WOMEN IN INDIAN ENGINEERING:

A Preliminary Analysis of Data from the Graduate Level Engineering Education Field in Kerala and Rajasthan

Sreelekha Nair

Occasional Paper No.58

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I am happy to bring out the report 'Women in Indian Engineering: A Preliminary Analysis of Data from the Graduate Level Engineering Education Field in Kerala and Rajasthan' in the form of an occasional paper from the Centre for Women's Development Studies, New Delhi. This is a 'work-in- progress' and I would like to treat this as the beginning of a major project on women in Indian Engineering.

One might wonder why women in Indian Engineering? Why not just engineering? I learnt during the process of this study that engineering in India like many other areas has a national character. It is important to highlight the identity of engineering in India especially due to its colonial past and fast growth along the international line while struggling for an identity of its own.

I would like to thank Roland Lardinois of the Department of Politics and Society in Centre de Sciences Humaines(CSH) for the initiation of the project 'Making of Indian Engineers of which this is a part, encouragement given for this study and the discussions. I am thankful to Basudeb Chaudhury, Director, CSH and Roland Lardinois for the financial support for this study, especially for my field work in Kerala and Rajasthan. I was able to travel to different engineering colleges, other institutions and was able to access different people because of the support.

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This study was done in the nature of a pilot study and I hope that interested persons will be able to use this study for understanding the gender dimensions of engineering in India.

Sreelekha Nair

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Introduction and Premises of the Study

Engineering has been associated with development ever since the origin of human civilization and it has always been included as an important agenda in the development discourse of the nation states especially in the context of their infrastructure growth. Participation in engineering by genders- numerically as well as qualitatively- is taken as an indicator of not just gender equality but as development of the society and the nation as well. Since the definition of infrastructure also has moved on from 'hard' objects like dams and bridges and so on to 'light and soft' things like computers -software and internet- engineers and engineering also underwent certain image changes. This image change is reflected in women being included as engineers in 'a profession that has been dubbed as masculine' (Carter and Kirkup 1990). Nevertheless images apart, are there substantial changes in the relationship between women and engineering? This is a fascinating question to explore considering that so little is studied on women engineers especially in India, situating them within the context of women's status and their role in the national development[1]. This study is trying to understand the trends and changed relationship in India, using the resources available from the engineering education field mainly in the states of Kerala and Rajasthan.

Literature, Methodology and Methods

Various studies that dealt with engineers in India and elsewhere also were reviewed to understand the existing literature on the subject. The review of literature confirmed the initial understanding that there are only a handful of studies on women engineers. It was interesting to note that this was a fact for most parts of the world. One interesting work on women in engineering that

situates engineering within the hierarchy and history of professions and that traces the evolution of women's participation in engineering is the work of Catherine Marry of France. 'Crossing Boundaries and Building Bridges: Comparing The History of Women Engineers 1970s-1990s' a volume edited by Ruth Oldenziel, Annie Canel and Karin Zachmann presents a broad picture of the trials and tribulations of the early women engineers in the European context[2]. The book outlines the fact that the struggles of the pioneering women were invaluable in bringing a larger number of women into their fold. Generally, the edited volumes that are available on women engineers in the contemporary world do provide useful insights but are often scattered as micro studies on different countries. And yet these studies are helpful in understanding the situation of women and engineering in contexts like that of India in a comparative framework. Two extensive studies in IIT Bombay in 1992 and 2000 (See Parikh and Sukhatme (1992) and for an account on this study, see (2004:193)) are the pioneering efforts in India in the direction of understanding the field of women and engineering[3].

This study makes use of secondary sources and material for the data on enrolment and outturn of men and women students in the states of Kerala and Rajasthan from the 1980s till the present. It relies on the Annual Technical Manpower Review of Institute of Applied Manpower Research for the purpose of evaluating the changes in the patterns of enrolment and outturn of engineers at the graduate level. Nodal Centres[4] of the National Technical Manpower Information System of Kerala and Rajasthan are the sources for detailed information on the education and employment scenario of graduate engineers. These reviews give us data on men and women and the ratio between men and women. All India level data available from the Manpower Profile, a publication of the Institute of Applied Manpower Research, New Delhi is also used in this paper.

It also uses qualitative methods of observation, interviews and group discussions to collect the data for the study. Techniques of observation and interviews in colleges in Kerala and Rajasthan were undertaken to gather detailed information on processes beyond enrolment and outturn. These are very much intended only to understand the trends and not to derive any conclusions on the overall Indian scenario as sample size of respondents and number of sites is limited. Thangal Kunju Musaliar College of Engineering (TKM) founded in 1958 at Kollam, Kerala was selected as the college for interviews for understanding the trends within the state of Kerala. This selection was done on the basis of the discussions with women engineers in the past regarding the women's enrolment in the college since its inception. This college is a private- aided institution[5] known for its quality teaching and academic orientation. However it was reported

that women's enrolment in this college was nil in the first few years and then very low later on and that there was a growth in the enrolment of women in recent decades. Birla Institute of Scientific Research in Jaipur was the institution selected for interviews in the state of Rajasthan. This institute is a case in point for the new genre of self-financing institutions. Group discussions and interviews were also conducted among a group of students in the Malaviya Institute of Technology(MIT), Jaipur as well. The sections below are organised as: Engineering Education in India, Graduate Engineering scenario in the state of Kerala, Section on Rajasthan and Findings and Summary.

Engineering Education in India

Engineering education has developed considerably over the last decades in India but engineers are still reported to be in short supply in many sectors. This situation seems to be the running theme[6] ever since Indian State took up the agenda of 'national development'. Thankamma Thankachan(2007:3) of Institute of Applied Manpower Research, New Delhi for example, points out that despite the position of engineering as the second largest profession in the world, at the time of independence India faced acute shortage of engineers. And technicians and engineers were needed mainly to meet the demand even in the basic and traditional industries such as irrigation, power, Public Works, Railways, Road etc. Most often engineering education is viewed in relation with and in the context of national development and demand-supply dynamics in the job market. This is an indicator of the almost complete 'instrumentalist' approach to engineering education both by the society, the state and in consequence, the students. Here the question is far from what was raised by Ruth Schwartz Cowan in her provocative piece[7]: are women in engineering gender benders?

A survey of the writings in the field on engineering and technology reveals that the growth and development of engineering[8] in India should be placed in different phases. Kumar et al (2008:3-7) uses the financial source of the funding of the higher educational institutions as the criterion for the categorisation of the phases. They also take into account the privatisation that happened in education sector as an important aspect of the new phase. Even Parikh and Sukhatme(2004) state the same with specific reference to the existence of private sector in engineering education and attribute the growth of the engineering sector to the privatisation process. Similarly Thankachan's report mentioned earlier says that India had 6.91 Scientists, Engineers and Technicians (SET) per thousand populations during 1996 and that the scenario changed in the following decade-global competition and information technology revolution led to shift in paradigm

in engineering practices. Number of engineering institutions has increased from 151 to 1084 (1991-2001) and the percentage of private institutions increased from 56 per cent to 80 per cent during the same period. Employment opportunities due to global offshore outsourcing market for software and backoffice services with unprecedented revenues attracted many to technical degrees. Kumar et al(ibid.) also mentions the demand side of the picture citing the emergence of a substantial number of Indian 'middle class' population that can pay higher tuition fees for a technical degree. Apart from outsourcing services, domestic IT companies and also computerisation of PSU, public sector and private companies are reported to have increased employment opportunities for those with technical qualifications. Nevertheless the fact remains that state governments are still the highest employer of engineers, followed by Central Public Sector Units(PSUs) and Public Limited Companies. During the last decade, however there is a negative rate of growth (-0.65 per cent) in State Government departments according to the IAMR report cited above. This may be due to disinvestment practices adopted by the Indian State as part of its privatisation policies.

Growth of higher technical education including that of the graduate level, which is the focus of this paper, is generally attributed to the increase in the number of institutions, growth and changes in the enrolment patterns, increase in the number of faculty, expansion of research facilities and its standardisation across the country bringing it at par with the global benchmark. This study finds that though these are spelt as important targets in the policy documents, they do not exist in practice and variations across regions and even institutions within the same region betray a dismal lack of regulation of standards in technical education across the country. Discussions with researchers and technical personnel point towards the malfunctioning of regulatory bodies like All India Council for Technical Education (AICTE) for the present state of affairs.

As mentioned earlier, this paper limits itself to the trends at the graduate level engineering courses for women in engineering. Towards that end, the following section presents tables on the enrolment and outturn of engineers over the last decades as an introduction to the sections on women and engineering in the states of Kerala and Rajasthan. According to the data provided by various sources like Ministry of Human Resource Development, University Grants Commission and AICTE, the number of students taken admission has increased manifold over the last three decades, from 18207 to 305370 in 2002(provisional figure). According to the NISTADS report[9], engineering has emerged as the fourth largest choice of students and moved from its 5th position in the year 2000. Engineering, according to this report, showed the highest growth rate of 12.65% among all the disciplines of higher education last decade.

Table 1:
Number of students taken admission and passed out at graduate level from 1971-2007 (All India).

Year	Admission	Outturn
1971	18207	18223*
1981	34835	19012
1986	36328	29291
1987	55508	30078
1989	62603	37615
1990	66686	41464
1991	70481	44724
1992	73018	44144
1996	103933	75450**
1997	138450	73936**
1998	122498	69280
1999	185360	72247
2000	197081	74323
2001***	262882**	94639***
2002***	305370	101914

Note: *Number of outturn is larger than the number of admission. No explanation is given for this. Reproduced from India Year Book 2008. However IAMR researchers explain that this must be due to students repeating the course and examination in that particular year. ***estimated***Provisional*

Source: Table on Select Professional Courses, pp.81, India Year Book 2008 (Made from resources of MHRD, NTMIS, AICTE, Govt of India)

Table 2:
Outturn (Discipline wise)(All India) at Graduate Degree Level in Engineering and Technology 1991-2002

Discipline	1991	1992	1996	1997	1998	1999	2000	2001*	2002*
Civil	8514	8147	8875	8998	8787	9119	9336	7422	7471
Mechanical	9257	9538	13582	12757	12877	13800	14191	17674	18132
Electrical	5399	3716	8160	7787	7982	8309	8309	8198	12199
Chemical	1734	1587	2411	2563	2622	2856	2901	3982	3886
Electronics and Telecomm.	6746	7322	18543	18758	18942	13500	13610	13485	18639
Metallurgy	497	469	788	965	987	927	928	849	759
Mining	348	536	508	522	537	542	552	509	419
Automobile	154	207	336	265	281	286	304	286	314
Aeronautical	58	75	102	113	117	90	90	132	127
Agriculture	202	164	359	295	306	265	265	426	337
Production	1112	1030	2132	2086	2092	2173	2173	2414	2706
Sugar	15	15	128	52	56	56	56	24	97
Oil tech	45	46	57	38	39	39	39	54	31
Textile	459	414	581	657	745	804	826	822	921
Architecture	815	743	1391	1379	1373	1597	1650	1672	1788
Food Tech	29	43	85	94	97	111	111	146	600
Instrumentation	863	845	1924	1987	2080	2040	2142	2004	1727
Ceramics	62	60	89	74	68	73	78	315	44
Leather	43	45	61	49	49	69	69	121	124
Others	8372	9139	15538	14497	15173	15591	16693	34104	31593
Total	**44724**	**44141**	**75450**	**73936**	**75210**	**72247**	**74323**	**94639**	**101914**

Source: NTMIS, AICTE, Govt of India.

Table above shows a substantial increase in the admission and outturn of students across disciplines from the 1990s till 2002. The section below will look at the all India scenario of women in engineering in terms of admission and outturn.

Women in Engineering in India

Engineering has been viewed as a men's domain in India(Gupta 2007; Nair 2004), quite in line with the universal pattern. In fact in India the participation of women in engineering remained negligible till the early 1980s. The enrolment of females

has been less than one percent of the total enrolment within the field of engineering till 1960s; it rose to 8.3 by the mid 1990s and by the year 2000 it has come to 16.2 percent[10]. Despite this understanding among researchers general discussions and newspapers talk of 'a crack in the academic glass ceiling'[11]. When you look at the aggregate numbers as this news report, the details of which is given in endnote no 11 does, a total of 276806 women were enrolled in engineering at the start of the 2009-2010 academic year in comparison to 124606 in 2000-2001. This means that the number more than doubled over the one decade that one is talking about here.

As we can see from the table below, men still dominate the field of engineering. Analysis of percentage of enrolment at graduate level in engineering of men and women by Kumar et al[12] suggest that the rate of growth of men entering the field has been stabilised whereas women's growth percentage is increasing steadily. This is in line with the trend in higher education in India. An analysis of the data on women in higher education shows that number of women enrolled increased across disciplines- from arts and humanities to commerce and law. However the ratio of men and women in engineering is low and a lot more remains to be done to bring about an equal gender ratio in the enrolment in higher education in general and engineering in particular.
Table 3 below shows the comparative picture of men and women enrolled in engineering and technology at graduate level in the 1990s and the first decade of the twenty first century.

Table 3:
Comparative Figures of Men and Women Enrolled at the Graduate Level Engineering (All-India)

Graduates	Year of Enrolment								
	1981			1986			2001		
	Men	Women	Ratio (M:W)	Men	Women	Ratio (M:W)	Men	Women	Ratio (M:W)
	111064	4942	01:0.04	169388	13061	01:0.08	423147	118234	01:0.28

Source :Table no. 2.1.9, Enrolment in Eng. / Technology /Architecture by Level Page no 65 Manpower Profile 2008.(Source: MHRD and UGC)

Table 3 clearly shows that gender ratio is highly skewed in favour of men. Women are not even half of the total number of men who are enrolled in engineering in the last decade[13]. Enrolment pattern is only one issue and there are other important issues even when enrolment of women is catching up with that of men

in some disciplines at least in states like Kerala that we will see later. Processes beyond the enrolment like classroom participation and laboratory exposure are important in the 'making of a good engineer'. Societal expectations and ascribed gender roles often restrain women from achieving 'the expected skills as an engineer'. As Gupta(2007) argues in the context of the study on doctoral science students in two IITs in India, informal milieu does not provide the ground for an equal level of participation by men and women. This is despite the critical mass that women are seen as turned into in recent years in some disciplines. The fault lies partly with the definition of engineering theory and practices in highly masculine terms.

Last decade witnessed certain changes in these strictly masculine images of engineering and, women are imagined and captured as symbolic imagery of future engineers in websites and brochures of educational institutions. Women's enrolment in certain new and fashionable branches like software and information technology has been high (Parikh and Sukhatme 2004: 193) and software in turn became the face of engineering in the last decade. This broke the image of engineering as hostile to women[14] and at the same time also led to the growing misconception of the 'crack in the academic glass ceiling'. This report finds, as will be shown below, that women's enrolment has remained the same in many of the specialisations and in fact on that basis we can categorise the specialisations into women friendly, moderately friendly to women and hostile to women. What is interesting in the context of Kerala and Rajasthan that may be applicable to the entire India is the fact that reasons for women entering engineering is for earning a livelihood. Even when they remain unemployed, 'acquiring a skill that will come handy in times of crises' has been one motivation for many to enrol for those branches of engineering that easily fetch jobs . That means that the relation between the discipline and its demand in the job market is an important factor and yet social acceptability of women entering spaces dominated by men has changed minimally.

The sections below will look at the two states taken up for this pilot study- Kerala and Rajasthan. Southern states occupy the highest positions in the list. It is in this context that this pilot study looks at the state of Kerala and Rajasthan. Kerala is a state known for women's participation in education among the Indian states. Its standard of living is often compared with China and other fast growing nations[15]. It is acknowledged that Kerala also leads in its participation in science and technology education. Kerala occupies sixth place in the list of number of students enrolled for engineering in India. Its first engineering college was established in 1939 at Thiruvananthapuram by the State. Parikh and Sukhatme's landmark study[16] places Kerala in another first with the finding that women

engineering students from Kerala wants to pursue higher studies in comparison to other students from other states. They find that in 1990, Kerala had the largest number of women engineers in the country, followed by Tamil Nadu,Karnataka and Maharashtra, the numbers being about 20, 18, 16 and 12 per cent of the total respectively. Disciplinewise, electrical engineering and electronics were the most preferred branches followed by civil engineering. Computer science/engineering population had started to grow rapidly during this period(Parikh and Sukhatme 2004:194).

Rajasthan on the other hand is known for its adverse ratio against women students and its women possess low literacy rate. Women's status in Rajasthan is considered as one of the lowest even within India. It got its first engineering educational institution in 1946. This was in the private sector under the initiative of the industrialist Mr. G.D.Birla. Second graduate degree level institution[17] was established in Jodhpur in 1951 by the state of Rajasthan with financial support from a private source and the third one in 1963 as a collaborative project between the Central and State governments. After that initiatives in engineering education had to wait for the private-public partnerships that finally gave the much needed fillip to graduate level engineering education in the state. It is important to state here that though these two states are taken for the study, this report does not venture into any major comparison between the two states considering the limited scope and objectives of the study undertaken. Hence I present the information and findings in respective sections on the two states.

Kerala and Women Engineers

Introduction

Technical education was institutionalised in the form of graduate degree college in 1939 in the region presently known as Kerala. Like in the case of primary education and primary healthcare, it was the princely state of Thiruvithamkoor that took the initiative to set up the first engineering college at Thiruvananthapuram.

Table 4:
Growth of Engineering Institutions (Graduate Level) in the State of Kerala

Year	No. of Engineering Colleges	Type
1941	1	Government
1951	1	Government
1961	6	Govt. & Pvt. Aided
1971	6	Govt. & Pvt. Aided
1981	6	Govt. & Pvt. Aided
1991	10	Govt. & Pvt. Aided
1995	16	Govt. & Pvt. Aided & Unaided
2000	33	Govt. & Pvt. Aided & Unaided
2002	77	Govt. & Pvt. Aided & Unaided
2005	191	Govt. & Pvt. Aided & Unaided
2008	194	Govt. & Pvt. Aided & Unaided

Source: Annual Technical Manpower Review (ATMR), Nodal Centre, Kerala, NTMIS, IAMR.

For about two decades this was the only college for training engineering students at the graduate level. In 1958 two more colleges were established, one as a private-aided college[18] and the other was in the public sector. Regional Engineering College was also established during this period. 1960s to the start of the 1980s witnessed a stagnant scenario where the number of degree level institutions did not grow. In 1990s saw a growth in number and it was 12 in 1993 of which government sector grew to 9 and private remained at 3. Late 1990s saw the private unaided self financing engineering college (these are of two types- private ones and those under various government programmes and departments) being established and its number grew to 47 in 2003 while private aided and government institutions remained at 3 and 31 respectively. At present there are 94 engineering colleges imparting 27 different courses out of which 39 are government or quasi-government institutions, 3 are private aided and 52 are private unaided[19]. The table above displays the growth in engineering institutions in the state of Kerala.

Number of institutions increased as we see in the table above and the 'genre' of these institutions also is diversified since the mid-1990s. This is part of the policy changes that has happened in the area of higher education. Private sector

participation in higher education and technical education has increased. As a result, private unaided institutions have grown to 52 and this rate of growth of institutions is unprecedented. Interviews with the principal of the TKM Engineering College and many others who have a stake in the engineering sector speak of a heightened demand for engineering. Availability of educational loan and mushrooming of call centres are reported to have raised the demand for a graduate degree in engineering.

Annual Technical Education Reviews(ATER) of Nodal Centre Kerala also indicate substantial growth in the field of engineering and spread of engineering across various sections of the population. "Middle class has always been interested in professional courses for their children in Kerala... and now lower middle class and poorer sections also want to have a professional degree, preferably in engineering because it is seen as prestigious and as having the ability to help raise the social mobility of not just the students themselves but their families too...It is this market that the new (private unaided) colleges target..."[20]

Table 5:
Intake of Graduate Students in Degree Institutions in Kerala by Discipline

Discipline	1991	1995	1996	1997	1998	1999	2000	2001	2002	2003
Civil	584	692	657	697	747	745	691	755	815	996
Electrical & Electronics	580	660	688	833	771	797	890	1096	1944	2287
Electronics & communication	375	892	946	866	1003	1265	2024	2892	4641	4602
Electronics & Instrumentation	-	-	-	-	-	-	104	98	171	213
Mechanical	581	966	992	918	1066	1091	1291	1214	1696	1941
Chemical	78	82	83	89	103	149	142	142	150	146
Information Technology	-	76	50	62	60	314	1037	1586	1894	1377
Computer Science & Engineering	255	664	737	780	830	1092	1852	2499	3460	3550
Industrial Engineering	21	21	21	30	30	30	30	29	30	29
Applied Electr.& Instrumentation	45	104	105	110	110	165	232	368	486	550
Bio Technology	-	-	-	-	-	-	-	-	284	285
Production Eng.	81	88	95	92	90	105	86	88	88	85
Total	**2795**	**4441**	**4657**	**4792**	**5122**	**6126**	**8739**	**11147**	**16143**	**16563**

Source: ATER and ATMR, Nodal Centre, Kerala, NTMIS, IAMR.

While a section cry foul about the quality of engineering courses, it is no secret that most prefer an engineering degree from a 'not-so-prestigious' college to a general arts and humanities degree from a famous university. Entry into an engineering college is based on marks in the Higher Secondary School Leaving Certificate Examination/ Plus Two[21] and engineering entrance examination rank. Data available in the Annual Technical Manpower Review(ATMR) of IAMR and Annual Reports of the MHRD show a substantial increase in the number of sanctioned and actual intake of students in engineering across various disciplines. This is corroborated by the pioneering study by Parikh and Sukhatme(2004:193). As the table above shows, some new disciplines started in the beginning of the present century and are much in demand in comparison to the traditional disciplines that are seen as 'less fashionable' and as providing few opportunities in the job market and this is attributed to demand from industry. And conventional subjects are not part of the programmes of many of the private unaided colleges. Thus Information Technology and Computer Science and Engineering are the most popular courses, followed by Electronics and Communication. In fact most of the self-financing colleges have only three disciplines- Information Technology, Computer Science and Electronics and Communication. And these are also the most preferred branch of engineering by women as we will see below. These developments aim purely at the job market and are described as 'bubbles' by some teachers[22]. But at the same time it is these new subjects that are able to accommodate women as 'engineers' as equal as men while some of the conventional branches like Mechanical Engineering still remain a male bastion.

Intake and Outturn of Men and Women in Different Disciplines

Table 6 below displays the ratio of men to women in different disciplines. Ratio between men and women are equal or at times are favourable to women as in the case of Information Technology ever since its introduction in the colleges of Kerala. Some others like Computer Science witness a steady increase in the ratio and this is the case with many other disciplines. However Mechanical Engineering sees almost no participation from women and the increase is negligible.

Table 6:
Distribution of Actual Intake into Degree Courses by Gender and Discipline

Discipline	1986-1987			
	Total	Women	Men	Ratio of Men to Women
Civil	559	216	343	1:0.63
Electrical	509	154	355	1:0.43
Electronics	60	20	40	1:0.50
Electrical & Electronics	-	-	-	-
Electronics & Communication	243	42	201	1:0.21
Electronics & Instrumentation	-	-	-	-
Mechanical	549	66	543	1:0.001
Chemical	84	37	47	1:0.79
Information technology	-	-	-	-
Computer Science & Engineering	107	16	91	1:0.18
Applied Electronics & Instrumentation	40	3	37	1:0.08
Bio Technology	-	-	-	-
Total*	**2458**	**535**	**1923**	**1: 0.28**

Discipline	1995-96			
	Total	Women	Men	Ratio of Men to Women
Civil	692	296	396	1:0.75
Electrical	660	239	421	1:0.57
Electronics	610	185	425	1:0.44
Electrical & Electronics	-	-	-	-
Electronics & Communication	282	83	199	1:0.42
Electronics & Instrumentation	-	-	-	-
Mechanical	906	21	885	1:0.02
Chemical	82	25	57	1:0.44
Information technology	76	31	45	1:0.69
Computer Science & Engineering	664	231	433	1:0.53
Applied Electronics & Instrumentation	104	39	65	1:0.60
Bio Technology	-	-	-	-
Total*	**-****	**-**	**-**	**-**

contd..

Discipline	2003 batch			
	Total	**Women**	**Men**	**Ratio**
Civil	996	392	604	1:0.65
Electrical & Electronics	2287	764	1523	1:0.50
Electronics & Communication	4602	1577	3025	1:0.52
Electr. & Instrumentation	213	60	153	1:0.39
Mechanical	1941	46	1895	1:0.02
Chemical	146	44	102	1:0.43
Information Technology	1377	699	678	1:1.03
Computer Science & Eng.	3550	1698	1852	1:0.92
Applied Elect. & Instrumentation	550	195	355	1:0.55
Bio-Tech.	285	85	200	1:2.4
Total	**16606**	**5850**	**10756**	**1:0.54**

Discipline	2004 batch			
	Total	**Women**	**Men**	**Ratio**
Civil	1063	404	659	1:0.61
Electrical & Electronics	2151	598	1553	1:0.39
Electronics & Communication	4945	1807	3138	1:0.58
Electr. & Instrumentation	160	36	124	1:0.29
Mechanical	2481	52	2429	1:0.02
Chemical	146	33	113	1:0.29
Information Technology	1043	566	477	1:1.19
Computer Science & Eng.	3473	1676	1797	1:0.93
Applied Elect. & Instrumentation	411	135	276	1:0.49
Bio-Tech.	273	182	91	1:2
Total	**16837**	**5670**	**11167**	**1:0.51**

contd..

Discipline	2007 batch			
	Total	Women	Men	Ratio
Civil	2050	1010	1040	1:0.97
Electrical & Electronics	4031	1652	2379	1:0.69
Electronics & Communication	6697	3059	3638	1:0.84
Electr. & Instrumentation	377	167	210	1:0.80
Mechanical	3842	67	3775	1:0.02
Chemical	215	71	144	1:0.49
Information Technology	2674	1528	1146	1:1.33
Computer Science & Eng.	5603	2818	2785	1:1
Applied Elect. & Instrumentation	377	167	210	1:0.80
Bio-Tech.	258	192	66	1:2.91
Total	**27975**	**11389**	**16586**	**1:0.69**

Source: ATER and ATMR, Nodal Centre, Kerala, NTMIS, IAMR.

**Include some other branches like ship building where the total intake is 20-30 there is no woman student. Only exception is 1986-87 batch where there was one woman out of 28 students.*

*** total is not given here.*

As table 6 shows, actual intake into different disciplines shows an increase in the number of women students and the ratio is growing in favour of them. However disciplinewise analysis shows that women enter some disciplines in much larger numbers than some others. Comparatively newer disciplines like Information Technology, Computer Science and Bio Technology have a ratio that is favourable to women. These branches have contributed to the higher participation of women in engineering. Traditional disciplines like Electrical and Civil Engineering show a gradual and stable increase in the number of women though ratio still is unfavourable to women candidates entering engineering. Traditional branches like Civil, Electrical, and Mechanical, as we see from the tables above, maintain a trend that is rather stable[23]. Among the traditional disciplines, Mechanical Engineering has a very low ratio of 1:0.02 over the decades for which data are presented here.

Some other disciplines like Automobile Engineering, Ship Building Technology and Production and Industrial Engineering have very few sanctioned and actual intake of students and women's number remains almost nil over the period from

the 1980s till 2007 batch. It is very clear that the high ratio of women in newer disciplines has led to the general belief that women are entering engineering in equal numbers as men.

It is clear that the field of technical education at the degree level has more women entering and passing out successfully during the last decade in comparison to earlier decades. Ratio of men to women who pass out is higher in favour of women. Large number of men seemed to have dropped out of the course after taking admission (See for example Civil Engineering of the batch 2003 in table 7.) Teachers attribute this to migration to more attractive courses and some amount of dropping out between the first year and fourth year for various reasons including leaving the course due to heavy workload.

Table 7

Discipline	Outturn of Men and Women in Different Disciplines Year							
	1983 batch				1986-87 batch*			
	T	W	M	R	T	W	M	R
Civil	467	178	289	1:0.62	527	169	358	1:0.47
Electrical	450	104	346	1:0.30	455	140	315	1:0.44
Electronics	24	4	20	1:0.20	27	6	21	1:0.29
Electr&Electronics	-	-	-	-	-	-	-	-
Mechanical	495	5	487	1:0.01	516	6	510	1:0.012
Computer Science	-	-	-	-	-	-	-	-
Information Tech.	-	-	-	-	-	-	-	-
El & commun.	160	26	134	1:0.19	70	19	51	1:0.37
Chemical*	36	8	28	1:0.29	55	28	27	1:1.03
Industrial Eng.	-	-	-	-	15	1	14	1:0.071
Total**	**1704**	**347**	**1357**	**1:0.20**	**1792**	**392**	**1400**	**1:0.28**

Discipline	Year							
	1991-92 batch				1995-96 batch			
	T	W	M	R	T	W	M	Ratio
Civil	416	168	248	1:0.68	418	196	222	1:0.88
Electrical	-	-	-	-	388	141	247	1:0.57
Electronics	-	-	-	-	34	7	27	1:0.26
Electr&Electronics	391	112	279	1:0.40	-	-	-	-
Mechanical	509	35	474	1:0.07	308	91	217	1:0.42
Computer Science	127	31	96	1:0.32	434	12	422	1:0.03
Information Tech.	-	-	-	-	-	-	-	-
El & commun.	289	83	206	1:0.42	180	52	128	1:0.41
Chemical*	72	22	50	1:0.44	74	20	54	1:0.37
Industrial Eng.	20	4	16	1:0.25	-	-	-	-
Total**	**2098**	**509**	**1589**	**1:0.32**	**2148**	**595**	**1553**	**1:0.38**

contd...

Discipline	Year							
	1999-2000 batch				2003 batch			
	T	W	M	Ratio	Total	W	M	Ratio
Civil	443	297	146	1:2.03	402	172	230	1:0.74
Electrical	-	-	-	-	-	-	-	-
Electronics	-	-	-	-	221	78	143	1:0.55
Electr&Electronics	558	338	220	1:1.54	488	229	259	1:0.88
Mechanical	831	306	525	1:0.58	396	125	271	1:0.46
Computer Science	694	33	661	1:0.05	545	7	538	1:0.013
Information Tech.	213	107	106	1:1.01	-	-		-
El & commun.	708	296	412	1:0.72	435	175	260	1:0.67
Chemical*	112	49	63	1:0.77	65	17	48	1:0.35
Industrial Eng.	12	2	10	1:0.2	-	-		-
Total**	**3944**	**1576**	**2368**	**1:0.67**	**2945**	**893**	**2052**	**1:0.43**

Discipline	Year			
	2008 batch			
	T	W	M	R
Civil	695	368	327	1:1.13
Electrical	1319	492	827	1:0.59
Electronics	-	-	-	-6
Electr&Electronics	-	-	-	-
Mechanical	2580	1167	1413	1:0.83
Computer Science	1238	10	1228	1:0.01
Information Tech.	444	264	180-	1:1.47
El & commun.	2001	1110	891	1:1.25
Chemical*	113	34	79	1:0.43
Industrial Eng.	26	8	18	1:0.44
Total**	**9377**	**3855**	**5522**	**1:0.70**

Source: ATER and ATMR, Nodal Centre, Kerala, NTMIS, IAMR.

Total number appeared for exam 33 men and 31 women; passed out numbers are given here.

**some years number include fine arts and pharmacy; total does not add up in some cases because some branches are not represented in the table but the total given here is the total passed out in that year.*

*** other branches too like naval ship building, bio medical, polymer eng., rubber technology, architecture, production eng., safety and fire eng. and instrumentation and control.*

Nonetheless all are not ready to look at the increase in the number of women as an 'innocent' development favourable for women. Ms. Sasikala who is a retired Chief Engineer from the Kerala State Electricity Board feels that increase of women in certain branches like Civil Engineering merely shows that men do not prefer these branches as their first choice. She herself is a graduate in Civil Engineering from the Trivandrum Engineering College of the 1968 batch. She thinks that engineering field in Kerala has stagnated and men look for highly prestigious institutions and better courses outside Kerala. And that is the reason for more women to enter engineering. Prof. Seema of the Department of Civil Engineering of TKM Engineering College shares that opinion. She feels that men opt for other branches and so more seats are available for students with lower ranks in the entrance examinations. Women are seen to get lower rank in entrance examination. However their argument does not explain the higher ratio of women in disciplines like Information Technology and Computer Science. Moreover one sees a better performance by women in AIEEE[24] in recent years. Easier access to entrance coaching centres and material and parents' willingness to send girls to distant places for pre-entrance period training made a difference to their performance in this examination. And yet we have to agree that men students have more freedom of mobility when it comes to selection of institutions even within Kerala. Boys and men are more exposed to events and practices outside colleges and classrooms due to their mobility outside home.

This however brings us to the fact that despite increase in women's number in various disciplines, Mechanical Engineering has very few women ever since its beginning and its lack of popularity among women has not changed even now. An interaction with the students of Mechanical department and observation of laboratory and workshops in TKM Engineering College revealed that these physical spaces where most of the Mechanical Engineering practical aspects are taught are not really perceived as 'space meant for women'. Women, I observed, did not want to hang around after their workshops even in Civil Engineering department where women form a critical mass at present. However, I was told that the workshop attendants had a hard time asking men students to vacate the workshops after their allotted time is over. This is very much in line with the larger society's perception about the spaces that should be occupied by women. While the increasing number of women is definitely bringing in an acceptance of women as belonging to the college, the increase does not often translate into favourable gender relations within the college and classrooms. Thus my contention is that the hypothesis put forward by the 'critical mass theory' seems to have limited application here (See Gupta and Sharma(2002:902) for a brief discussion on this aspect).

Interviews indicated a mixed opinion about women's participation in Mechanical Engineering and workshops. This seemed to be a sensitive issue even among the students and they are aware of the very low number of women students in this department. It appeared that the images of disciplines within engineering as hard or soft and women's employability have an important role to play in their popularity among women. Mechanical has an image, undoubtedly, as a discipline that is not suitable for women. Despite the entry of new technology and modern equipments, Mechanical still maintains its image as a hard discipline and this image works against women entering it.

> *"One has to dirty one's hand when one is in the workshop and the kind of job one will do after the degree courses requires that one sweats and becomes untidy... Women cannot do all that...Physical exertion is inevitable...Men even when they are tiny (like me) they are still stronger physically in comparison to women... It is definitely easier for men... It is not that women cannot pass or do work as engineers after passing out in this branch... They can... but they prefer getting into teaching after they finish their studies..."*[25]

In my interviews women students were not vocal about their experiences in Mechanical Engineering workshops. They answered mostly in monosyllables. The question of absence of a 'critical mass' appeared here and I was told that there were not many women in Mechanical Engineering department and so they chose to return to hostel after their classes. They did not prolong their stay in the workshops or in the college. One student whom I could meet said they, as women students, did not face any problem in the workshop but she would have chosen electronics if she got it. Since she wanted to be in this college because this was nearer to her family, there was no choice.

> *"...I wanted to do Electronics...It is not that I do not like Mechanical Engineering... My father said that it was not meant for girls... but they did not want to send me to a hostel and so I decided to do my B.Tech. in Mechanical and will change over to computer after my graduation...Teachers say that since there are not many women in Mechanical, it may be easier to get a teaching job..."*[26]

Teachers maintain that there are choices even within the discipline of Mechanical Engineering where one can opt for design work or teaching where women face no problems. Following the discussions with students and teachers, it was clear that practical issues dominate women's minds when they decide not to take up

certain branches. Prof. Jyothi, Head of the Department of Chemical Engineering in TKM Engineering College says that though images are important more practical issues dominate the decision-making of women students. Chemical, for example, according to Prof. Jyothi, has immense potential in future job market within India and globally and its image has never been that of a subject that is hostile to women. But traditionally women Chemical engineers globally get a lower preference in job market in comparison to men and in Kerala it is even more difficult for women. She says that in Kerala companies do not prefer women when they conduct job interviews. They do not say overtly that they would not employ them but always cite reasons like lack of technical knowledge or lack of exposure to certain technical aspects as reason for not selecting a candidate they do not prefer. Kerala Minerals and Metals, a Public Sector Undertaking employing Chemical engineers, does not have even one lady engineer on its board and it is hard to believe that they could not find a woman engineer who deserved to be there.

Problem is that companies do not want to pay for the upkeep of women especially after factory laws passed by the government have made it clear that safety of women is the responsibility of the company. This means that women can be employed in the day-shift only and in many cases women leave the job once they marry and relocate. Women also do not want to do fusing work because that involves working with furnace. Pregnant women and menstruating women often find it difficult to collect samples in the case of 'ambient monitoring' in pollution measuring assignments. These issues can be overcome with adequate supporting system for women but that costs extra in comparison to the cost incurred on men.

Prof. Jyothi's experience shows that there are more avenues that do not limit women's choices outside Kerala than within, even after considering their biological and practical 'limitations'. She says that biological characteristics of women are not limiting in themselves but the way the practices and jobs developed favour men's participation. She says that all her women classmates who migrated to places outside Kerala reached top positions (non-teaching) in their places of work. She feels that women too act with a lot more self-confidence when they reach another place, away from Kerala. She feels that Chemical Engineering always attracted lesser women to its fold in comparison to Electrical and Civil due to the above practical issues though the former's image is not that of a very masculine discipline.

Group discussions with teachers of the Civil Engineering Department showed that there are clear cut understanding of gender role expectations of men and

women students from teachers, parents and even the non-teaching staff. They do not expect women to 'lose their femininity' just because they are in engineering colleges. And it is no wonder then that women students play by these expectations. At the same time a complaint very often voiced by Heads of the Departments and teachers who are in charge[27] of students' associations has been that 'girl students are indifferent'. They are described as 'learning by rote' which when put positively is described as 'sincerity' of women students. Classroom participation and discussions show that men dominate them. Women students are described as 'meek' and 'in need of constant push and encouragement' from teachers. Participation outside the classroom by women students too was perceived much less in comparison. Women are less active in the activities of professional associations like the student chapter of Indian Institute of Chemical Engineers. While the TKM College is proud to have received ENCON-2010 award for the best college in conducting activities for energy conservation and environmental protection, participation of women students in the ENCON Club is said to be minimum.

A Professor and Head of one of the Departments in the college who did not want to be identified told me that he makes extra effort to make sure that women students get elected as class leaders and representatives. But once they are elected he has to instruct them to do specific activities and no initiative is taken by women students. But on the other hand men students who are in charge of classes come up with ideas often and they are easier to work with. I understand from the observations that women students are expected to take initiative when they are asked to do and otherwise they are not encouraged to make any decisions on behalf of the class. I found that these students are only going by the expectations of the teachers. Students who take initiative in areas that are not expected of them are often described as 'over smart' by their teachers, fellow students and even the non-teaching staff. There are strict lines that divide the activities of women students that are encouraged and discouraged and in the case of men, these are more flexible. Only physical fights, any news of substance abuse and long absence from classrooms are taken serious notice and punished in the case of men. Lack of discipline by men students is frowned upon but women do face stricter expectations of submission to norms in comparison.

On the other hand, while feminine qualities are encouraged for girl students, their need for privacy (especially when they menstruate or feel unwell) is not understood as important. Facilities meant only for girl students are reported to have evoked comments that they are a waste of money. A senior teacher who persuaded the college management to construct a ladies' rest room in the campus for those who fall sick faced stiff opposition from a section of the faculty. She had

found that girl students and women staff did not have a place to rest and there were specific cases of pregnant and menstruating women suffering due to that. They used to be sent to someone's house or the nearest hostel. She said she could not convince the people in charge of finance that this was an important investment for the institution. Finally members of the upper body of the management had to be persuaded to divert the fund for this building. But a visit to the 'Ladies' Corner' with this teacher gave me the understanding that any policy decision favouring women students are not welcome. The teacher concerned told me that she had specifically asked for a bed or a 'divan' to be placed in the room and instead a huge table was bought. Now this table is not useful for women students if they want to lie down. This teacher very poignantly pointed towards the fact that the expectation of a woman to be an engineer sometimes deprives the women students of the facilities that they can avail in general colleges. This is an important point that, to my understanding, did not get enough attention from even other women teaching staff.

Summary and Observations

Data on enrolment and outturn show that there are positive changes in the number of women candidates in engineering in Kerala but these changes are limited to increase in numbers. Though this is important in the present scenario of engineering education, women have still not attained a level of parity with their male counterparts as women's participation varies according to the discipline and its social acceptability as suitable for women. It is clear that traditional branches like Civil, Mechanical and Electrical show much less rate of growth in comparison to the new ones like Computers and Electronics. New generation branches witness an increasing interest from women candidates and they are known as 'women friendly' branches also.

Privatisation and entry of private management have boosted the number of institutions and access to them has become easier. Interviews with students and teachers reveal that there are still pockets of prejudices against women entering engineering. Socio-economic location of the families – rural or urban, parents' education, main sources of income- and the opinion of the girls themselves make a lot of difference to the way girls enrol in a course. Periodic gender sensitisation of college staff including that of the teachers and students will prove to be beneficial for members of both the gender. Policy interventions play an important role apart from availability of courses in the colleges. Distance of colleges from their place of residence too plays an important role in the decision-making of women students. Tag or brand name has become an important factor that decides the choice of engineering disciplines and colleges.

Engineering Education in Rajasthan

"At the time of Independence there was no facility for technical education in the State of Rajasthan. As such the state had to (be) content with open competition and limited seats allotted to the state in institutions located outside the state. The programs for increasing the facility for technical education in Rajasthan was launched only after Independence."[28] The very first initiative in technical graduate level education was taken up by private sector around the period of Indian independence.

Table 8
Growth of Engineering Institutions (Graduate Level) in the State of Rajasthan

Year	No. of Engineering Degree Institutions	Type of Institutions
1950	1	Private
1960	2	Private and govt.
1970	4	Private and govt
1980	5	Private and govt
1990	6	Private and govt.
2000	23	Private, govt & pvt unaided
2006	48	Private, govt. & pvt unaided
2007	65	Private, govt & pvt unaided
2008	82	Private, govt & pvt unaided

Source: ATMR 2008, Nodal Centre, Rajasthan, NTMIS, IAMR

First engineering college for graduate degree was set up by private capital and initiative in Pilani and this is a Deemed University right now. Annual Technical Manpower Review of Nodal Centre Rajasthan marks the year 2000 as the beginning of the era of private engineering colleges. Nine private engineering colleges were opened during this year only. This last decade saw the expansion of degree level engineering institutions in Rajasthan mainly due to the setting up of private unaided colleges. The new models of private unaided colleges became the major players since the policy of privatisation of higher education sector started getting operationalised in the mid-1990s.

The following table shows the increase in the number of disciplines of engineering and students in various disciplines ever since more engineering colleges opened in the state of Rajasthan.

Table 9
Actual Admissions of Engineering Degree Courses in the state of Rajasthan

Discipline	1991	2000	2001	2002	2003	2004	2005	2006	2007	2008
Agriculture	50	47	50	47	52	46	34	34	44	50
Architecture	30	81	131	135	127	130	157	161	187	150
Automobile	-	-	-	--	-	92-	134	142	73	88
Bio-Medical	-	-	--	--	-	60-	2	72	47	36
Bio-Technology	-	-	--	149	148	156	143	185	168	186
Ceramic	-	-	--	--	--	--		--	54	66
Chemical	75	118	127	121	121	150	134	129	170	181
Civil	275	225	235	288	327	348	397	381	893	1225
Computer	20	1172	1364	1882	2197	2300	2714	2811	4720	6671
Dairy	-	-	--	--	-	25	26	24	23	28
Electrical	175	569	817	1045	1556	1338	1457	1601	2380	2920
Electronics	203	1020	1226	1533	2408	3090	3470	3778	5545	6888
Eng. &	-	10	9	13	8	9	7	9	10	10
Electrical & Electronics	85	112	116	85	96	96	92	98	95	100
Food	-	-	-	36	30	74	60	78	43	39
Information System	-	35	58	40	49	50	51	50	50	53
Information Technology	-	420	1141	1369	973	1148	1537	1811	3349	4673
Instrumentation	20	184	208	314	479	529	503	592	656	712
Industrial Engineering	--		-	--	--	57	4	--	17	--
Mechanical	235	406	459	639	1112	1382	1548	1717	2187	2834
Metallurgy	50	50	47	49	35	49	48	50	53	60
Mining	40	60	59	57	59	50	44	39	58	52
Production Engineering	20	82	96	78	72	59	60	54	55	57
Textile	-	-	--	--	--	--		--	33	40
Textile	-	20	18	19	20	20	20	19	40	40
Textile	30	60	57	57	60	60	60	60	80	86
Total	**1308**	**4671**	**6218**	**7956**	**9929**	**11318**	**12702**	**13917**	**21013**	**27245**

Source: ATMR2008,NodalCentre,Rajasthan.

Just as in the case of Kerala's engineering colleges, number of disciplines increased in the last decade starting in the year 2000. Many new disciplines started their entry into these colleges in line with developments in the international engineering education syllabus. Executive Director of Birla Institute of Scientific Research (BISR) (Mesra), Jaipur Campus spoke about this at length and concluded that

this was the result of higher demand from students due to job opportunities available for the graduates in these disciplines. He thinks that this is a good sign and shows that Indian engineering field is responsive to the developments in international educational arena and job market[29]. In 2000 number of disciplines was 18 and the number of students taking admission was 4671 while in a rather short period of 8 years the number of disciplines increased to 28 and the number of students to 27245.

Table 10
Distribution of Actual Intake into Degree Courses by Gender and Discipline in Rajasthan

Discipline	1996 batch*			1998 batch		
	Women	Men	Ratio	Women	Men	Ratio
Agriculture	0	68	1:0	1	29	1:0.03
Architecture	5	12	1:0.42	6	36	1:0.16
Automobile	-	-	-	-	-	-
Bio-Medical	-	-	-	-	-	-
Bio-Technology	-	-	-	-	-	-
Chemical	13	70	1:0.19	5	87	1:0.06
Civil	18	178	1:0.10	14	194	1:0.07
Computer Science	14	108	1:0.13	26	136	1:0.19
Dairy Technology	-	-	-	-	-	-
Electrical	13	166	1:0.08	10	120	1:0.08
Electronics	10	141	1:0.07	15	91	1:0.16
Engineering & Technology	5	13	1:0.38	2	12	1:0.17
Electrical & Elect. (E & E)	18	94	1:0.19	21	100	1:0.21
Food Technology	-	-	-	-	-	-
Information System	4	20	1:0.2	8	22	1:0.36
Information Technology	-	-	-	-	-	-
Instrumentation	6	61	1:0.10	19	59	1:0.32
Mechanical	11	238	1:0.05	3	249	1:0.01
Metallurgy	0	43	1:0	4	38	1:0.11
Mining	0	34	1:0	0	30	1:0
Production Eng.	0	50	1:0	3	46	1:0.07
Textile Chemistry	-	-	-	0	8	1:0
Textile Technology	-	-	-	1	11	1:0.09
Total	**118**	**1311**	**1:0.09**	**140**	**1303**	**1:0.11**

contd...

Discipline	2000 batch			2002 batch		
	Women	Men	Ratio	Women	Men	Ratio
Agriculture	3	28	1:0.11	6	36	1:0.17
Architecture	13	13	1:1	5	12	1:0.45
Automobile	-	-	-	-	-	-
Bio-Medical	-	-	-	-	-	-
Bio-Technology	-	-	-	-	-	-
Chemical	23	64	1:0.36	24	72	1:0.33
Civil	18	146	1:0.12	26	162	1:0.16
Computer Science	31	132	1:0.23	99	167	1:0.59
Dairy Technology	-	-	-	-	-	-
Electrical	17	154	1:0.11	47	207	1:0.23
Electronics	35	84	1:0.42	81	198	1:0.41
Engineering & Technology	3	7	1:0.43	2	6	1:0.33
Electrical & Elect. (E & E)	28	104	1:0.27	28	80	1:0.35
Food Technology	-	-	-	-	-	-
Information System	3	31	1:0.10	21	19	1: 1.11
Information Technology	-	-	-	-	-	-
Instrumentation	1	68	1:0.01	17	100	1:0.17
Mechanical	7	267	1:0.03	8	296	1:0.03
Metallurgy	3	21	1:0.32	4	27	1:0.15
Mining	0	46	1:0	0	40	1:0
Production Eng.	1	36	1:0.03	1	48	1:0.02
Textile Chemistry	0	31	1:0	1	6	1:0.17
Textile Technology	4	34	1:0.12	2	53	1:0.04
Total	**192**	**1253**	**1:0.15**	**372**	**1529**	**1:0.24**

contd...

Discipline	2008 batch		
	Women	Men	Ratio
Agriculture	8	33	1:0.24
Architecture	36	31	1:1.16
Automobile	0	31	1:0
Bio-Medical	6	15	1:0.4
Bio-Technology	12	42	1:0.29
Chemical	44	95	1:0.46
Civil	103	263	1:0.39
Computer Science	749	1571	1:0.481:0.23
Dairy Technology	6	16	1:0.36
Electrical	266	863	1:0.31
Electronics	588	1669	1:0.35
Engineering & Technology	3	7	1:0.43
Electrical & Elect. (E & E)	40	148	1:0.27
Food Technology	8	34	1:0.24
Information System	23	53	1:0.43
Information Technology	378	651	1:0.58
Instrumentation	60	381	1:0.16
Mechanical	194	839	1:0.23
Metallurgy	8	32	1:0.14
Mining	0	30	1:0
Production Eng.	10	27	1:0.37
Textile Chemistry	2	17	1:0.12
Textile Technology	6	43	1:0.14
Total	**2550**	**6891**	**1:0.37**

**this is the first report on the state of Rajasthan in which outturn of students is given by gender and discipline.*
Source: ATMR, Nodal Centre, Rajasthan, NTMIS, IAMR.

Ratio between men and women students as shown in the table above is far from satisfactory though has increased over the years. Disciplines like Civil, Chemical, Electrical and Electronics display a consistent increase in ratio over the years. And Information Systems, Information Technology, Computer Science and such new disciplines show a better ratio of women though there is no sign of parity in the coming years between men and women. Similarly outturn at the degree level in engineering colleges in Rajasthan shown in table 11 below also shows

increasing trend in the number of women students. Ratio of women to men who pass out has increased since the year 2000. However this increase is not very high as in the case of intake. In comparison to the data on Kerala the ratio is well behind though in the case of Mechanical Engineering both states show the same kind of trend.

Interviews were conducted in Birla Institute of Scientific Research(BISR), (Mesra) Jaipur Extension Campus and Malaviya Institute of Technology(MIT), Jaipur. Birla Institute of Scientific Research was established in 1995 in Jaipur 'with the objective of providing quality education through innovative programmes & practices'. The Jaipur Campus, like other centres functions under the academic guidance of the parent University at Mesra, Ranchi. MIT is one of the oldest campuses and engineering colleges in Rajasthan. While MIT is one of the oldest colleges in Rajasthan and has all the disciplines and courses, BISR is one of those colleges which, according to the placement officer[1] 'run programmes according to the demands of the society'. As mentioned earlier, Executive Director of BISR, Mr. P. Ghosh, is also emphatic that the 'new age colleges' fare better than the old one. Job market demands certain skills that are provided by institutes that focus on these skills. He says that these new institutions also have better gender ratio. This, he says, can be attributed to the nature of disciplines as well, that is, how a discipline is perceived by the candidates. He thinks that women do not have any physical disadvantage but they are 'socially disabled' when it comes to certain disciplines. For example, he says, working culture in an automobile factory full of male workers is culturally difficult and even impossible for women engineers to manage. It is not that they need to use a lot of physical strength now. Even in Mechanical Engineering department computer managed designing is used. But "in my experience girls find it difficult to tackle low skilled workmen. In turn workers find it difficult to take orders from girls…" He found in his long career in the higher education sector that it is basically social prejudices that work against girls; engineering is no different.

The Director and the TPO, Mr. S. Thampi pointed out that there will not be any gender specific data available with the college. This was also an issue raised by Dr. Suresh Babu, Principal, TKM Engineering College, Kollam. Mr. Thampi thinks that it is not fair to ask about the gender as the college should treat both the gender the same way. However he asserts that at the time of admission the college favours women. The University of Mesra has a policy of positive discrimination towards women students, he adds. BISR, under the University, follows a policy of 20 per cent reservation of girls in normal merit category[2]. Weightage given to plus-two marks (PCM-Physics, Chemistry and Mathematics) is 80 per cent while AIEEE is given a weightage of 20 per cent. Scheduled Castes

and Scheduled tribes get a reservation of 7.5 and 15 per cent respectively. After admission, however they are students and not women or men or SC and ST. In line with the new trend Business Administration courses are also run by the institute to supplement the engineering degree.

Interview with students revealed that a substantial percentage of the students are migrants from other states including Southern India. Though higher proportion of migrant students is boys (and not girls) in this institute, girls also come here from other states. While there are boys from Southern states, at present there are no girls from these states. Ratheesh who hails from Karnataka says that girls are not coming from southern India because the institute does not have its own hostel[3]. Boys can manage better than girls, says Nimisha, a first year BCA student from Jhansi, Uttar Pradesh, when accommodation is not offered by the institute. She stays in a Paying Guest (PG) arrangement that is approved by the institute. Distance between the institute and the hostel is covered by walking. The distance is not an issue and does not bother her but she feels that a hostel provided by the institute could have been a better solution. She felt that many more girl students would have taken admission in various courses if there were hostel facilities.

Shelly, a 20 year old student of Electronics from a nearby village of Bhopal, Madhya Pradesh said that she did not get any advantage because of the 20 per cent reservation for girl students but lack of hostel facilities does bother her. There is no concern of safety in the PG accommodation but privacy and space available to individual student are areas of concern there. She also feels that high fees paid by students are not compensated by the reservation policy. Fees structure should be made more student-friendly. That is the best way to attract women students. Review of literature on women and science suggests that families in India are more willing to invest in their sons' education than in their daughters (Mukhopadhyay 1994:103-32). Any type of fees concession might make a difference especially in a state like Rajasthan where women's higher education is still not a popular issue. Deepika who hails from Bharatpur in Rajasthan, says that her family sent her away to study after much fight. She wanted to study in a prestigious university outside Rajasthan but her family was not willing to send her. She spent a year preparing for entrance examination and trying in vain to make her family permit her move away from Rajasthan. She feels that her career will not take off if she does not move out of Rajasthan preferably to a metro like Bangalore or Mumbai. She felt that her parents were not interested in sending her for studies outside Rajasthan because they still have a 'small-town mentality'. This according to her works against girls and not so much against boys. Her father is employed in a bank and he knows the value of earning for oneself but he does not want his daughter 'to study to earn' but wants her to

marry into a good family. Since engineering degree will be a good investment while seeking alliance to a family with liberal values her father agreed to send her to Jaipur the nearest big city and capital of Rajasthan.

Madhuri Sinha, Head of the Department of Computer Science feels that there is some truth in Deepika's story but is not ready to generalise on the status of educational decision-making of girls in Indian families on that basis. She says that much of it depends on the nature of the family, exposure that the family had in the past and its economic status. If the family has limited resource that it has to share between the education of its son and daughter, son most probably will get the preference. She feels that it is because a man without education and employment is looked down upon by the society while a woman has a choice of getting married to an earning man. According to her there have been a lot of changes over the last 20 years in women's education in science and technology. She thinks that though there is a lot more to change in enrolment pattern, women who come to study want to have a career for themselves. She finished her Bachelor's Degree in Computer Science in 1989 in the women's university of Banasthali. She thinks that the idea of women's university and college still are relevant in the minds of the rural population despite the change in the mindset ever since profile of women's job and job environment have changed.

As a teacher she experienced that first priority at the time of the admission of their son and daughter to colleges is spelt differently by parents. Parents say that safety is their concern when they admit girls while they say that they are concerned about the quality of education in the college when they admit the boys. These in a sense indicate what the parents are looking for in the lives of their sons and daughters. Parents from metro cities however most often show a different mentality. There is a reverse migration from metros like Delhi to smaller cities like Jaipur and when they visit the colleges they make it clear that they are looking for quality of education for girls and boys though safety still is the first consideration for girls.

Teachers in a group discussion in the Department of Electricals at MIT felt that brand and tag matter a lot in educational sector. Parents do risk social respectability and send their girls to institutions like IITs if the girls get admission. But the question is: Do the parents invest enough to prepare the girls in getting admissions in such institutions? Discussions suggest that an open-minded approach to this question is still limited to a section of parents among the elites and metro-urban population. Students in the Civil Engineering Department whom I could gather for a group discussion in MIT felt that if job is forthcoming for women, there will be changes in the ratio of men and women in favour of the

latter in engineering. Another issue, they felt, is that women also do not prefer to work in an industry or shop floor[4] but prefer teaching jobs in colleges or universities. There are limited opportunities here and therefore women are unemployed even after possessing a degree. Vinod says: "They(women) want a job with 9-5 timing..." Deepa who was listening to this agrees and says that she will also want a job where she has to be present by 9 am and can leave at 5 pm. She thinks that a job where travel is involved is for men.

This perspective though rooted in the social reality does not take into account the fact women demand '9-5 jobs' because of social perceptions. Gender roles demand that women are back from colleges and offices by evening to attend to their family responsibilities. It can be assumed that if women do not have to take care of the family and are free from childcare responsibilities, they would most probably behave differently in their professional lives. These are the costs they pay for being 'women in our society'. The understanding that the existing patriarchal system compels women and men to behave in certain ways is completely missing in the discussions. Childcare and family responsibilities are seen purely as women's responsibilities.

Summary and Observations

Data on enrolment and outturn in Rajasthan show that there are positive changes in the number of women candidates in engineering but these changes are very marginal and minimal. Present scenario of engineering education shows that engineering is still not women's area. Participation of women, like in Kerala, varies according to the discipline and its social acceptability as suitable for women. Traditional branches like Civil, Mechanical and Electrical show growth in the number of women participating in them but there is much to catch up in comparison to other states like Kerala. New disciplines like Computer Science and Electronics present an increasing interest from women candidates.

Privatisation and entry of private management have boosted the number of institutions and access to them has become easier. However many of the students who enrol are from places outside Rajasthan. Interviews with students and teachers reveal that migration to the state is an important aspect of this trend. Migration to Rajasthan for education has to be studied in detail to understand the dynamics of growth that is presented above in tabular form. This is especially relevant because of institutions like BITS Pilani which is known all over India for high educational standard. Socio-economic location of the families, aspiration of students and job opportunities are counted as the most important factors that determine the decision-making of women students.

Women in Engineering Education: Findings and summary

Engineering played an important role in the discourse on national development in post- independent India. This development discourse has been a highly masculinised discourse where 'men matter'. Engineering in the post-independence India unlike in the west did not officially have a history of discrimination against women. There have never been written rules stopping women from entering the institutions of engineering education. India does have an egalitarian constitution and a legal system to make sure that women are not ill-treated anywhere in the name of their biological sex. Despite all these advantages, a visit to a few classes in engineering colleges in the two states of the country-Kerala and Rajasthan-gives a picture of unequal participation of women in comparison with men. One realises that engineering and the space occupied by it are gendered. Gender neutral principles only help reinforce and perpetrate the already existing gender prejudices in the classrooms and wider society. It is also important to understand that the gender neutral, egalitarian values of the educational institutions that are meant to give an atmosphere of equality for women and men students are not sufficient in themselves. After all these institutions are part of the society that practise norms and customs which do not treat men and women at par.

Interventions for improving the participation of women in the development framework in India have been based broadly on concerns for democratic social relations and feminist approaches. Though there is no visible organised opposition against women entering science and technology in states like Kerala, social prejudices and hostility at an individual level often act as stumbling blocks against women's equal participation in engineering. Informal glass ceiling, organisational culture and institutional traditions that favour men in the system act adversely against women. The fact is that various actors, parents, students themselves, teachers and employers might not even be aware of many of the systemic biases against women. Such programmes and institutions are structured by men and as a result have serious limitations in letting women be active agents and sometimes even in accommodating women. Women have been absent from the development and design of these establishments and their viewpoints are missing from their planning.

Helen Longino of the Department of Philosophy, Stanford University[5] says that the Feminist science studies in the West emerged initially from three concerns: the paucity of women in scientific fields, the persistent use of putative biological considerations to justify gender inequality, and the lack of attention to women's issues in health and social sciences research. It soon became clear to some feminist scholars that a deeper analysis of the structure of scientific knowledge

and of scientific institutions was required to make progress in developing scientific research that was inclusive of, rather than inimical to, women's interests. Likewise in India the ideal of inclusive growth has been used by academics to include marginal groups in the development process and yet the theoretical stimulus for studying women and gender has come mainly from feminist discourse in the west, especially from English and American tradition.

'Add women and stir' strategy has been the most common approach of the government projects and educational programmes towards making an all-inclusive policy towards women. Such additive approaches made unrealistic predictions about the participation of women and their development. Such projects thrive on tokenism and in fact this is a major challenge and has to be kept in mind while undertaking elaborate studies on women in engineering. National level frameworks and policy interventions are essential to promote gender equality and to assure standardisation. However, local practices and implementation matter at the end of the day as the most important factor making immediate impact in the community.

Specialisations within engineering and technology are gendered to different degrees. This is true of both Kerala- which made considerable progress in the entry of women into engineering and Rajasthan-that is still struggling with the enrolment of women into any kind of educational institution. Enrolment still is an issue in many parts of our country and that has to be noted. One important characteristic of engineering subjects has been that it is seen as one subject whereas various specialisations within it are actually seen as subjects with masculine and feminine qualities. This is why a disciplinewise analysis of enrolment becomes important. Cultural expectations play an important role in the entry of women in various disciplines. For example, women are not 'expected to do well' in Mechanical Engineering during or after the studies. It is widely known that labour market for Mechanical Engineers does not welcome women, and then how many women will enter this specialisation?

Interlinkage between labour market and subject choice has emerged as an important indicator of the future trend. Connection between labour market and subject choice may look farfetched at the outset but interviews with teachers and students reveal that the latter actually try to assess their labour market chances before taking a decision on the specialisation. This is the most important factor in the decision-making of students and preferences based on aptitude are also reported as important after job opportunity. Families play an important role in the decision-making as well. Women students reported that they actually try to foresee at the time of marriage whether they and their future spouse will be

able to work together and take care of the children in future in the event of an absence of support from their families.

Differences in the rural urban pattern are an important factor especially in Rajasthan. Kerala seems to have a rural-urban continuum and the gap between rural and urban areas is comparatively less. Despite the fact that urban and rural India are two different worlds, there is definite perception of India as moving forward in technology and the 'IT revolution' has changed India's image as 'backward' as well as the image of engineering. The connection with labour market and subject choice is evident in the initial rise and then the stabilization of demand for IT among students. It is important to note that women as a group benefited from the introduction of IT. Data from Kerala show a consistent rise in the number of women students and very high ratio in favour of them in IT. This industry has, for some time now, been moving away from basic skills to knowledge-centric hiring and is thought to have contributed to a higher number of women entering master's programme[66] The demand-supply gap at the entry level is closing and increasingly specialised talent through a master's programme or a doctoral degree is welcomed.

In conclusion, image of engineering as 'all-man career' has changed among the general public. Much of the credit goes to Software Engineering where women outnumber men in states like Kerala and urban centres. The representation of the skilled personnel called engineer has changed as that of a man in a construction site to one fashionable man or woman sitting in front of a computer, having expressions of serious thoughts on his/her face. However are engineers gender benders? Just like in any other profession, there cannot be any stereotyped opinions about them also. Engineers whom I met for this study do not seem to do anything extraordinary when they are confronted by the societal expectations of adhering to traditional norms of femininity and masculinity.

So has Indian engineering changed? Is it only IT as we get to hear a lot about the Silicon Valley of India and a lot of news in international press about IT revolution in India? With the prominence IT got, Indian engineering seems to have moved on from being backward to a matured level. But what happens to the other engineering specialisations? What happens to gender in engineering? What happens to the new hierarchy within the technological realm? What has been the strategy of Indian state for engineering development? Where does the role of women's college have come in? And what has it achieved?

Cultural stereotypes remain consistently obtrusive though their forms change in the field of women's engineering education. Biological determinism seems to

have given way to 'cost-benefit-analysis driven' argument against employment of women in sweatshops and shop floors. In short, notions of masculinity and femininity are getting contested at least in certain quarters but in the name of practicality and not for ideology of equity and equality or in favour of social change. That means that these contestations will not enter into the society as an ideological change anytime soon. This will be a gradual social change that may take centuries in societies like Kerala. Women and men are renegotiating their gendered roles without making any major change in the present system.

Suggestions for further study

1. Enrolment and outturn are still important issues. Data available on them have to be probed thoroughly.
2. Migration of students-genderwise- across states and regions will give an important insight into their mobility or lack of it.
3. More in-depth understanding of issues on classroom participation and participation in immediate community.
4. Practical implications of balancing equality with special needs. Eg. Need to have a ladies' rest room without undermining their right to equality in the educational institution.
5. Curriculum flexibility- availability of different electives.
6. Residential campus is also rated as contributing to students' lives in terms of their studies and all-round development.
7. Policy interventions including that of women-only educational institutions. Participation and facilities and encouragement of students for GATE, CAT etc is an indication of competitiveness of the place.
8. Alumni association.
9. Campus recruitment and potential employers.
10. Interlinkages between education and labour market. Expansion in private sector in education and employment sectors.
11. Role of families in decision making in engineering education and types of investment and opportunity cost incurred by the families.

(Endnote)

[1] So far studies either 'add women and stir' or exclude women altogether. On this aspect one can read Harding, Sandra 1995 Just Add Women and Stir? In Gender Working Group, UN Commission on Science and Technology for Development edited Missing Link Gender Equity in Science and Technology for Development, New York: UNIFEM, pp.295-307 for an interesting discussion on the methodology of studying women.

[2] This edited volume gives insights into the development of engineering in predominantly a western context and how gender shapes and reshapes the meaning, theory and practices of engineering in those contexts.

[3] Most of the studies like that of Parikh and Sukhatme, Kumar and Gupta are done in government institutions and/or are also financially supported by government agencies.

[4] I thank the nodal centres of Kerala and Rajasthan situated respectively at Cochin University of Science and Technology, Kochi and Malaviya Institute of Science and Technology, Jaipur for providing me the data required for this study.

[5] There are three types of institutions at present in Kerala categorised according to the source of funding and management- government institutions, private-aided and private unaided or self-financing institutions. The last one is the product of the present wave of privatisation of higher education.

[6] Interview with E. Sreedharan, Director, Delhi Metro Rail Corporation, Times City, Times of India, 19 January 2011, pp.4 was an interesting recent sample of the discourse on national development and its relation with the availability of engineering personnel. Similarly newspaper reports talk of shortage in supply of engineering skill in India. For example S.Choudhury reports that 20 per cent of engineers in the country are without jobs in The Hindustan Times, November 8 2004, pp. 6.

[7] This is a short and yet interesting foreword 'Musings about the Woman Engineer as Muse' to the book Crossing Boundaries and Building Bridges: Comparing The History of Women Engineers 1970s-1990s edited by Ruth Oldenziel, Annie Canel and Karin Zachmann, Routledge, London, 2004.

[8] Kumar et al divides the history of higher education in India into two periods: from Indian independence to the 1990s and from 1990s till the present. Pattern of Enrolment at Different Educational Level, India: Science and Technology 2008,NISTADS, New Delhi, 2008, pp3-7. This periodisation is very relevant for technical education and especially engineering. See http://www.nistads.res.in for extended summaries given in the report.

[9] Kumar et al, Pattern of Enrolment at Different Educational Levels, pp.28 in http://www.nistads.res.in

[10] Kumar, Neelam Gender and Science, India: Science and Technology 2008, http://www.nistads.res.in

[11] Taken from the title of the news item 'Women engineers a crack in academic glass ceiling' from pp.10 of The Hindustan Times, 11 January 2011.

[12] Figure 8, Percentage enrolment at Graduate level in Engineering degree and Polytechnics, in Kumar et al, Pattern of Enrolments at Different Educational Levels, http://www.nistads.res.in

[13] Thankamma Thankachan reports that the first woman who obtained engineering degree was in 1892, Distribution of Employed Engineers in India during the Post-Liberalization Period (By State, Sector and Discipline) Research Report 1/2007, Institute of Applied Manpower Research, New Delhi, pp.3.

[14] However this breaking of the image is selective and not applicable to engineering as a whole. Moreover as a news report on sexism in technology world in the United States of America indicates 'women are out of the loop in Silicon Valley' when it comes to the top posts in the

companies that include the Chief Executives. Though women are increasingly entering the computer world, barriers prevent them from reaching the level of top management in the companies.See, Deccan Herald, 9 June 2010, pp.1.

[15] Kerala was lauded for its equitable growth that emphasised land reforms, poverty reduction, access to primary healthcare and primary education. Amartya Sen argued that Kerala's experience and achievements in social, economic and political fields through education has been spectacular and the rest of India had much to learn from it. However feminists have been the fiercest critics of the discourse that praised Kerala as a state with high status for women. It has been well argued that Kerala women face very high incidence of domestic violence, sexual harassment in public space and gender seclusion has been reported to be high as well. However participation of women in higher education has been commendably high.

[16] P.P. Parikh and S.P. Sukhatme, Women Engineers in India, IIT, Bombay,1992. Their analysis use data on enrolment in engineering colleges, out-turn, job opportunities, career status and other factors. Responses of women engineers and employers on perceptions and barriers collected through mailed questionnaires have also been analysed. They find that though there has been a significant increase in out-turn of women engineers, their prospects of employment and career advancement profiles remain matters of concern.

[17] This institution specialises in mining and is an all-male institution.

[18]This is TKM Engineering College. This report relies heavily on the feedback given by students and faculty of this college to my questions during interviews.

[19] Annual Technical Education Review, 2008, Nodal Centre, NTMIS, IAMR, Kerala, pp.9.

Fee structures are different in these colleges. Government colleges and private aided colleges charge the same fees while private unaided colleges charge fees almost seven times higher in comparison. Government fixes the fees of all these institutions from time to time.

[20] Mr. Viswambharan Nair, parent of Mr. Santosh V.S. in third year B.Tech who was visiting the college for a meeting with the faculty of Civil Engineering Department.

[21] 50% in Mathematics and 50% in Mathematics, Physics & Chemistry put together in Higher Secondary Examination(Plus Two) for candidates who are not eligible for any reservation, 45% in Higher Secondary Examination for Other Backward Classes and 40% in Higher Secondary Examination for Scheduled Castes and Scheduled Tribes.

[22] Interview with Prof. Gauri Antarjanam, Department of Civil Engineering, TKM Engineering College, Kollam. A teacher, who did not want to be identified in the Department of Mechanical had the same opinion though he thought that these disciplines are going to be merged with the traditional disciplines in future rather than them going to stay in the field in their own right.

[23] Electronics has changed its permutations and combinations several times over the last decade and this is in response to the developments in the industry and international engineering education syllabus.

[24]All India Engineering Entrance Examination

[25] Jyothi Krishna, Second Year Mechanical Engineering Student.

[26] Maya, a day scholar, whose father is an engineer and works with a public limited company, also does not want to stay in a hostel. One of the teachers mentioned that initially they tried to counsel her into going to Trivandrum to get into her favourite subject.

[27] The very idea of a member of faculty being put in charge of students' associations rather than letting the students conduct their affairs independently shows the extent to which students can 'take initiatives'. This arrangement works on the basis of the understanding that the students will take suggestions from the teacher and do the basic coordination of activities and organisation of events by running errands. This might have been inevitable in the initial years but the aim should be to train students to develop the capacity to run these associations on their own.

[28] Annual Technical Manpower Review 2008, Nodal Centre, Rajasthan, NTMIS, IAMR, pp.3.

[29] On the contrary, teachers in the Civil and Mechanical Engineering department in TKM College, Kollam, Kerala said that the new, emerging disciplines are like bubbles. They thought that the students, of late, went after money and high salary ignoring a career for them in good companies. One of them says that there is some hope as increasingly students are realizing the harm done to them by this decision and the traditional branches will win back their popularity.

[30] Placement Officer is called TPO or Training and Placement Officer. This officer is in charge of all the non-academic and administrative issues like monitoring the attendance of students and at the same time also academic dimensions of campus placement of students.

[31] Mr. Thampi says that the management has adopted a policy of 'uplifting women' in a country like India through these measures.

[32] Institute is expanding as one can see from the work on physical infrastructure that is going on in the campus.

[33] This reminded me of a casual remark by one of the teachers in the Chemical Department in TKM. He said that many of the industries do not employ women because it is inconvenient for men to work in the same area. This has recorded parallels in the past in educational institutions. Boel Berner discusses the 'distracting effect women would make to the male students if the former are admitted' was discussed in Sweden in 1893 in Swedish Royal Institute of Technology. Educating Men: Women and the Swedish Royal Institute of Technology1880-1930, in Annie Canel et al (eds.) Crossing Boundaries, Building Bridges Comparing The History of Women Engineers 1870s-1990s, pp. 81.

[34] From her presentation on women and science in the west at India International Centre-Annexe, New Delhi, December 24, 2010.

[35] Informal discussions with Tata Consultancy Services training centre employees, Thiruvananthapuram, Kerala.

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Times City 2011 Interview with E. Sreedharan, Director, Delhi Metro Rail Corporation, Times City, Times of India, 19 January, pp.4

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