

How to Improve Enrollment of Women in Engineering: Lessons Learnt from the Developing World

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Abstract

Previous research on international variation in women's participation in undergraduate engineering education suggests that there are several *necessary preconditions* that must be met in order for there to be relatively high enrollment and subsequent employment of women in the field. In addition, there are *facilitating conditions*, which support women's participation in engineering venues. This research focuses on engineering enrollment in Kerala in India. Kerala has seen higher enrollment of women in engineering for a decade or more. This study examines the cultural, political and social aspects that have made engineering enrollment in Kerala reach levels that are rarely seen in the United States or the Western world, and assesses how the social, cultural and political aspects of the region can create the preconditions and facilitating conditions necessary for higher enrollment of women in engineering. The study will also focus on lessons learnt from this region of the world, which can be adopted in other countries to improve the enrollment of women in engineering. The paper also describes a study which is currently underway among female engineering graduates in Kerala which will contribute to understanding the role of cultural, social and political factors in the high enrollment of women among Kerala's engineering students.

Introduction

To improve enrollment of women in engineering, it has been shown that there are some *necessary preconditions, which must be present, and additional conditions, which facilitate* women's enrollment in engineering. The necessary preconditions include opportunities for education, access to education and acceptance of women in education and in the labor force in this profession^[1,2]. The facilitating conditions that are required are a high gender ratio, motivation on the part of the female population, self-confidence, and a good childcare infrastructure that assists women in pursuing employment in fields such as engineering. In this paper, it will be shown that when most of these factors come together, the enrollment of women in engineering can be significantly improved as for example in Kerala, India.

Kerala is the southern most state in India (Figure 1). It has an area of 15,005 sq. miles [38,863 sq. km.], about one percent of the total land area of India. The state stretches for about 360 miles along the Malabar Coast on the western side of the Indian peninsula; its width varies from 20 to 75 miles. It is bordered by the states of Karnataka in the north, Tamil Nadu to the east and

the Arabian Sea to the west. The state has 14 districts and the capital is Thiruvananthapuram (Trivandrum). It is a region of heavy rainfall during the summer and winter monsoons, and has more than 40 streams and rivers that originate along the crest of the Western Ghats and flows westward into backwaters and the Arabian Sea. It also has tropical vegetation, and an abundance of rice fields and coconut groves. Aside from its natural beauty, it has been touted as a model by the country and internationally for social development. The purpose of this paper is not to remark on the exclusivity of Kerala in the developing world but to try and draw lessons from the experiences in Kerala for other developing and developed countries. Kerala's population according to the 2001 census was 31,838,619. The religious distribution of the Hindus, Muslims and Christian population in the state is in the ratio of 57:23:19.



Figure 1: Indian States ^[3]

Necessary Preconditions

Opportunities and access to education in Kerala

Kerala has the highest literacy rate for any state in India. The State has an average of 90.92 per cent literacy, against the national average of 65.38 in India and compares well with most developed countries. There is little difference between male and female literacy rates, unlike the rest of India, which has greater disparity between the genders and lower literacy rates overall. A feature of Kerala's development performance is that there are no great disparities between achievements in the urban areas and rural areas. The absence of great disparities is because public policy is so targeted; this has been also aided by the geographical distribution of towns and villages. The distinction between towns and villages are less sharp leading to a "rural-urban continuum" commonly referred to as "rurban" in Kerala ^[4].

Table 1: Adult Literacy Rates (Indian Census data, 2001)

	Persons	Males	Females
India	65.4	76.0	54.3
Kerala	90.9	94.2	87.9

Drèze and Sen ^[5] have attributed Kerala's achievements to public action. In Kerala, the action of mass organizations and mass movements against social, political, and economic oppression and the policy actions of the governments have been the most important constituents of public action. Enlightening public discussion in Kerala clearly has had a considerable role in creating a cultural atmosphere that has acted against the gender bias in the family, and it also seems to have played an important part in challenging social inequalities without necessarily involving the agency of the government. The social development has taken place despite conditions of low-production growth; Kerala faces an acute crisis of unemployment and material production. Unemployment in Kerala is 20 per cent right now and 35 per cent among the 15-29 year olds ^[5].

Kerala is part of a democratic India. It has also seen more leftist governments in power than any other state in India except West Bengal. The left forces ascended to power in India in 1957 and since then the politics of the state have oscillated between the Congress Party and the Communist Party of India. Universalization of education along with regulatory measures to check unhealthy commercialization practices was a major policy pursued by the state governments. The high literacy and educational levels attained by the state have been attributed to several factors including some of the socio-economic factors discussed above. In addition, social reform movements that started at the beginning of the 20th century, awakening of nationalist consciousness, and the advances in the mobilization of the working class and peasantry brought education to the fore of the agenda. The rise of democratic forces in the middle decades of the twentieth century caused an acceleration of educational progress. This resulted in a rapid increase in the literacy rate, especially among women. In addition, the education funding in Kerala is derived less from federal or state funding as compared to most other states. Kerala also offers more choice in primary and secondary education than most states by providing a voucher system. This has also enhanced the quality of school education tremendously ^[4]. Another important factor that emerged at a later stage was the incentives provided by the job opportunities within the state, in other states of the country, and abroad. This has also influenced the higher female enrollment in engineering.

Women's status

Among most of the Hindu population in Kerala, a matrilineal system of inheritance was followed, with some communities even being matrilineal. The matrilineal system was an enormous influence on social and cultural development in Kerala. It contributed to achieving a more equal society in terms of health care and education. The lesson to be had here is not that

achievements of the educational levels that people of Kerala have acquired requires a system of matriliney, but that a precondition for health and demographic transitions is a progressive social attitude towards female survival and education.

Facilitating Conditions

High gender ratio

Kerala has retained its pre-eminent position in the gender ratio, i.e., the number of females per thousand males in India. The proportion of female to male population is 1058 per 1000 in the 2001 census, while the national average is 933^[6], and compares well with the gender ratio in developed countries. The infant mortality rate in Kerala is the lowest in the developing world^[7].

Enrollment of women in engineering

Female enrollments in engineering have been increasing since the 1960s and have reached a plateau since the 1980s. The percentage of women in engineering in Kerala as compared to the United States is shown in Table 2.

Table 2: Female Enrollment in Engineering

	Women Enrolled in Engineering	Men Enrolled in Engineering	% Women in Engineering
Kerala*	6764	15511	30.4
India*	93279	418193	18.2
United States [#]	70765	294593	19.4

*Selected Educational Statistics 2000-01, Department of Secondary & Higher Education, Ministry of Human Resource Development, Govt. of India.

[#] Women Minorities and Persons with Disabilities in Science and Engineering, NSF, 2002

Enrollments in some of the major engineering disciplines are as follows averaged over the last few years.

Table 3: Female Enrollment in Various Engineering Disciplines

Engineering Discipline	% Female Enrollment in Kerala	% Female Enrollment in U.S.
Electronics	30 – 35	-
Electrical	40 - 50	14
Civil	45 – 55	22.5
ME	0.1 – 0.2	13.9
Computer Science	25 – 30	16
Architecture	25 - 30	

Data source for Kerala: Calculated from the Indiastat webpage data

Data source for U.S.: Engineering workforce commission, 2001

In every discipline but mechanical engineering, there is a higher enrollment of women in Kerala than in the US. Mechanical engineering is usually perceived as dealing with heavy machinery and the profession is not perceived as suitable for women and hence the reason for the lower enrollment in ME. The reasons for the higher enrolment of women in engineering in Kerala have not been explored in much detail before. The researcher will attempt to evaluate the factors that she believes are responsible for the higher enrollment of women in light of past research that has been done in the field, as well as based on a survey of the alumni of various engineering schools in Kerala.

Engineering education in Kerala is modeled along the British system of engineering education. There are 32 engineering colleges, of which 9 are financed by the government, 7 are partially funded by the government, and 16 are privately funded^[8]. Admission to the government engineering schools is very competitive, and is based on performance in entrance examinations specially crafted to test understanding of the sciences and mathematics. Generally, the engineering curriculum in India is very traditional and does not have any of the attributes that have been cited in the literature as female friendly^[9]. In the first year, a student takes introductory courses in all engineering disciplines. In addition, students also take some courses in mathematics, and the sciences. In the second, and third years, students take foundation courses, with additional courses in the mathematics and science subject areas, to give students the required level of knowledge. The third year covers much of the core material and is a preparation for immediate professional practice. In the fourth year, the courses aim to develop the in-depth understanding in electives of the student's choice. In addition to taught courses, the student also undertakes work on an original research or design project. In addition, the women face some of the same issues in the engineering workplace as faced by engineers in the West including the glass ceiling, lack of mentoring, and harassment^[10,11].

Some of the reasons that can be attributed to the higher enrollment are:

- Primary and Secondary School Education: The number of women teachers in primary to secondary school is high as evidenced in Table 4. Single sex schools also exist in large numbers, but even in co-educational schools, there is very little perceived difference in confidence level between the male and female students.

Table 4: Percentage of Women Teachers^[12]

	Primary School	Middle School	Secondary	Higher Secondary
Kerala	70.7	66.9	42.9	77.5
India	34.5	36.1	32.9	33.5

- More female role models, especially in terms of women faculty: The number of female faculty are high in the fields that show a high percentage of female enrollment like Civil Engineering, Electrical and Electronics Engineering, Computer Science, and Architecture. The percentage of women faculty in engineering institutions in Kerala range from 25 to 42 %^[13]. It has been shown by past researchers that female faculty in engineering or the sciences improves retention of female students in those majors^[14]. These faculties serve as role models for the younger women joining the universities.

- Higher confidence level of women students in science and mathematics: One of the major reasons cited for women not choosing engineering as a career in the United States is the drop in confidence of women students especially as they progress through middle and high school [15-18]. From the principle author's personal experience, this is not very evident in Kerala. This can in turn be attributed to cultural factors, differences in primary and secondary education, and economic factors. In addition, because of the very selective nature of admission to the engineering programs, it is only students who are good in science and math that succeed. This is a difference from the situation in the US, where socialization factors play a more major role in the decision of boys to pursue engineering as a career rather than their abilities in the science and math.
- Cultural Differences: Women students in Kerala do not face the same pressures as their Western counterparts in the social sphere because of an absence of peer pressure to date or socialize. Kerala is still a traditional society, where arranged marriages are the norm rather than the exception.
- Economic factors: The economics of the region can also be a major factor that is contributing to the higher percentages of women in engineering. As mentioned earlier, unemployment is very high at 20% and as a consequence future employment opportunities weigh heavily on the student's career choice. Engineering jobs tend to be more available than other jobs. In the United States, even though engineering is a good career choice if potential earnings and employment opportunities are considered; the students still have a greater choice of majors, which would provide a more satisfying career choice.
- Parental encouragement: Family members create the impetus for women pursuing an engineering career in Kerala. Parents or relatives provide the encouragement necessary to pursue engineering, just as in most cases in the United States especially to women who show a strong science and math ability [19].

A survey of various alumni from the engineering colleges is presently underway and preliminary results will be presented at the conference. The survey assesses the reasons for women choosing engineering as a career in Kerala. It attempts to determine their pre-college experience, college experience and post-college experience in engineering. The survey also assesses factors such as availability of childcare, employment conditions, and existence of family friendly policies, if any. The sample size being surveyed is about 200 to 300 engineering graduates. The actual sample size will depend on the number of responses that will be obtained.

Conclusions

Previous research on international variation in women's participation in undergraduate engineering education suggests that there are several *necessary preconditions* that must be met in order for there to be relatively high enrollment and subsequent employment of women in the field. In addition, there are *facilitating conditions*, which support women's participation in engineering venues. In Kerala, India these conditions appear to have come together to create conditions that seem to facilitate higher enrollment of women in engineering. The various factors that appear to facilitate engineering enrollment includes a less patriarchal social

establishment, greater encouragement of women to continue in science and mathematics, and a social system that values intellectual development.

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