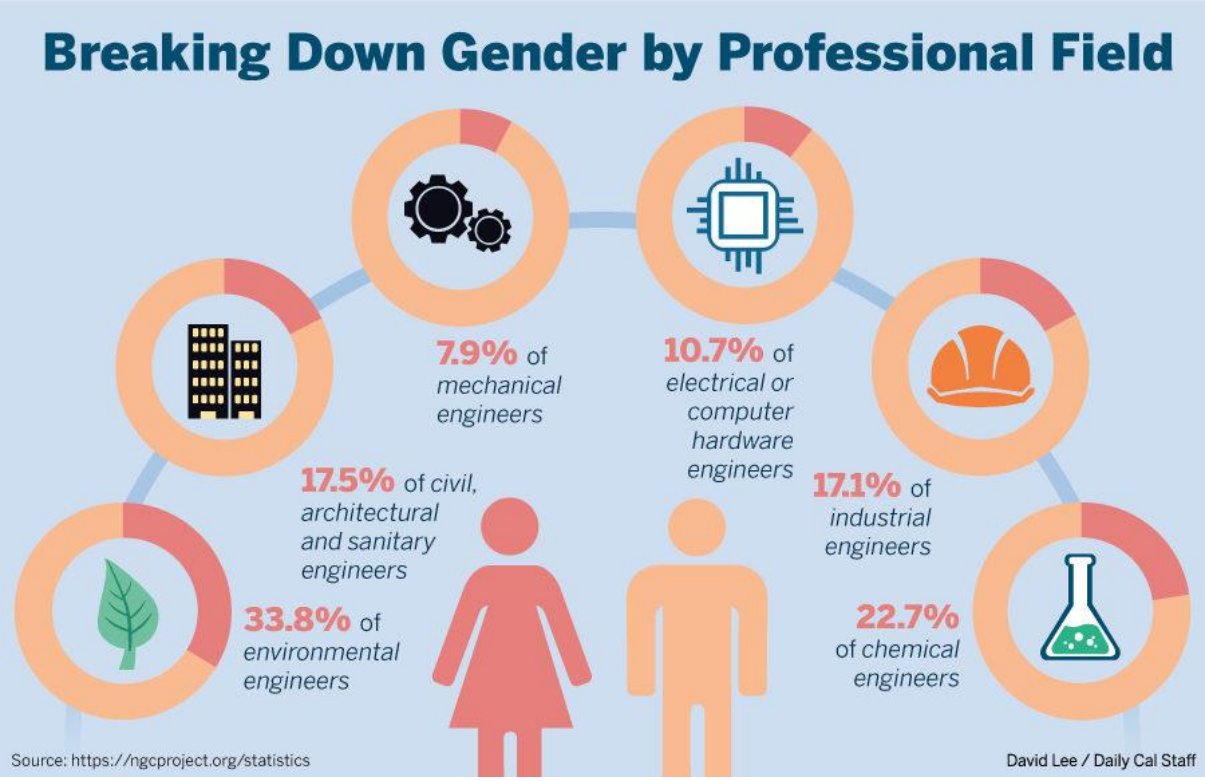
Chart 2 : Depicts the Female representation by industry group, among members with software engineering skills.

Source : LinkedIn Analysis over its women user-base in 2013. [3]

IV. Women in Different Fields of Engineering Professions and Discrimination faced by them

By '*Img 2*' we can infer that in various professions in the domain of engineering, The percentage of females to males is roughly about **18.28%**, with the highest percentage of females being in professions relating to environmental engineering, and lowest in professions relating to mechanical engineering.

Also, in accordance with the previous data, less than roughly **82%** percent of the women graduating in fields of engineering, pursue engineering further as a career.



Img 2 : Statistics regarding the distribution of Male and Females across various domains of Engineering Professions.
Source : National Science Board – Science & Engineering Indicators 2018. [4]

In the referenced articles [4], various reasons are provided in accordance to '*Img 2*':

- Low number of women co-workers and a very few numbers of women leader's cum role-models may influence upcoming women professionals find the work environment social unpleasant and awkward.

- Management at top-level companies are driven by male workforce. Often, the management is discriminative towards the resources and appreciation provided to female employee's as compared to their male counterparts.

- Many companies have yet to implement employee policies, such as maternity leaves, sick leaves and other benefits that women may receive in non-engineering job sectors.

V. Gender Pay Gap in Engineering

'*Graph 3'* depicts the Median Annual Earning and Earnings Gap in Select Engineering and computing occupations, by Gender, 2016. We can roughly estimate that women are paid **10.08%** less on average as compared to men.

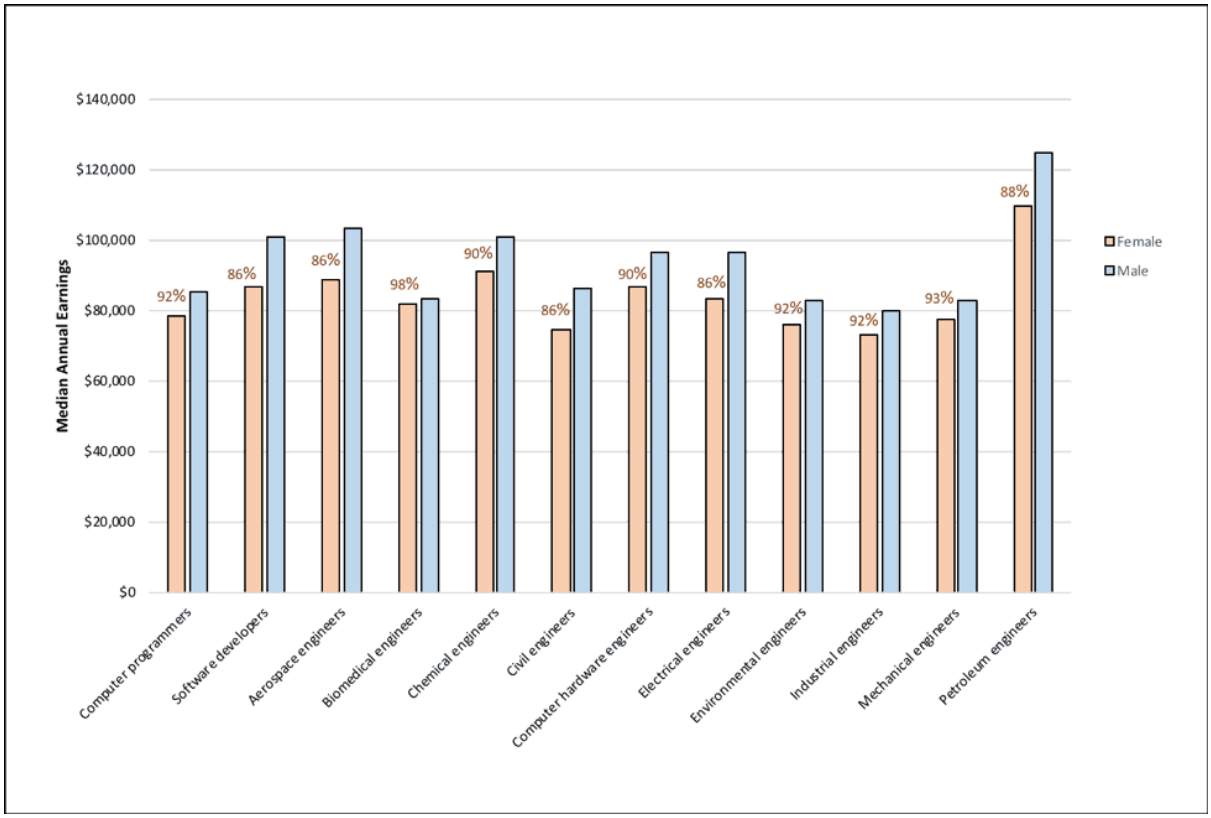


Chart 3 : Median Annual Earnings and Earning Gap in Select Engineering and Computing Occupations by gender
Source : U.S Census Bureau. 2016 American Community Survey 5-year estimates: Tables B24122 and B24123. Data retrieved from www.factfinder.census.gov [5]

Despite progress made over the last few decades, the gender pay gap is still pervasive across US and other parts of the world. Women still make 20% less than

men in similar positions.

In corporations, gender pay gap exists across every division, department and every geographic location. Data from the U.S Census Bureau indicates that the gap varies by engineering discipline, with the smallest gap among biomedical engineers and the largest among software developers, aerospace engineers, civil engineers and electrical engineers.

VI. India and Women in Engineering

Women's workforce participation in India is the lowest among the BRICS nations. **37%** of other countries do much better than India, including such as Bahrain, Malaysia and even Somalia.

The total workforce participation rate (WPR) for women in 2011 was **25.5%**, with the WPR for women in rural India at **30%** per cent and women in urban India at **15.4%**. In contrast, WPR for men in rural and urban areas were **53%** per cent and **53.8%** respectively.

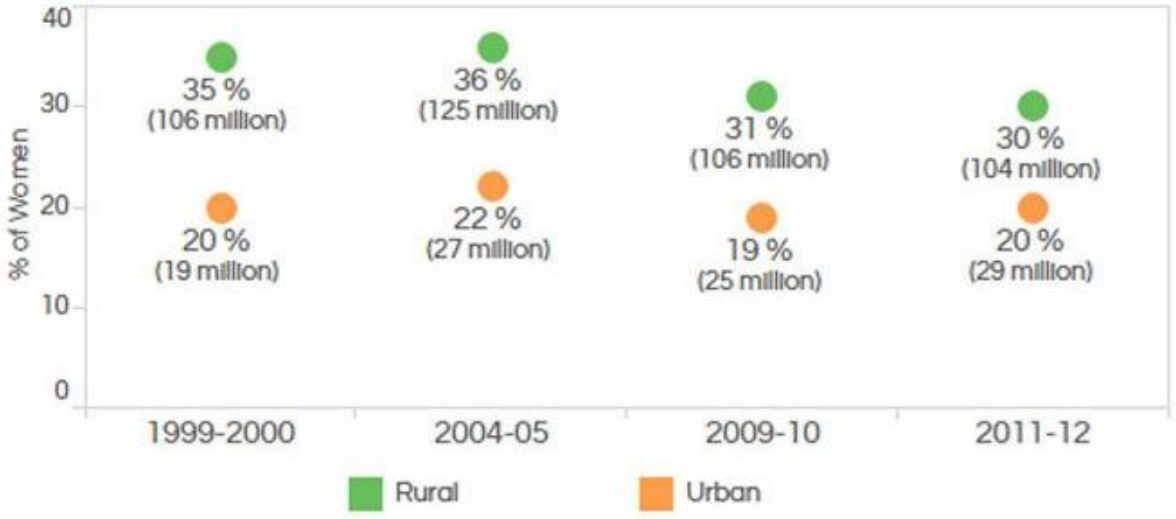


Chart 4 : Workforce Participation Rates for Women in Rural & Urban India, National Sample Survey Organisation.
Source : National Sample Survey Organisation (68th Round 2011-12). [6]

The majority of female workers in rural areas, around **80%** work in agriculture sector. Manufacturing is a distant second at **7.5%**, followed by construction at **5.2%** and services at **7%**.

The biggest employer of urban women, at **39%**, is the "other services" sector, which included domestic work, followed by manufacturing with **27%**.

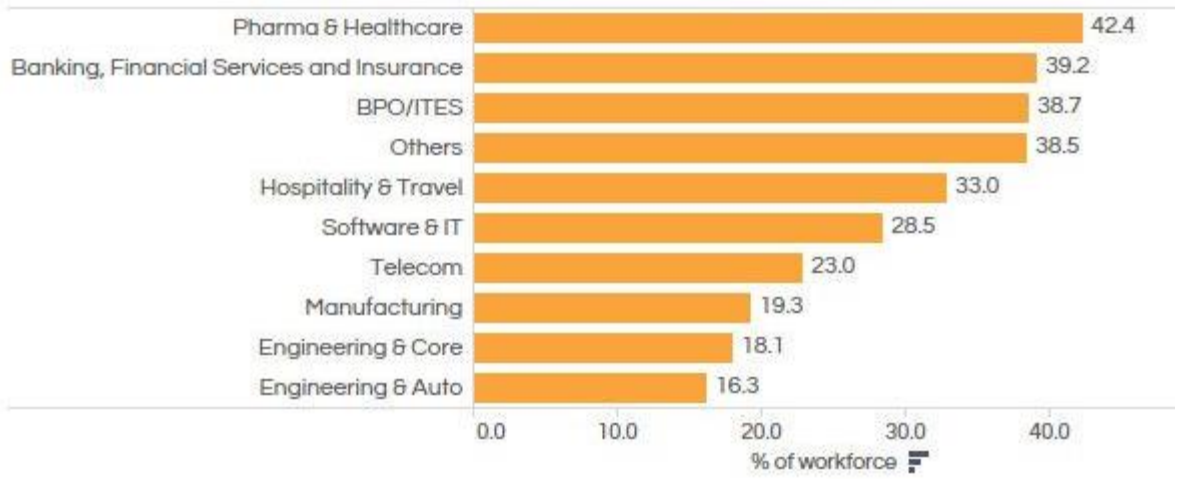


Chart 5 : Women as percentage of workforce in different sectors.
Source : Confederation of Indian Industry. [6]

Inferring from '*Chart 5'* , In urban India, women are a minority in most industries, even in the service sector where they tend to be in more visible roles.

Core engineering and automobile sectors have the least representation of female workers, employing **16%** and **18%** respectively.

The highest number of women are in pharmaceuticals and healthcare: **42.4%**. This situation spotlights the fact that most women working in urban areas are not skilled. A third of urban women workers are illiterate, as compared to **11%** of men.

Women in urban areas are engaged primarily in services like public administration, health, education, domestic workers, followed by trade and manufacturing. In urban areas, **2.9%** of women are technical educated, as compared to **7%** of men.

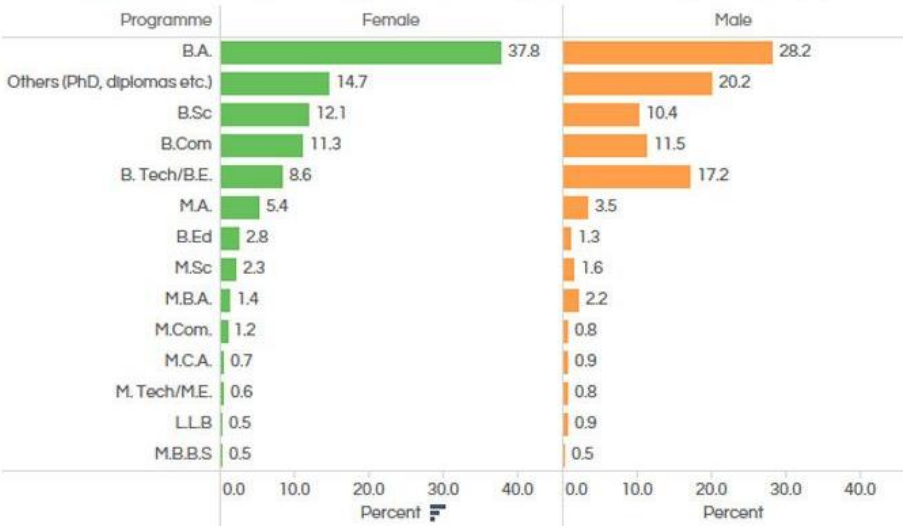


Chart 6 : Enrolment in Different Programmes in Higher Education, 2012-13.
Source : Confederation of Indian Industry. [6]

In the field on engineering, **9.2%** of the female graduates choose engineering as a career as compared to **18%** of boys. Also, the number of women pursuing post-graduation is engineering is **6%**, depicting few women enrol in post-graduate engineering courses.

In many analyses, it was found that women in India were dropping out of higher education programmes which has indirectly affected female participation in the corporate workforce.

Reproductive roles, household and care responsibilities, cultural sanctions and patriarchal hierarchies play a major role in withdrawal of women from the labour force. Women's employment is a critical factor in the economic empowerment and the overall status of the society.

VII. India and Women in Technology

The number of women employed in the IT industry in India has seen a rapid increase over the past 10 years, with more than **30%** of employees now being female, with contrasts with stagnation in the participation of women in IT in many Western countries.

According to NASSCOM's Women and IT Scorecard – India, a study undertaken with the UK's Open University, women represented **46.8%** of the postgraduates in IT and computing during the academic year 2014-2015 in India. This is more than double the rate seen in UK.

Culturally and politically in India there is great interest in women doing engineering, where STEM topics are seen as a natural career path for women and an area where they can shine. India now has a large influx of women taking up education and building careers in the tech sector because the country has encouraged this over a period of time.

This is reflected in India's strength in enrolling women in Information Technology as a tertiary education field of study.

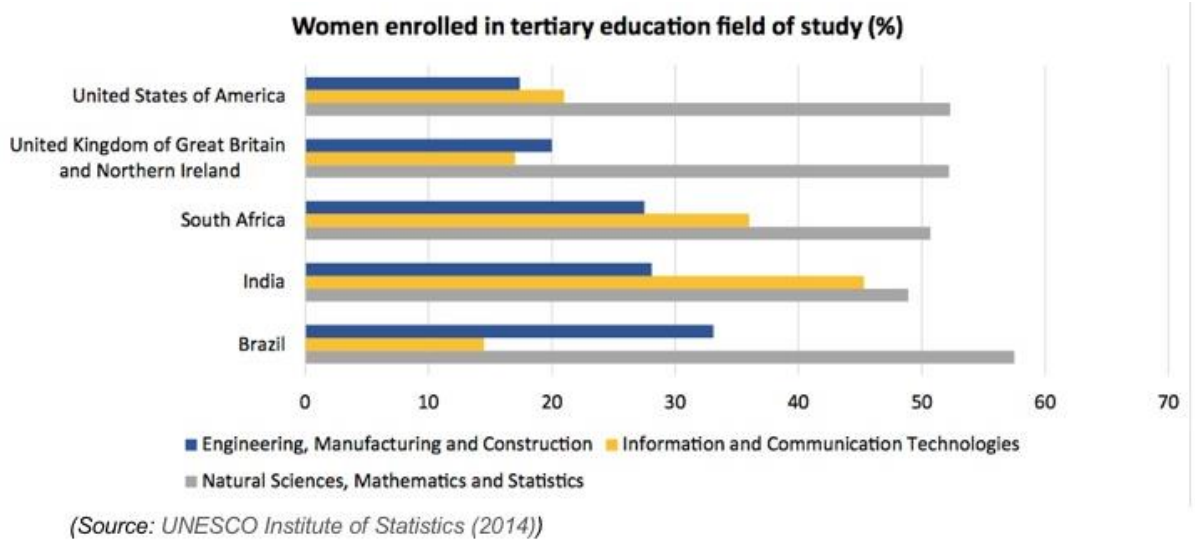


Chart 7 : Women enrolled in tertiary education field of study (%) in Engineering, Manufacturing and construction, Information and communication Technology & Natural Sciences, Mathematics and statistics as against US, UK, South Africa & Brazil.
Source : UNESCO Institute of Statistics (2014). [7]

Inferring from the '*Chart 7'* , India's IT-BPM (*Information Technology & Business Process Management*) industry currently employs nearly **3.9 million** people, and over **34%** are women (~ **1.3 million**). While this percentage is much better than the overall female share (**24%**) of India's total workforce, an analysis indicates that over **51%** of entry-level recruits are women, over **25%** of women are in managerial positions, but less than **1%** are in the C-Suite.

Thus, India now needs supportive policies for midlife, to manage work and life in corporate environment. India now has a large base of women engineers, and it needs to ensure they are represented at management level.

Addressing issues such as staff attrition, setting up annual diversity events with awards to recognize best practices, addressing areas such as flexible working & work from home, and all-round education for the HR services function, can be the first phase to adopt within India to tackle gender inequality.

It is well understood in the West that marriage and motherhood handicap many women in their career progression. This is no different in India, where the government has introduced 26-Week maternity leave for the private sector, up from the prior 12-week period. Other advantages of the Maternity Benefit Amendment Act include day-care facilities or creches for working mothers, a non-discriminatory performance appraisal system that acknowledges the female employee's absence, and work-from home policies.

Various IT companies in India have launched women mentorship and empowerment initiatives where women undergo extensive training to upgrade their technical and business skills, as required for today's work environment. Women are aligned to senior leaders as mentors to support their role aspiration. The mentors are the guides who help them create their development action plan, and provide them with an opportunity to learn new skills in technology and of leadership.

Social networking platforms are now also providing a platform to women leaders, where they have an opportunity to interact with top leadership and the senior level management of various organizations. Peer coaching, experiential learning, networking workshops, leadership talk sessions and self-paced learning modules are some important elements.

These programs and policies are a good fit for women employees that want career advancement.

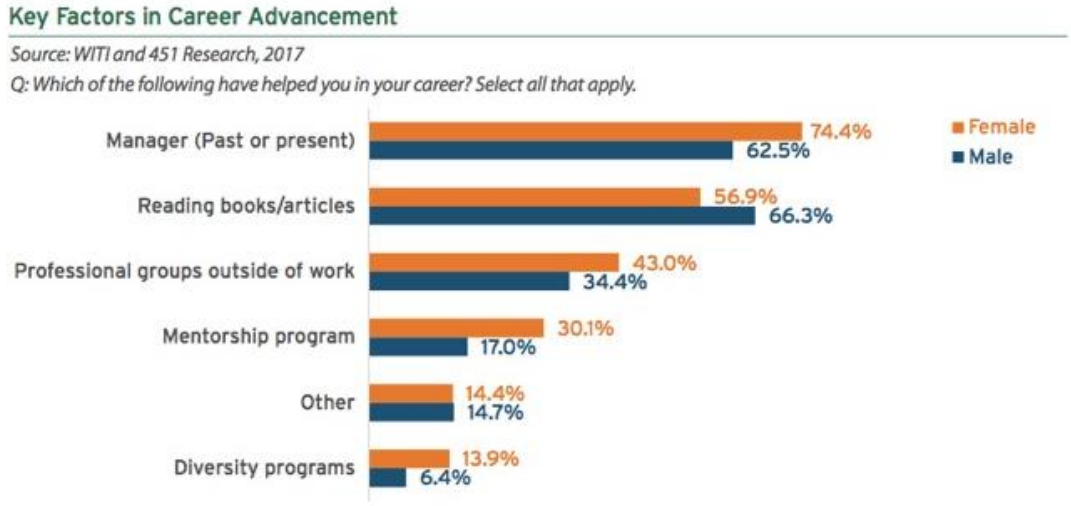


Chart 8 : Mentorship data, indicating female respondents cite factors in their career advancement. Source : WITI and 451 Research, 2017. [7]

As indicated in '*Chart 8'*, female respondents cite other people as a factor in their career advancement more than male respondents do. While past or present managers were the most-cited factor helping women's careers (**74%**), in contrast to just **62.5%** of men.

Women also are drawn to professional groups outside of work and to mentoring. Slightly more female respondents (**43%**) credit professional groups for career advancement. While **13.9%** of women found diversity programs helpful in their career, less than half that percentage of men did.

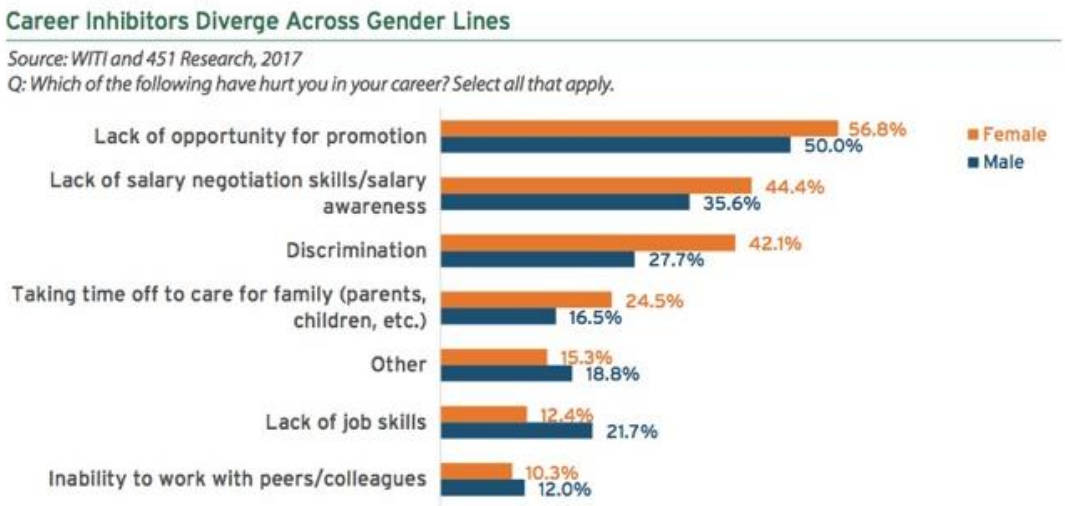


Chart 9 : Career Inhibitors across Gender Lines
Source : WITI and 451 Research, 2017. [7]

Referring to '*Chart 9'* , all respondents cited lack of opportunity for promotion as a top career inhibitors, but when it comes to secondary factors, the data showed a divergence across gender lines.

More women (**42.1%**) felt that discrimination has hurt their career than men do (**27.7%**). Women also feel than an inability to adequately negotiate for a better salary has had a negative impact on their career.

The role of family care also has a far greater impact on women than men. Nearly a quarter (**24.5%**) of female respondents felt that taking time off for family has hurt their career, in contrast to just **16.5%** of their male counterparts.

In India, the Indian government has been proactive in tackling some of the secondary inhibitors cited by women by introducing 2017 Maternity Bill, as well as by tackling sexual harassment in the workplace. Now companies in India must report sexual harassment incidents, and their resolution in their company's annual returns – it is a compliance issue. So, companies in India are setting up committees and awareness programs to address the problem. The Indian government is also stipulating that each company must have one female board member, which should create more female role models.

There is a broader acceptance of the need for diversity in the workplace, and so the Indian Government is now focusing on policy development to increase gender diversity in corporate job sectors.

CONCLUSION

The number of Women pursuing engineering at graduation level has significantly increased over the last decades. The increasing number of women-role models in the technological industry has paved the path for newer generations.

In this paper, we have shed light on various matters and concerns regarding involvement of women in engineering related professions. The major concern being the gap between the number of male professionals employed to the number of female professionals employed.

This gap has to be addressed with a substantial attention. Policies and amendments such as decreasing or eliminating the gender pay gap, diversify gender-based hiring, provide more leadership opportunities to women, and increasing and improving work policies for female engineers can not only decrease the gender gap, but also diversify the workplace.

In India, Women now make up **34%** of the IT workforce, with the majority of these workers under the age of 30. Indeed, the youth of the Indian IT labour force has significantly powered its rapid growth, and the country is now almost at **50:50** gender parity rate in STEM graduates. The next challenge is retaining gender diversity through into middle management and leadership roles.

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