

Women Engineers: A Comparative Study between India and Australia

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Abstract

Though India and Australia are quite different from each other on so many economic indicators but women participation in engineering is low at both places. However, after globalization and advent of information technology, participation of women in engineering education has increased manifold in India and it has gone ahead of the participation of women engineer in Australia while in Australia, it is experiencing a plateau. On the basis of twenty four case studies among which fifty-fifty are from India and Australia, the paper tries to study socio-cultural reasons for present status.

Keyword - engineering education, market, discrimination, liberalisation, gender, employment, work-life balance

1. INTRODUCTION

Engineering is, generally, considered to be a male bastion and women participation is very low. The paper tries to discuss that it is true for both countries, India and Australia even though socio-economic life of women at both places are quite different from each other. The second section of the paper discusses that participation of women in engineering education is quite low in both the countries which is followed by inquiry of probable reasons on the basis of case studies of women engineers in the third section. Concerted efforts made to enhance participation in both Australia and India has been discussed in the fourth section. Some suggestions for improving the situation have been discussed in the fifth section. Last section concludes the discussion.

2. WOMEN STUDENTS IN ENGINEERING IN INDIA AND AUSTRALIA

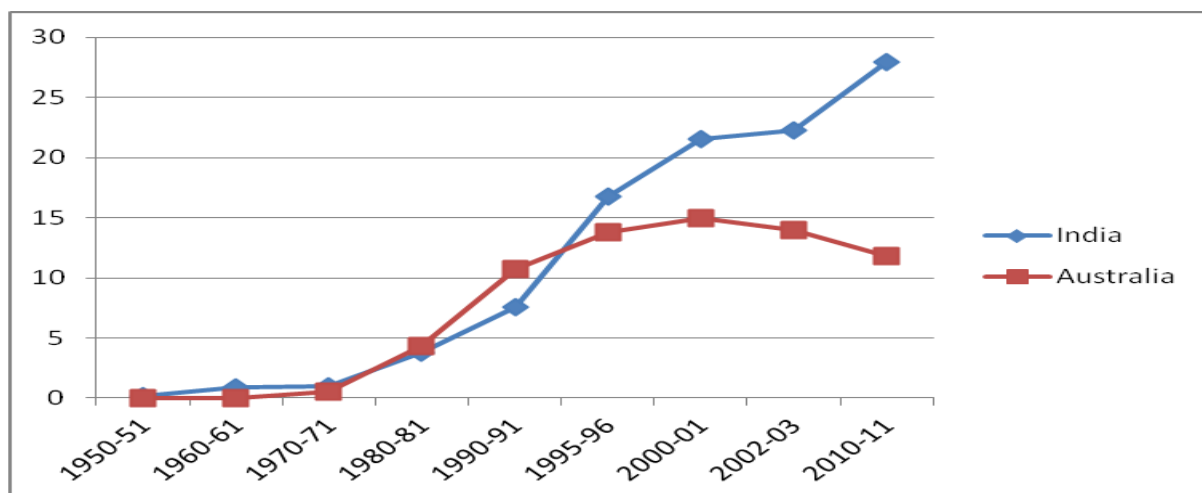
A comparison between the Development Indicators of India and Australia has been made in the Table-1 which shows the differences in socio-economic life of women exist in both countries. Women's share in Australian population is more than fifty percent while they are only 48.3 percent in India. Again, the per capita GNI in Australia is 36 times of the per capita GNI of India. There is universal primary and secondary education among women in Australia while in India participation in the primary education was just 73% in 1991 which has

Table 1: Development Indicators in India and Australia

Sl.no.	Indicators	Year, unit	India	Australia
1.	Gross national income per capita	2010 in \$	1,270	46,200
2.	Female Population	2010 as %	48.3	50.2
3.	Ratio of girls to boys enrolments in primary and secondary education (%)	2010	92	98
		1991	73	100
4.	Maternal mortality ratio per 1,00,000 live births	2008	230	8
5.	Women as % age of total labour force	2000	27.8	43.8
		2010	25.3	45.3
6.	Female part-time employment (% of total)	2005–10	-----	70

Source: Table1.1, Table1-2, Table 1.3 , Table 2.2, Table 1.5, [10]

increased to 92 % in 2010. Thanks to Sarva Shiksha Abhiyan, a compulsory primary education programme of the central government of India. Maternal mortality rate is 30 times more for 1,00,000 live birth in India than Australia. In short, Australian women have better socio-economic life than their Indian counterparts. However when it comes to comparing their participation in engineering education, the percentage of Australian women is lower than their Indian counterpart.



Graph 1: Women engineers in India and Australia

The trend regarding participation of women in engineering has clearly emerged in the Table 2. and Fig-1 [3, 5 and 11]. In the beginning, participation of women in both countries was lowest in engineering in comparison of other stream of education. Over the years, it has increased but remained lowest. When compared these two countries,

participation was almost same till 1990-91 but beyond it, growth of engineering in India is quite amazing. During the first decade of globalisation (1991-92 – 2000-01), it has grown almost three times and increased to 21.5 per cent in 2000-01 which further rose to 27.9 per cent in 2010-11 while, it has decreased in Australia during 2000 and 2010. Along with other reasons, a main factor for the decrease is decline in the number of girls studying science and mathematics in schools during this period. ‘The research by John Mack and Barry Walsh reveals a growing gender disparity over the last 10 years, with just 1.5% of girls studying advanced mathematics alongside physics and chemistry. There was a disparity in educational choice as said by Dr. Wilson which was a major contributor to the decline in engineering participation, with 13.5% of girls choosing to study family and community studies in 2011, a subject that was not on

Table 2: Percentage of Women Students in respective Disciplines in Both Countries

SN	Years	India				Australia			
		Eng/Tech	Science	Medical	Arts	Engi/Tech	Science	Medical	Arts
1	1950-51	0.2	7.1	16.3	16.1	0	18	17.5	33
2	1960-61	0.9	10.5	21.9	24.6	0	17.7	15	44.6
3	1970-71	1.0	17.8	22.8	31.7	0.5	12	N/A	60
4	1980-81	3.8	28.8	24.4	37.7	4.3	33.6	38	62
5	1990-91	7.6	32.9	33.2	41.8	10.7	39.7	41	68
6	1995-96	16.8	37.0	39.8	40.6	13.8	42.2	45	68.7
6	2000-01	21.5	39.4	44.0	44.2	15	41.7	54	66
7	2002-03	22.3	40.2	44.7	45.4	14	34	55	68
8	2010-11	27.9	43.1	50.6	47	11.8	40	54	68

**Source: 1. data up to 2002-03 for India [5], For data 2010-11 –UGC, Higher Education in India at a Glance; Data for 2010-11- UGC
2. data on Australia up to 1970-71 [1]
For all other data: [3]**

offer in 2001 [1,2 and 4]. In Australia, there is concern that the competition to obtain a higher tertiary entrance result score have seen high school students choosing easier subjects such as

humanities compared to the more difficult subjects such mathematics and science. These subjects are also perceived as competitive and boring subjects which are unpopular choices for many girls which may have led to the under representation of girls and women in technology and engineering tertiary studies. Therefore, engineering is a male dominated profession. The culture of these male dominated careers, in turn, affected the girls' choice of tertiary studies. There is also a shortage of mathematics teachers as the supply of graduates in this area have gone to do medical, finance or commerce career [3 and 4].

3. CASE STUDIES ON WOMEN ENGINEERS IN AUSTRALIAN AND INDIAN LABOUR MARKET

All together 24 case studies¹ have been taken here. Out of which first half are from Australia and rest are from India. These case studies have been discussed with the belief that they may be able to decipher some of the reasons for the low participation. They are as follows:

E1 (49 years) is a high achiever from a selective school for girls. She obtained high marks in English, Mathematics and Chemistry in the early 1980s. She chose to study engineering and science as she is interested in both the applied and theoretical disciplines. She was always given the task of writing down data during all the practical work at the university.

Upon graduation with good marks, she applied for many jobs but she was unsuccessful. Eventually she worked as a management trainee and never worked as an engineer. However, she was successful in the corporate world as she could implement logical thinking process to her varied projects. Her workplace was inflexible and working hours were long. She only took a few months maternity leave, less than the entitlement of 12 months, after the birth of her two children. She left the corporate world exhausted as combining motherhood with long hours was unsustainable. The stress of a marriage breakdown and being a single mother of two young children, now teenagers means having to work harder and long hours. She set up her own consultancy 4 years ago, training in occupational health and safety and first aid. In hindsight, she said she would have chosen to study a more female orientated profession as she felt she was never given a chance to work as a professional engineer.

E2 (31years) wanted to be an engineer as it is an applied subject. After finishing high school, she was highly stressed and decided to take some time away from studies. It was useful as she said it was a time for personal growth. A year later, she enrolled to study engineering at the university. She started as a civil design engineer and then briefly in construction. She was

discouraged to continue onsite and transferred to the design office. She soon resigned and now works long hours as a construction engineer in another company. She enjoys the outdoor work but she now finds herself exhausted when she comes home. The older male engineers treated her like an assistant administration officer. She gets on well with contractors as she is physically strong and tolerant. She is not sure if she could combine family and work in the future, as the four women engineers she works with, three have no children or one with grown up adult children.

E3 (52 years) is hard working and a determined person. She got along well with the male blue collar workers and other male engineers of her age. Her male supervisor was sexist and discriminated against her. As an example, she would not be invited after work to join the other workers for a social in a small town where she worked. She soon left the company and moved with her husband to Melbourne. She applied for many jobs and she never received any interview as she felt she has a female name on the resume. Eventually she joined a research body where new legislation was introduced to recognise equal opportunity in the workplace. She has three children and it became harder to juggle a family while working fulltime, she subsequently resigned when she was in her mid thirties. She volunteered in her children's schools, played golf and joined a choir.

E4 (53 years) is good in numeracy and she was encouraged by her mother to do engineering. Her college had programs to support girls in engineering. She worked in administration part time before she completed her engineering course and then changed to an engineering position upon graduating. She was not happy at work as her supervisor was unsupportive. It came as no surprise that she resigned from her job with the government department to have her first baby. She now regretted the decision as she found that it was very difficult to return to engineering after having three children. Her children are now adults. She helped in the kindergarten, school and sporting activities. She now works part time in a theatre serving food.

E5 (56 years) was studying for her engineering doctorate when her husband had a car accident. She did not complete her degree and cared for the family. She taught computer programming. She faced discrimination based on her accent. She left her teaching role after few years and now works in administration. She has an adult daughter who is now an engineer.

E6 (31 years) is good in both Mathematics and Environmental Science. Her parents love nature and her father is a draftsman. She enjoyed university life but a lecturer once told her in front of the class of 40 that "...girls should not have done engineering" in response to a question she asked. She worked in design office and managed projects. Unfortunately, she felt she had not been briefed or supported which was disappointing. She has to struggle through many tasks and eventually resigned. Interestingly, both supervisors were female engineers. She then studied horticulture and now, happily supervising environmental community projects

E7 (33 years) achieved excellent results in her Higher School Certificate. She studied a combined degree in Engineering and Arts because she wanted to do practical work and also learn a new language. She also had a scholarship throughout her university course as well as work experience. She fitted in the engineering course very well and upon graduation, she applied to many engineering jobs but received very few interviews. She finally got a job as a process supervisor in a brewery. She was chosen because the company wanted someone to help to change their internal culture. It was not an engineering position. She was given overnight shift work. She faced verbal abuse and she was very unhappy. Her supervisor was unethical and sexist. He was also a bully. She soon applied successfully for an engineering position with a global company and she moved to New Zealand with her engineer husband. He landed in an engineering position easily and this has greatly developed his skills. In New Zealand, she was in charge of a gas plant and when she was seven months pregnant, her workload in an isolated plant did not change. She had to climb up many stairs to shutoff a control which was one of her many responsibilities and she feared for her safety and health. The workplace was 70 km away from home. She was discrimination as she was not given lighter duties and eventually, she resigned. Now, she has two young children. For career, she wants to be involved with local government and the community. She retrained to be a teacher as the job is flexible and is a family friendly career. She aspire to be a writer.

E8 (54 years) graduated in engineering over an extended time. She worked hard and she supported her husband while he was studying for his PhD. She reflected fondly about the projects she worked in Malaysia and the respect she received. When she returned to Australia, she worked for a consultant. She went on site to discuss a major project and the client asked if she could be replaced, as he preferred to deal with a male engineer on the project. She took a career break when her son was born. She had a stressful time combining full time work and

looking after her family. She has no support because her husband, an engineer was transferred interstate. She also had no support network that she could call on to assist in the new place.

E9 (22 years) is a high achiever and she was one of the top students in the state. Her parents were not happy when she announced to study engineering rather than medicine. Three years into her study of the combined degree of Engineering and Commerce, she told me that the course is too theoretical and she was pleased for doing Commerce too which will balance the engineering experience. She went to England for six months on an exchange program.

E10 (50 years) is strong in numeracy compared to literacy. She went to college 30 years ago and was very well supported as by policy, they were encouraging girls to study engineering. She then worked in a consultancy firm where she was highly regarded. She loves working as an engineer and continued to work very hard until her second child was born. She asked her director if she could bring the baby into work which was refused. She felt compromised and resigned soon after that. She taught at her old engineering college for few years and later, set up her own engineering consultancy business from home. She is very busy bringing up teenagers while working fulltime and helping her aged parents.

Twenty five years ago, E11 (50 years), as a researcher, she received verbal and physical abuse from a male colleague who tried to undermine her. She was promoted to a senior research position for which he was unsuccessful. Being very upset, he sabotaged her research. She complained to the management but she received no support. A common bullying tactic is exclusion which she received. She also has a family. She felt that she should have had a mentor like the other men scientists. She volunteers in environmental educational program.

E12 (55 years) was good in Mathematics, Science and languages in high school. She has great communication skills and in 2012 organised the 30th reunion of her engineering university class. She has good engineering career specialising in designing water supply systems and project management. She was well regarded by her peers and chose to leave full time engineering to raise her family. She trained as a teacher and taught at the vocational level. She also volunteered in her children's school. She also consults in her husband's engineering company and continues volunteering in the community.

Being a good student, E13 (47 years) wanted to be a civil engineer like her father but the idea was vehemently opposed by her guardian because a civil engineer has to go for field work frequently which is not an ideal situation for a woman. They wanted her to pursue medicine. The negotiating point for them was pursuing electrical engineering. She graduated in electrical engineering in 1988 from Maulana Azad Regional Engineering College (Now, NIT, Bhopal). She joined ITI (a public sector undertaking) at Allahabad, UP. When she got married, she could not manage and left job to join her husband. Later on, as her in-laws were at Delhi, she joined a reputed engineering college as guest faculty in 1992-93 later on as a permanent faculty. She did her ME and Ph.D. from the same college. As her husband is also an engineer, she has got the support as her husband. Her only son is also pursuing engineering.

E14 (52 years) is a Civil Engineer and works in a consultancy firm. When she expressed her preference for engineering profession it was opposed by the family members as no one in her paternal family was engineer. However, a maternal uncle, who was himself an engineer, supported her. She graduated in Civil Engineering from in 1982. She was selected through campus placement by big construction company but was fired when the company came to know that she is preparing for a job. After working for other organisations, she left to take care of her two kids. In 1995, she started her own consultancy firm but could not handle and now, working as a senior executive with a consultancy firm in New Delhi. Apart from her consultancy firm, she is quite busy with growth of women in the profession. She frequently participate in International conferences and seminars on engineering education and is founder President of Women in Science & Engineering (WISE) India. She has two grown up kids. Her son is studying civil engineering in UK.

E15 (27 years) works as Contract faculty in computer engineering with a reputed engineering institution at Delhi for which she has migrated from her home town. Though she studied Biology at high school, she was more interested to join engineering like her father. She is eldest of five. All her three sisters are pursuing professional education and the brother studies in school. Her mother is a Post-graduate Degree holder in Zoology and was teaching in schools but as the daughters grew up, she preferred to stay at home to look after her daughters. She is Muslim by religion.

E16 (37 years) had Mathematics and Biology at plus two level². But she could clear engineering entrance test only and graduated in computer engineering in 2002 at an

government engineering college in Assam. Her father is a teacher who gave importance to education. Thus, all three sisters are well educated and are employed, but she is the only one who is an engineer. After graduation she started teaching in an engineering college as guest Faculty but migrated to Delhi to accompany her husband. At Delhi, she joined as contract faculty and pursuing Master's programme from the same technological university.

E17 (50 years) is daughter of a businessman in the capital. Family belonged to upper middle class. As she was good in mathematics and at that time, there was no entrance test. She joined engineering in a government engineering college. Just after passing final examination she got teaching job and later on, married her classmate. Her husband started his own business. She continued teaching till the time she completed 20 years of service. After that, she took voluntary retirement and joined her husband in his business. Her two children are now grown up but during their childhood, her mother looked after them, whenever required.

E18 (52 years) gives credit to her science teacher for joining engineering. The teacher use to give his students enough time to experience science in their day to day life contrary to today's children who are in the rat race of getting high marks. The teacher always helped her in exploring science. After plus two, engineering was an obvious choice. She has always tried to explore new and emerging fields. She gives credit to her husband and mother for her achievement as at the workplace, she has to fight for her rights. Now, she is senior scientist in one of the government's R&D lab.

E19 (25 years) is daughter of an Indian Administrative Officer. She was born with proverbial silver spoon. As technical lines are more rewarding than traditional lines and now with so many private engineering college, getting admission is not difficult, she opted for engineering. Though she could not get campus placement but now, she works with an IT firm on a recommendation of one of her relative who is a very high post in the same organisation. For parents, engineering background was a good option for getting a better groom for their daughter but now, she is enjoying her independence and does not want to get married so early in her life. She is bargaining with parents for further study abroad.

E20 (30 years) is daughter of a college Professor. Everybody in her neighbourhood was trying for engineering, so, it was an automatic choice for her and her elder brother who is one year older. Both of them could not clear entrance test of government engineering college and the

private engineering college was the only option for them for which they have paid high fees. Financially it was a tough decision and all four years were quite difficult for them but ultimately, it has paid off. Both of the siblings cleared their engineering and ultimately joined industry. Though timing was quite erratic but she was enjoying the independence. However, parents persuaded her for marriage. Though getting good match is difficult but as she was an engineer, it was not difficult for her. Ultimately, she has been married to an engineer who is working at Ireland, UK. She left job to join her husband and will work, if she gets there.

E21 (29 years), a civil engineer from not so good engineering college, is a daughter of civil engineer who is running a construction firm very successfully. Though she is sure that she can get a job but she is working in her father's firm. She is not in hurry to get married and concentrating on her work.

E22 (23 years) is one of the two daughters of a police officer. She wanted to pursue English literature but parents forced her to opt for engineering for early settlement and respect associated with engineering. She graduated B. Tech. in Information Technology. Being topper of her batch, she got selected through campus in an MNC but hectic time schedule and uncertainty she did not join. She is now preparing for the Indian Administrative Services³.

E23 (45 years) was good students in mathematics and opted for engineering. Her father was a government servant in Andhra Pradesh. After doing graduation in electrical engineering she joined State government. After marriage, she migrated to Delhi and could never join the work again. Her husband is a chartered accountant. Her only son is pursuing engineering.

Formerly a Class I Engineer of Government of India, E 24 (59 years) is a Mumbai based Project Administration Consultant in field in the construction sector. Basically, she has a rural background. Fondly, she remembers that once an engineer came to his village whom they all use to respect a lot. Being girl of one of the richest family of the village, she got the opportunity to talk to him and it was very inspiring moment for her. But ultimately, it was her brother-in-law⁴ who found that she was very quick in solving mathematics and advised her to take up engineering. She did her B.Tech. in civil engineering from a government college. There was not a ladies toilet in the college and she has to share the ladies staff toilet with the clerk- the only ladies staff in the college. She has always to fight for her right. She feels that women engineers need some adjustment according to their domestic responsibilities and they

will be far superior employees. She has had brilliant academic career and has received many national and international awards.

3 Interpretation of Case Studies

3.1 Opportunities for Engineering Education

Engineering seems to be a challenging profession for brilliant and high scoring students but it needs lots of concentration and hard work. At the same time, there are wider choices of tertiary studies available for girls [7] which are similarly stimulating but requires less time and concentration. That is one of the reasons for fewer women pursuing engineering in Australia. In case of India, getting admission was very difficult before opening of many private colleges if parents are ready to pay very high college fees. Globalisation, opening up of the economy and advent of information technology has expanded demand for engineering manpower. Early settlement, social recognition, higher chances of getting better groom are some of the reasons due to which parents are ready to pay higher tuition fees. Young women engineers are also enjoying their enhanced self esteem and economic independence.

3.2 Profession Selection

From the case studies, it is clear that most of the adult children of women engineers in Australia has not opted for engineering at university except for one who has Sri Lankan heritage⁵. So, there is a freedom of letting young people choose to study in the areas they are interested in. However, this is not the case for new migrant families, as there are still strong expectations from parents. However, the case is not same for India. Most of the women engineers have either father or uncle, an engineer, and their off springs have opted for engineering. Could this be a cultural expectation in India to continue to study in areas to meet with the expectations of the parents?

3.3 Life-Work Balance

Though, women bear the larger proportion of housework and child care but housework is normally done by the husband and wife in Australia.. Currently there are insufficient childcare places for preschool aged children in Australia which makes it very difficult to combine work and motherhood. Many are also having the responsibility of looking after their aged parents. They are exhausted from working fulltime at the workplace and continuing to work more at home. However, in case of their Indian counterparts, earlier standard family size was quite large. So, either the old age parents prefer to stay with the son whose wife stays at home or their engineer daughter-in-law will hire a full-time help at reasonable price. So in case of

senior engineers, their inability to get a job with their husband was the reason for unemployment and not the work pressure. In recent times, many women engineers are joining labour market but their parents are not so aged who requires care. In fact, they may take care of their grandchildren. However, with the school aged children, women engineers themselves do not want to travel or work for longer period outside home. Unless there is flexibility in their engineering profession, more women engineers will be leaving the profession during this stage of their lives.

3.4 Family Size

Many woman engineers in Australia have three children but their counterpart in India in the study, has one or two only. It needs to be further investigated that whether one or two children norm is common among Indian women and three among Australian or specific to engineers only. In case of three children, one can understand volume of house hold work which is required to put in on the regular basis. Theoretically, it is perceived as women participation in the labour market increases, number of children per women decreases which has culminated in a slogan, 'Development is the best contraceptive'.

3.5 Less Flexibility in the Indian labour Market then Australian

As the number of women doing engineering is plateauing in Australia. Measures are being taken for retention of experienced people in the workforce, Flexible working legislation, Fair Work Act 2009 has been introduced. As a result, there have been women design engineers working part time when they become mothers. Time will tell if this legislation will help to encourage more girls to choose engineering as a career. For now, majority of female engineering students have chosen environmental engineering as this suggests they prefer caring, nurturing of natural life. Women engineers who are working full time either do not have children or have adult children, otherwise they leave. Indian labour market is not as flexible and with the school aged children, women engineers themselves do not want to travel or work for longer period. So, unless there is flexibility in engineering profession, more women engineers will be leaving the profession during this stage of their lives.

3.6 Self Perception for Unpaid Care Work

The capability of doing paid work has been given a lot of focus in Amartya Sen's framework of development as freedom. His contention is that paid jobs help women become financially independent from their husbands and fathers and to make their own choices in the consumer and financial markets. He also adds that the freedom that goes with the paid labour brings

important values for women such as self-esteem, dignity and autonomy [6]. A question often arise in this context that if all women would engage in paid work than who would do the unpaid caring? In all likelihood, either woman would be overburdened with a double workday or many caring needs would be unattended. Case studies done in Australia reveal that woman engineers have to do very hard work both at home and the workplace. So, many of them have left the mainstream engineering profession and have decided for both paid and unpaid care work in the education and community sector.

3.7 Cultural and Social Aspect Influences the Decision

The case studies have been able to show that not only economic aspect but the cultural and social aspect influences the decision. Engineering is still perceived as a competitive male profession. Girls and women prefer to engage in career which is socially acceptable and meaningful to them. So the social and cultural influences cannot be overlooked in conducting further studies.

4. EFFORTS TO ENHANCE PARTICIPATION OF WOMEN AT ENGINEERING IN AUSTRALIA AND INDIA

There have been concerted efforts for over 30 years to encourage more women to study engineering and science [3 and 4]. Both in India and Australia, there have been many efforts to encourage students to continue studying mathematics and applied sciences in high school by offering scholarships and encouraging teachers to opt for better teaching methodologies to make these subjects more interesting and practical. The challenge is to increase number of female students to study mathematics and applied sciences and to encourage them to choose engineering as a career. At college level, there are reservations of seats for female students. Some companies provide female students with a supportive environment where they can gain insights into engineering from a female perspective with mentoring from successful female engineers. But if the participation is still very low, evaluation needs to be conducted as to whether these measures are effective. Role of association and societies like WISE and INWES in mentoring young women engineers in their professional career is very important. The advantage of having more women in these fields are well known as diversity will add to the richness of ideas, planning, problem solving, operation and construction of projects. Women engineers would bring a different perspective of thinking, planning and implementing projects which may be complementary to male engineers or scientists [8].

5. Conclusion

Though India and Australia are quite different from each other on so many economic indicators but women participation is low at both places. However, it is important to note that till 1991 it was more or less same but Indian percentage participation has overtaken Australian. Second important aspect is large attrition during child bearing years. Unless steps are taken to prevent the attrition, there will be a continued loss economically to the country. Women engineers are an asset as they are good collaborators and communicators. It has been inferred that greater responsibility of care work, lack of support system for domestic work within and outside family, male chauvinism among some of the male bosses and opportunity of working part time are some of the reasons for low participation in Australia. While in India, availability of support system, expansion of engineering education system and financial independence at early age are some of the factors which are attracting young girls towards engineering education. As most of the mothers are house wife and at some point of time, they may have wished financial independence, are extending full support to their daughter and there are greater chances of getting better groom for their daughter also. However, they lack mentoring and there is need that associations of women engineers to extend their helping hands towards women engineers.

Notes:

1. Half of the case studies (13 to 24) from India [9]
2. In India, school education is of 7+3+2 years. Plus two means last two years
3. Indian Administrative Services (IAS) in India is highest level of administrative services.
4. Husband of elder sister. When number of children of a couple is six or more. There is quite large difference between the age of younger and eldest sibling.
5. Cultural expectations of first generation migrant families.

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