Disguised Gender (Dis) Parity in Selected Engineering Programs in Indian Higher Education

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***Abstract*— Higher education in India has experienced significant growth in terms of the number of institutions and student enrolments, along with improved gender parity in overall enrolments. However, this growth masks ongoing gender disparities in specific disciplines, particularly in engineering and technology. This paper aims to assess the growth and gender disparities in enrolment in engineering programs at various levels of higher education. The analysis is based on reliable and comparable secondary data from the All-India Survey on Higher Education (AISHE). Findings indicate that the proportion of female enrolments has consistently remained below half of that of male enrolments in engineering disciplines: 31 percent at the undergraduate level, 40 percent at the postgraduate level, and 32 percent at the Ph.D. level. Among different engineering fields, mechanical, metallurgical, mining, and civil engineering have particularly low shares of female enrolments. Increasing female enrolments in engineering programs is crucial for ensuring better career opportunities and higher earnings in engineering careers. Moreover, a higher presence of women in the field could lead to innovations geared towards female welfare. The underrepresentation of females can be attributed to various factors, including patriarchal societal norms and non-supportive educational and employment environments for women. To enhance gender equity, government interventions and sustained efforts are essential to address the societal and employment stigmas that hinder female participation in engineering education and careers.**

***Keywords*— Disciplines; Engineering Education; Gender Disparity; India; Programs.**

***JEET Category*—Research**

I. INTRODUCTION

HIGHER education has a significant role in transforming society in the globalized world. It can catalyze social and economic upliftment for individuals and nations (Whalley and Zhao, 2010; Hanushek and Woessmann, 2008; Barro, 2013). A higher proportion of educated graduates (more STEM) in the labor force has greater labor productivity as they can adopt technology and innovate (Bloom et al., 2014; Altbach, 2013; The World Bank, 2002). It is necessary to ensure that the workforce is equipped with appropriate skills to succeed in a future that is greatly influenced and transformed by technology and engineering (Borrego, Foster, and Froyd, 2015; Kim, Sinatra, and Seyranian, 2018; Xu et al., 2019). Therefore, all should have access, prospects, encouragement, and tools to participate in the innovation economy and to flourish amidst technological advancement and transformation, irrespective of any discrimination like gender (Conlon, 2008; Graham, 2018; Madgavkar et al., 2019, Nikum, 2022).

Several illustrations also show that when more females pursue engineering and technology-related education and careers, the outcome in the form of various engineering and technological inventions is more likely to benefit females. Female engineers and technologists have more lived experiences, and hence can understand the problems faced by females more vividly and comprehensively. Due to a greater understanding and relatability of female challenges, female engineers and technologists are likelier to invent goods and services that can enhance female welfare (Vyas, 2021; Firstpost, 2022).

During the past few decades, there has been a steep rise in higher education enrolment worldwide, particularly in developing countries. The reduction in gender disparity in higher education accompanied the remarkable increase in educational enrolment. Over time, women achieved parity with men's levels of education and gradually achieved higher levels of education than men. The convergence of men’s and women’s enrolment patterns evolved with a drastic enhancement in women's enrolment in education.

However, the average enrolment trend, when observed for the entire population, conceals gender disparities. The average enrolment trend disguises gender discrimination across various disciplines of study. The distribution is noticeably uneven in a few fields that include engineering. This underrepresentation of female students in engineering fields also concurs with the underrepresentation of female faculty and researchers in the engineering and technology fields.

The Elsevier Gender Report (2020) shows that males publish more articles on average than females. The discrepancy increases when considering the top journals. Female

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researchers as authors have fewer publications than men in most countries. The underrepresentation is pronounced in high-impact journals and articles with high citation rates (Bendels et al., 2018; Fisher et al., 2020).

India's higher education system is the biggest in the world in terms of the number of institutes and caters to 41.3 million students. Despite this mammoth size, the Gross Enrolment Ratio (GER) in higher education is 27.1. An overall Gender Parity Index (GPI) of 1.01 in higher education persists (MoE, 2021).

A large segment of future professionals will be in the science and technology fields (Schulze and Heerden, 2015; Torkington, 2016). This generates concerns about current discrepancies in science and technology fields, particularly in technology and engineering, where male enrolments overshadow those of females in India (Zander et al., 2015). Despite the worldwide expansion of higher education systems, participation rates among females in technology and engineering higher education and in the academic staff are considerably behind their male counterparts (David, 2011). Gender equity in enrolment in technology and engineering higher education is still unaddressed. The gender gap in technology and engineering is more persuasive, with male enrolment far surpassing female enrolment in many of the disciplines within these fields. In India, despite policy initiatives to increase women's participation in higher education, women remain underrepresented in technology and engineering fields at all levels within higher education, like in many other countries (Marginson et al., 2013; UNESCO, 2016; Amirtham and Kumar, 2021; Joshi and Ahir, 2021). Women's recruitment and retention in technology and engineering disciplines continue to face problems in higher education institutions in India. It is unfortunate, given that many women in India epitomize untapped human capital that can augment the technology and engineering labour force. Analogous to this, women's representation as faculty in these fields is also equally inadequate (Joshi and Ahir, 2021). Surprisingly, very little information is known regarding the attributes and experiences of those Indian women who enroll and teach in technology and engineering fields.

II. Review of Literature

The OECD Science, Technology, and Innovation Outlook 2018 explicitly confirms that gender inequalities in STEM continue, notwithstanding numerous policies adopted by several OECD countries, akin to many other nations (Gonzalez, Fernande, and Wilson, 2021; OECD, 2018; David, 2018; Baillie and Pawley, 2012; Ramirez and Wotipka, 2001). Studies also reveal that the disparity is more tangible in the technology and engineering fields (Varma, 2010; Sax et al., 2017; Shi, 2018).

The disparity between males and females in STEM can be ascribed to several factors, which include restricted educational access (Marginson et al., 2013; Chachashvili-Bolotin et al., 2016; McClure et al., 2017), persistent stereotypes of inability and prejudice (Chase, 2012; Corbett and Hill, 2015; Cvencek et al., 2015), as well as the nonexistence of female mentors (Cacace, 2009; Dawson, Bernstein, and Bekki, 2015; Barker-Williams, 2017; Fuesting and Diekman, 2017) and role models (Cacace, 2009; Cheryan et al., 2011; Corbett and Hill, 2015; Almukhambetova and Kuzhabekova, 2020; Holmes et al., 2018). Gender differences in scientific thoughts, behaviours, and achievements have also been examined in the field of psychology (Feist, 2011; Feist, 2012).

The institutional culture, classroom environment, and lived experiences that act as hindrances to technology and engineering education have also been documented (Hurlock, 2014; Fischer, 2017; Deemer et al., 2014; Adornato, 2017; Dawson, 2014; Comeaux et al., 2017; Gupta and Sawhney, 2023). The retention and persistence of women in technology and engineering programs have been reviewed in the recent past. Studies have revealed that interactive engagement with females in the class, faculty approach, psychological counselling, and coaching programs within the institution impact retention (Corbett and Hill, 2015; Blair et al., 2017; Wilker, 2017). The persistence of women in technology and engineering has been related to their career adaptability, internal motivation, advisors' support, family attitude, and resilience to gender stereotypes (McPherson, 2012; Robinson, 2012; Clark et al., 2016; Prime et al., 2015; Ceglie and Settlage, 2016).

Insufficient female faculty in STEM disciplines and associated issues of workload, tenure, promotion, work-family balance, institutional policies, etc., need attention for encouraging gender equity (Carrigan, Quinn, and Riskin, 2011; Soto, 2014; Kachchaf et al., 2015; Meyer, Cimpian, and Leslie, 2015; Hart, 2016). The number of women in senior academic positions is unreasonably low in engineering fields, like other STEM disciplines (Gewin, 2011; Sheltzer and Smith, 2014). The consulting, patent filing, and patent ownership rates of women are also very low (Ding, and Choi, 2011; Thursby and Thursby, 2005). The less active participation of women in academics is also attributed to family obligations, gender biases, and institutional policy (Busolt and Kugele, 2009; Abreu and Grinevich, 2017; Ahl and Nelson, 2015; Giuri et al., 2020).

Despite the increase in women's engagement in entrepreneurial activity, studies on the gender gap in STEM entrepreneurship narrate the underrepresentation of women (Kelley et al., 2015; Beede et al., 2011). A few studies also reveal gender-related problems in the context of STEM (more focus on technology and engineering) for women entrepreneurs. The major issues relate to access to internal resources, support structures, lack of management expertise, professional networks, etc. (Ezzedeen and Zikic, 2012; Orser, Riding, and Stanley, 2012). The strategies adopted by successful women entrepreneurs have also been studied (Marlow and McAdam, 2015; Martin et al., 2015; Kanter, 1993).

While various hindrances exist that restrict female education and careers in engineering, female engineers can better relate to the challenges faced by females in day-to-day life and thus are better placed to resolve these challenges. Several illustrations highlight how female engineers' pioneering inventions played a pivotal role in ensuring that the tasks generally associated with females are eased (Archana, Vijaya Kumar, and Shyamasundar, 2022). A case in point is the invention of a new female car crash dummy created by Dr. Astrid Linder, which attempts to address the 73 percent greater likelihood of females suffering from serious injuries. While dummies have been in use to test car safety during crashes since the 1970s, it took more than five decades and a female engineering research team to create female car crash dummies! (Firstpost, 2022). Pranoti Nagarkar-Israni's invention of Rotimatic – a kitchen robot that can make homemade healthy wraps and rotis, Gilbreath's invention of inserting shelves in the refrigerators, invention of hair curling iron by Theora Stephens, invention of foot pedal trash can and electric mixer by Lillian Glibreth, invention of pastry fork by Anna Magrin, invention of an adjustable belt made for sanitary napkins featuring a moisture-proof pocket that secured the pad by Mary Beatrice Davidson Kenner, invention of fruit press to squeeze juice by Madeline Turner, invention of waterproof disposable diapers by Marion O'Brien Donovan, invention of clothes wringer by Ellen Elgin, invention of dishwasher by Josephine Cochrane, home security system invention by Marie Van Brittan Brown, invention of scotch guard to remove soil stains by Patsy Sherman, Caresse Crosby's patent for the modern bra to replace uncomfortable undergarment corset, are some more illustrations of the inventions by females, improving the lives of females in particular (Linder, 2020; Vyas, 2021; Mellionard, 2023). While several other acclaimed women inventors invented several products that benefited males and females alike, the above-described inventions were particularly beneficial for reducing drudgery or improving the lives of females. Most of these inventions were the outcome of drudgery either faced or observed by females, since many males were not involved in doing these tasks; these inventions were the outcome of the effort of females. If these females had not invented the said inventions, females in the modern world would have continued to face drudgery and, at times, life-threatening situations. Hence, females need to pursue education and a career in engineering.

In developing countries like India, the adverse view of society about women's ability, early marriage, patriarchy, discrimination, and parents' perception are regarded as the foremost explanations for the low enrolment of women in STEM, more specifically in engineering (Chandrakar, 2014; Kaaya and Waiganjao, 2015; Singh, 2007; Thasniya, 2014; Nwojiewho and Deebom, 2017; Thelwall et al., 2019; Dol, 2022). Despite these studies, women in technology and engineering higher education in India remain an unexplored avenue (Joshi and Ahir, 2016) that needs to be researched to address gender inequity.

III. Objectives and Research Questions

The research explored in this paper was inspired by the stated considerations: (1) we recognize the element that gender equity is a significant concern in the socio-economic and political ecology of developing countries like India; (2) India, like many other developing countries, has undertaken steps to address gender inequity in education over the past few decades; (3) earlier findings suggest that the Gross Enrolment Ratio (GER) is not the utmost inclusive indicator of gender equity; rather, unequal gender proportions can be observed across the disciplines, especially in engineering.

Therefore, the current research is an attempt to enhance current knowledge by presenting trends over a decade regarding gender disparity in Indian higher education in general and engineering in particular. The Gender Parity Index (GPI) for engineering disciplines at different levels of higher education has been calculated. A decadal analysis of gender parity shows the change in gender enrolment over time. Accordingly, the following research question has been considered:

Does gender parity in enrolment exist in Indian higher education, or is it confined to selected disciplines only, particularly in engineering programs?

Research on gender inequities in higher education in India exists, but literature that focuses on women in engineering fields at all levels of higher education is still unmapped. The objectives of this study in the context of India are as follows:

The first objective is to assess the growth and gender disparity in enrolment in Indian higher education and the state of women's enrolment across various disciplines in higher education in India. The second objective is to examine the gender inequity in engineering programs at different levels of higher education.

IV. Conceptual Framework

This study makes use of the theories of liberal feminism and radical feminism. Liberal feminists argue that women's unequal status in society is due to inherited traditions and institutions riddled with patriarchy and call for efforts to identify and address such institutions and traditions for remedy (Walby, 1996; Millet, 1971; Crenshaw, 1989; Okin, 1989; Eswaran and Malhotra, 2011). Radical feminism considers patriarchy to divide rights, privileges, and power primarily by gender (Tong, 1989; Beasely, 1999). Liberal feminism and radical feminism theories are based upon the principle of equal opportunity and freedom, in which gender equity is not determined by sex.

The conceptual framework of the study shall consider the order of three approaches: (a) encouragement to increase awareness about causal gender-disparity issues; (b) a gender-affirmative-action method for the employee and training a significant number of female technocrats, engineers, and researchers; and (c) advancement of gender mainstreaming as a means of imbibing gender standpoints into the higher education culture. This framework shall be supplemented by structuration theory to enlighten the understanding and perceptions of females in technology and engineering programs in India. The conceptual and theoretical framework is likely to explicate how the development and effective execution of gender policies can transmute institutional, social, and global structures.

V. Discussion

This study was carried out for two purposes. First, look at the growth of Indian higher education in the context of gender participation across disciplines. Second, to analyze the gender disparity in selected engineering disciplines at various levels of higher education.

Higher education in India has grown immensely since 1950–51. The steep growth took place in the post-2000-01 period. During 1950–51 to 2000–01, the number of universities and colleges grew at a Compound Annual Growth Rate (CAGR) of 4.38 percent and 6 percent, respectively (UGC, 2013). However, during the 2000–01 and 2020–21 periods, the universities and colleges grew at a CAGR of 7.67 percent and 8.9 percent, respectively (MHRD, 2002; MoE, 2021).

Enrolments of students in higher education registered a high growth from 0.4 million (with 0.35 million boys and 0.05 million girls) in 1950–51 to 41.3 million students in 2020–21, out of which 21.2 million (51.3 percent) were boys and 20.1 million were girls (48.7 percent). In terms of enrolment, Indian higher education is the second-largest system in the world, next to China. However, the Gross Enrolment Ratio for higher education was 27.3 in 2020–21, with GER for males at 26.7 and GER for females at 27.9. The Gender Parity Index (GPI) was 1.05 at the higher education level in India. To understand parity further in a true sense, it is necessary to consider gender participation across disciplines by levels of higher education (UGC, 2013; MoE, 2021).

At the undergraduate level, the share of female participation is 48.56 percent during 2020–21. However, female participation is not the same across all disciplines. Female participation is higher than male participation in disciplines like arts (52.06%), science (51.9%), education (63.08 %), medical science (58.59%), social science (50.42%), and home science (90.49%). In contrast, in engineering, the share of female participation is very low at 29 percent.

At the postgraduate level, the share of female participation in 2020–21 is 56.4 percent. Female participation is again observed to be higher than male participation in disciplines like commerce (66.49 percent), cultural studies (62.72 percent), education (64.45 percent), Indian languages (65.60 percent), home science (93.15 percent), science (61.3 percent), and social science (56.52 percent). Although the share of female participation in engineering is quite low at 33.43 percent, it is better than at the undergraduate level.

At the Ph.D. level, the share of female participation during 2020–21 is 45 percent. Female participation is higher in disciplines like commerce (58.1 percent), cultural studies (52.2 percent), and education (56.0 percent). The share of female participation in engineering at the Ph.D. level of higher education is only 33.33 percent.

The essential question is: why does the proportion of women in engineering and technology not keep pace with the higher proportion of females in languages, sciences, and social sciences in higher education? Several aspects have been documented as likely contributors to the gender difference in engineering and technology. Among the significant aspects, the ‘nature’ versus ‘nurture’ discussion is significant. One of the basic premises of the nature debate is that females’ brains develop differently from males’ and that biological variances elucidate the gender gap (Ceci, Williams, and Barnett, 2009). This argument has been rejected by those who state that the evidence that biological factors lead to gender disparity is unsatisfying (UNESCO, 2010; Eccles et al., 2009).

TABLE I
ENROLMENT SHARE OF MALES & FEMALES IN MAJOR DISCIPLINES AT THE UNDERGRADUATE LEVEL DURING 2010-11 AND 2020-21

	2010-2011			2020-2021		
Discipline	Male	Female	Total	Male	Female	Total
Arts/ Humanities/ Social Sciences	14.4	14.2	28.7	18.7	20.5	39.2
Engineering & Technology	7.7	3.2	10.9	8.4	3.4	11.9
Commerce	4.9	3.5	8.3	7.2	6.8	13.9
Science	3.6	3.1	6.7	7.5	8.3	15.8
Computer Science/Computer Application	1.2	0.7	1.8	1.7	1.1	2.8
Medical Science	0.8	0.9	1.7	2.1	2.9	5.1
Management	1.0	0.5	1.5	1.7	1.0	2.6
Law	0.4	0.2	0.6	1.0	0.5	1.5
Agriculture & Allied	0.3	0.1	0.4	0.7	0.3	1.0
Grand Total	55.1	44.9	100.0	51.4	48.6	100.0

Source: Calculated by authors from MHRD, 2011, and MoE, 2021

There are several aspects related to the nurture argument and its connection with the observed gender differences in engineering and technology. The foremost one is adverse stereotyping. It has been well documented that stereotype threat leads to gaps in academic performance between women and men (Zafar, 2013).

A. Enrolment Scenario in Indian Higher Education across major programs and disciplines

The enrolment shares of major disciplines at the undergraduate level for the year 2010–11 in Table I show that the highest enrolment was in social science (28.7 percent), followed by engineering and technology (10.9 percent), commerce (8.3 percent), and science (6.7 percent). Disaggregating by males and females, the preference for engineering by females (3.2 percent) was much lower than that for males (7.7 percent). In 2020–21, undergraduate enrolment share shows that the highest enrolment was in social science, albeit lower than in 2010–11 (39.2 percent), followed by science (15.8 percent), commerce (13.9 percent), and engineering and technology (11.9 percent). Although the absolute enrolments in undergraduate engineering and technology increased during the last ten years, the percentage share of enrolments in engineering and technology moderately increased from 10.9 percent to 11.9 percent. The share of females in undergraduate programs increased from 44.9 percent in 2010–11 to 48.6 percent in 2020–21. In 2010–11, female enrolment was low in engineering and technology (3.2 percent), and it negligibly increased to 3.4 percent over a decade. The share of female enrolment in engineering and technology increased less than proportionately as compared to the increase in male enrolment in engineering and technology.

The enrolment shares at the postgraduate level by disciplines show (Table II) that in the year 2010–11, the highest enrolment was in management (18 percent), followed by arts and social sciences (18.9 percent), science (9.3 percent), and commerce

(5.5 percent). It is noticeable that while at the undergraduate level, engineering and technology were the second most enrolled disciplines, at the postgraduate level, they enrolled the fourth highest number of students.

TABLE II
ENROLMENT SHARE OF MAJOR DISCIPLINES AT POSTGRADUATE LEVEL 2010-11 AND 2020-21

Major Disciplines	2010-11 Male	Female	Total	2020-21 Male	Female	Total
Social Science	9.5	9.3	18.9	8.9	11.6	20.6
Management	13.1	4.9	18.0	8.5	6.5	15.0
Science	4.5	4.8	9.3	5.7	9.1	14.8
Engineering & Technology	3.2	2.0	6.4	2.6	1.3	3.9
Indian Language	2.5	3.6	6.1	2.4	4.6	7.0
Commerce	2.8	2.8	5.5	3.9	7.8	11.7
Computer Science/ Computer	3.3	1.8	5.1	2.3	2.1	4.4
Foreign Language	1.3	1.7	3.0	1.7	3.2	4.9
Linguistics	1.1	1.5	2.7	0.0	0.0	0.0
Medical Science	1.0	0.7	1.7	2.0	2.9	4.9
	55.5	44.5	100.0	43.6	56.4	100.0

Source: Calculated by authors from MHRD, 2011, and MoE, 2021

Instead, disciplines like science and management enrolled a greater number of students at the postgraduate level than engineering and technology. In the year 2020–21, the share of enrolment in social sciences (20.6 percent) slightly increased, along with management (15 percent), sciences (14.8 percent), and commerce too, which almost doubled (11.7 percent). On the other hand, the share of engineering and technology students enrolled at the postgraduate level declined to almost half the number as compared to that in 2010–11 (3.9 percent), which increased. The share of females in postgraduate programs increased dramatically from 44.5 percent in 2010–11 to 56.4 percent in 2020–21. In 2010–11, the female enrolment share in engineering and technology was 2 percent, and it further reduced to 1.3 percent in 2020–21.

The enrolment shares of major disciplines at the Ph.D. level for the year 2010–11 show (Table III) that the highest enrolment was in science (29.3 percent), followed by engineering and technology (19.72 percent) and social science (19.63 percent). The Ph.D. enrolment share for the year 2020–21 shows that the highest enrolment was in engineering and technology (27.3 percent), followed by science (23.4 percent), and social science (10.2 percent). The share of females in Ph.D. programs increased from 38.33 percent in 2010–11 to 45 percent in 2020–21. In 2010–11, the female enrolment share in the engineering and technology Ph.D. program was 4.6 percent, which increased to 9.1 percent in 2020–21. However, the share of females in enrolment in the Ph.D. program in engineering and technology (9.1 percent) was exactly half that of males (18.2 percent).

Among all students enrolled at the undergraduate level, 7.7 percent of males and 3.2 percent of females enrolled in engineering and technology in 2010–11, which increased to 8.4 percent and 3.4 percent for males and females, respectively, in 2020–21. However, the share of males and females pursuing engineering and technology among all students pursuing postgraduate programs in 2010–11 was 3.2 and 2, respectively, while the same numbers for 2020–21 were reduced further to 2.6 and 1.3, respectively, for males and females. It is surprising to note that the absolute number of students pursuing engineering and technology in the postgraduate program also observed a decline between 2010–11 (Male: 105,816, Female: 66,688, Total: 209,484) and 2020–21 (Male: 118,012, Female: 59,267, Total: 177,279).

TABLE III
ENROLMENT SHARE OF MAJOR DISCIPLINES AT PH.D. LEVEL DURING 2010-11 AND 2020-21

Discipline	2010-11 Male	Female	Total	2020-21 Male	Female	Total
Science	17.6	11.7	29.3	12.0	11.4	23.4
Engineering & Technology	15.1	4.6	19.7	18.2	9.1	27.3
Social Science	10.5	9.1	19.6	5.2	5.0	10.2
Indian Language	3.4	2.7	6.1	2.5	2.1	4.6
Management	3.0	1.8	4.8	3.1	2.7	5.8
Agriculture & Allied	2.5	0.9	3.4	1.8	1.4	3.3
Commerce	2.0	1.3	3.3	1.3	1.8	3.1
Foreign Language	1.3	1.2	2.5	1.0	1.5	2.5
Medical Science	1.5	0.8	2.3	3.2	3.1	6.3
Computer Science/ Computer Application	1.0	0.8	1.8	0.9	1.0	1.9
Grand Total	61.7	38.3	100.0	55.0	45.0	100.0

Source: Calculated by the authors from MHRD, 2011, and MoE, 2021

Fig. 1 and Table IV show that the share of males and females in engineering education has remained almost stagnant during the last ten years, i.e., from 2010–11 to 2020–21.

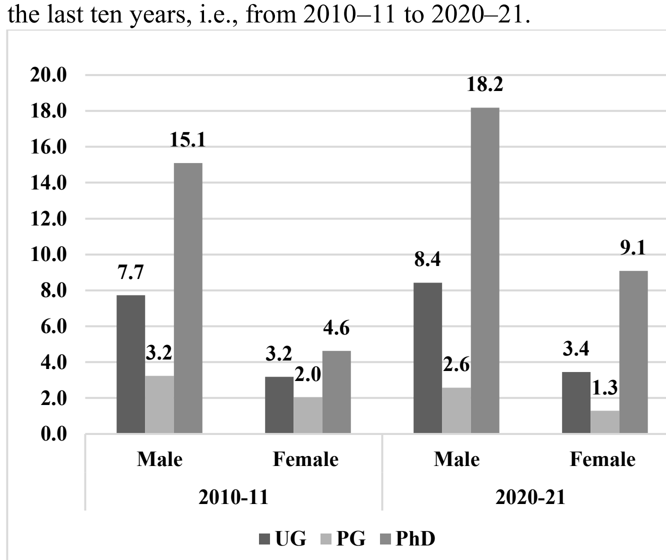

Fig. 1. Enrolment of Males and Females in Engineering as a share of total enrolments in Higher Education in India during 2010-11 and 2020-21 (Source: Extracted by authors from MHRD, 2011, and MoE, 2021)

Although the enrolment in absolute numbers shows a rise, gender inequality of almost the same proportion prevails. Both in 2010–11 and in 2020–21, the share of males at the undergraduate level was about 70 percent, and that of females was about 30 percent. Over almost a decade, no change could be observed in gender parity for engineering programs at the undergraduate level. However, the share of females increased at the postgraduate level and the level of the PhD by about 2 percent and 10 percent, respectively.

TABLE IV
SHARE OF FEMALES IN ENGINEERING HIGHER EDUCATION AS A PERCENTAGE OF TOTAL ENROLMENT IN ENGINEERING EDUCATION FOR UG, PG, AND PHD LEVELS

	Percentage share of females in engineering education		
	Undergraduate level	Postgraduate Level	Ph.D. level
2010-2011	29.15	31.83	23.46
2011-2012	28.51	35.18	28.52
2012-2013	28.78	36.8	28.06
2013-2014	28.39	38.22	27.76
2014-2015	28.07	38.92	28.53
2015-2016	27.92	39.09	29.5
2016-2017	28.36	38.29	30.93
2017-2018	28.6	37.37	30.84
2018-2019	28.88	37.06	31.32
2019-2020	29.22	35.19	31.69
2020-2021	29	33.43	33.33

Source: Extracted by authors from MHRD, 2011 and MoE, 2021

B. Female: Male proportions for engineering programs

A comparison of shares in total enrolments provides a partial understanding of the prevalence of gender disparity. The proportion of females to males in the total engineering programs gives a better perspective on the gender disparity. It shows that for every male pursuing engineering education, how many females are pursuing engineering programs. Fig. 2 depicts females as a proportion of males in all engineering programs together for undergraduate, postgraduate, and engineering programs from 2010–11 to 2020–21. For most of the years, for the undergraduate programs, the proportion of females as compared to males has been around 40 percent. Only for post-graduate courses was the proportion of females relatively higher compared to UG and PhD programs. Although for postgraduate programs too, the proportion observes a rising and then a falling trend. While Ph.D. engineering programs have enrolled a rising number of females over the years, the highest proportion in 2020–21 was still as low as 50 percent.

Hence, it is explicit that females, as a proportion of males, enroll in far lesser absolute numbers across all programs, namely, undergraduate, postgraduate, and Ph.D. programs.

1) Gender Parity in selected engineering undergraduate programs

The analysis so far proves that the total enrolment in engineering programs has been biased in favour of males. Although it should be considered that such total enrolments may average out and disguise the differences existing in various types of engineering programs. A microanalysis comparing enrolments in various disciplines of engineering can bring to the forefront greater biases existing in favour of males in certain types of engineering programs. To understand the gender disparity in the engineering discipline, ten engineering programs have been considered. The ten programs have been selected given time series data consistency and major representation. These programs are electronics engineering, computer engineering, mechanical engineering, electrical engineering, civil engineering, chemical engineering, metallurgical engineering, agriculture engineering, mining engineering, and dairy technology.

If we disaggregate undergraduate engineering by programs, as shown in fig. 3, we can observe that gender parity does not prevail in any of the programs, and this trend has been visible during the ten years of analysis. In 2020–21, the highest gender disparity was in mining engineering (0.08), mechanical engineering (0.07), civil engineering (0.3), metallurgical engineering (0.32), and chemical engineering (0.33). During the period 2010–11 to 2020–21, there has not been an effective change in the disparity status of these engineering courses that are rarely opted for by females.
In contrast, computer engineering, which is largely believed to be a desk job, had more female enrolments.

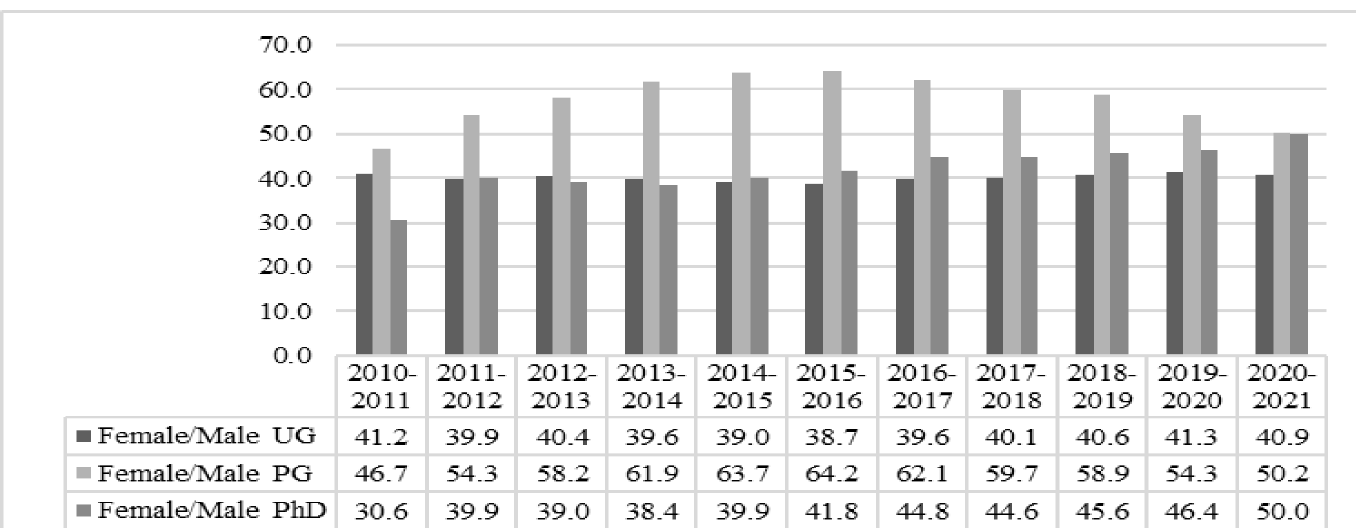

Fig. 2. Females as a proportion of males in engineering programs from 2010-11 to 2020-21 (Source: Calculated by authors from MHRD, 2011, and MoE, 2021)

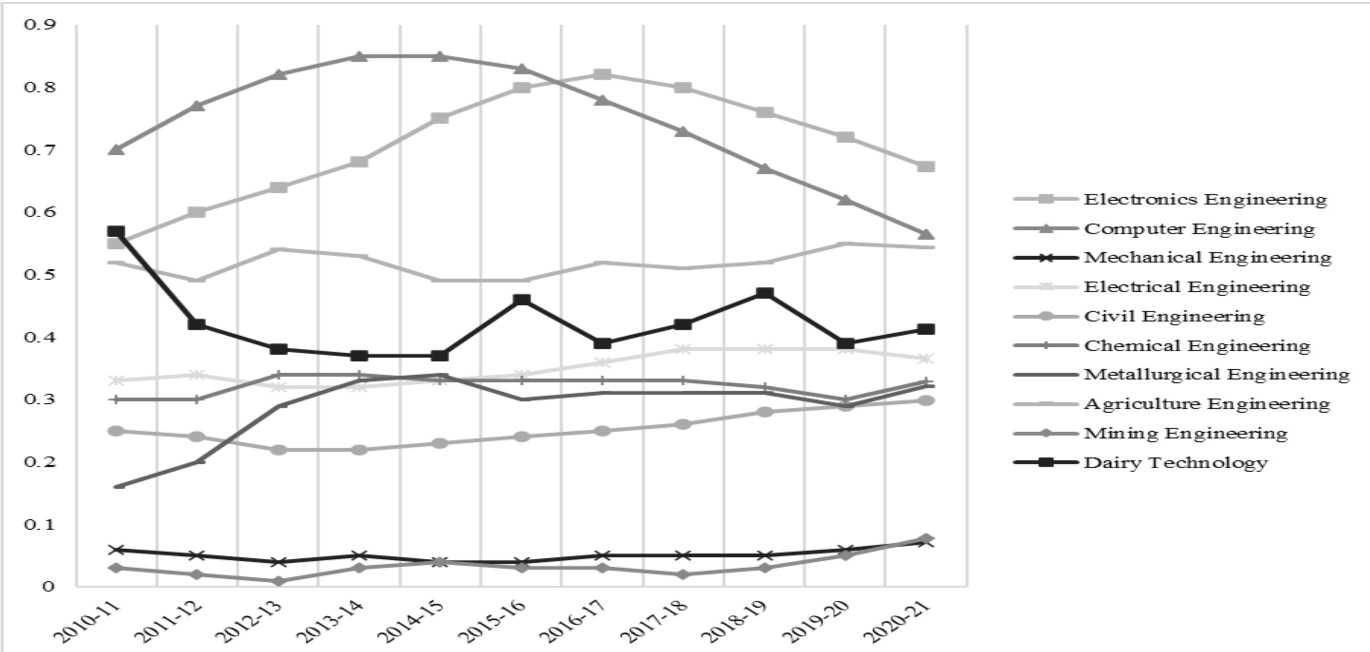

Fig. 3. Gender Parity in selected Undergraduate Engineering programs for the period 2020-11 to 2020-21 (Source: Extracted by authors from MHRD, 2011, and MoE, 2021)

2) Gender Parity in selected engineering postgraduate programs

Analogous to the undergraduate scenario in the year 2020–21, the gender disparity at the postgraduate level (fig. 4) was high in mining engineering (0.1), mechanical engineering (0.12), metallurgical engineering (0.2), dairy technology (0.36), and civil engineering (0.39). The gender disparity tangibly decreased over the period across all postgraduate programs in engineering. The two postgraduate programs where the participation of females was relatively high were electronics engineering (0.94) and computer engineering (0.92). However, it can be observed that the less and more popular disciplines do not largely change when undergraduate and postgraduate programs are compared.

3) Gender Parity in selected engineering Ph.D. programs

Again, it can be observed in fig. 5 that during PhD programs too, the preference of females for certain engineering disciplines and the lack of the same for other disciplines do not change much. The gender disparity at the Ph.D. level was again high in mining engineering (0.09), mechanical engineering (0.1), metallurgical engineering (0.27), civil engineering (0.36), and electrical engineering (0.37). The gender disparity tangibly decreased over the period across all Ph.D. programs in engineering. Dairy technology engineering has observed a maximum fluctuation in enrolments in Ph.D. programs during 2020–21. The two Ph.D. programs where the participation of females is better than the others are computer engineering (0.73) and electronics engineering (0.65).

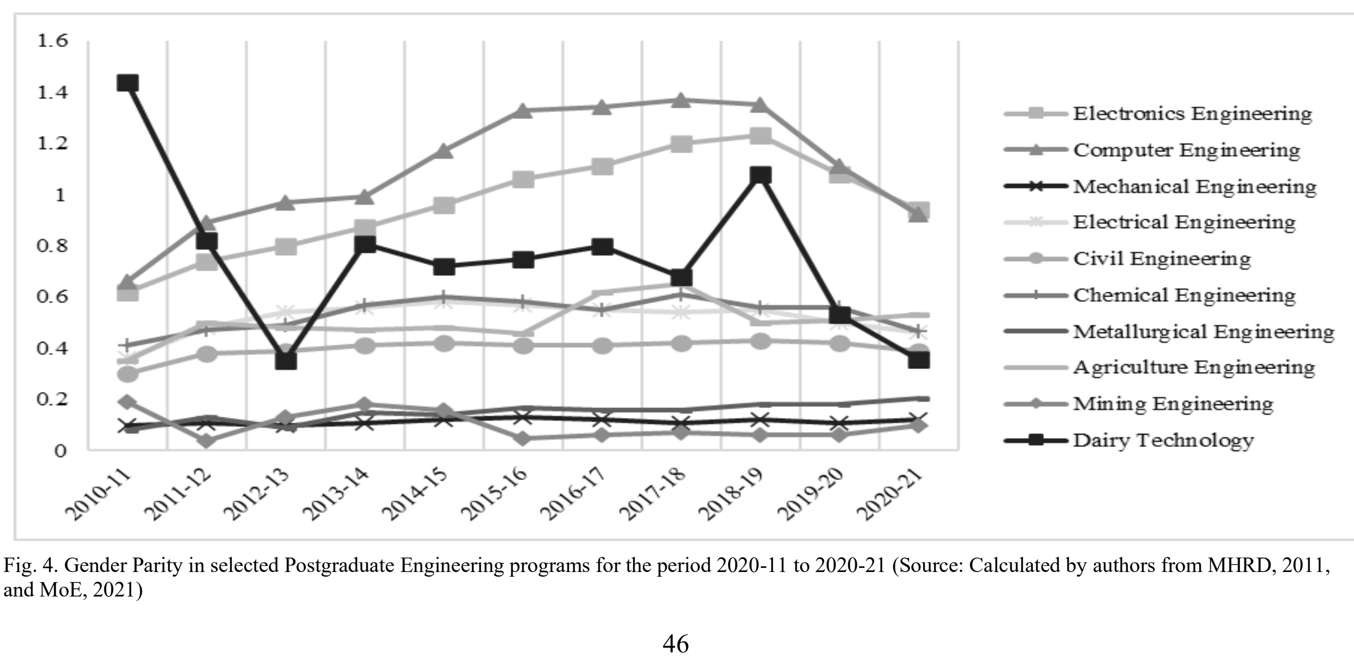

Fig. 4. Gender Parity in selected Postgraduate Engineering programs for the period 2020-11 to 2020-21 (Source: Calculated by authors from MHRD, 2011, and MoE, 2021)

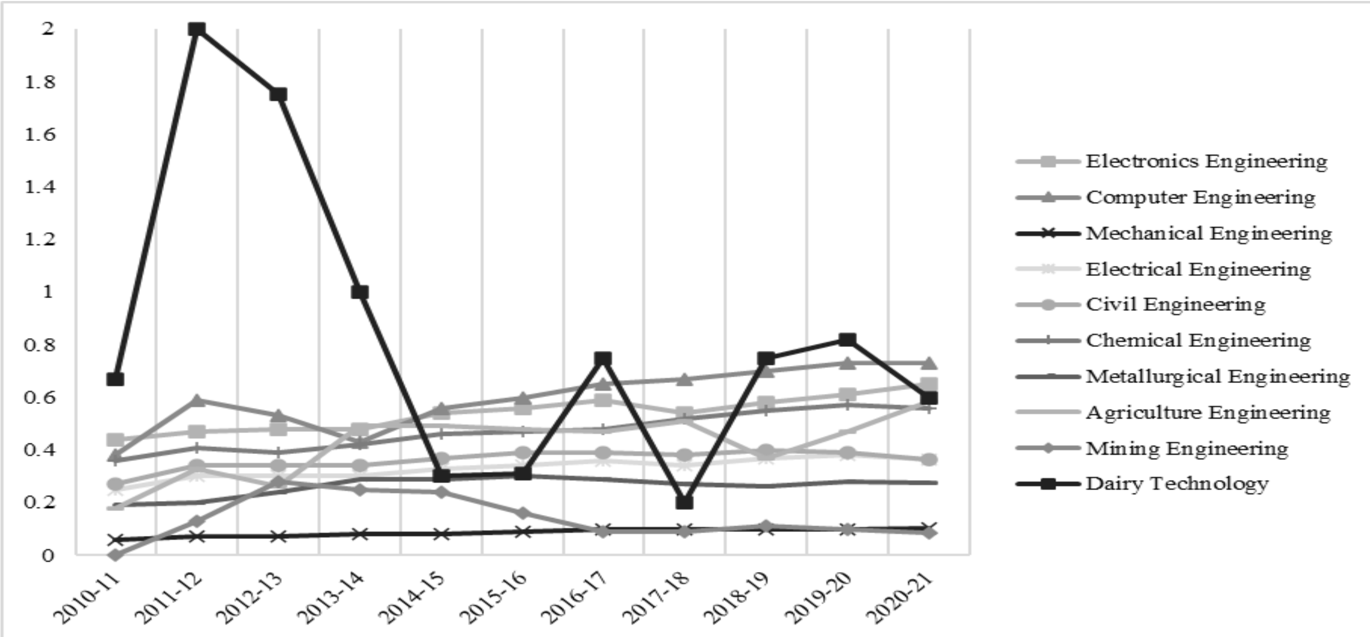

Fig. 5. Gender Parity in selected PhD Engineering programs for the period 2020-11 to 2020-21 (Source: Calculated by authors from MHRD, 2011, and MoE, 2021)

VI. Conclusion

In India, degree courses in engineering and technology have consistently proved unattractive for female students, especially in disciplines like mechanical engineering, metallurgical engineering, mining engineering, civil engineering, and chemical engineering. This prevails even though a significant proportion of school girls have high academic performance in mathematics and the natural sciences.

It has also been felt that engineering education in India needs to be renewed as per the changes required. With the change in technology and future job demands, engineering education will have to mould its curricula and training. The higher education institutions offering engineering programs will have to ensure that engineering graduates achieve learning outcomes that are suitable and appropriate to the engineering profession.

Sensitive interventions are required for enhancing enrolments, reducing dropouts at various levels, and ensuring that the careers offered in job markets are accommodating to the needs of females. Mentors, who may be advisors, teachers, or counsellors, can influence and attract more females into engineering and technology careers. Affordable engineering education, easy accessibility in the vicinity, safe transportation to the institutes offering engineering programs, and more female mentors and role models who succeed in these careers may provide the necessary impetus for enrolment in engineering education for females. More government interventions to incentivize continued education from undergraduate to postgraduate to PhD programs may be necessary to ensure greater retention of females in academics. Social factors may act as a strong hindrance in the form of marriage for females, and the need to earn a living for males may be difficult and unyielding to fight against, particularly considering the age cohort of 18 years to 23 years in the Indian socio-economic context. While the ultimate aim of pursuing education for many students may be to secure high-rewarding jobs in the job market, certain career options in engineering may not prove to be very conducive and accommodating for females. Working in factories as mechanical engineers with greased hands, as electrical engineers working with wires and circuits, or in remote places as metallurgical engineers may not be societally acceptable for females. In contrast, handling computers on a desk and also availing of work-from-home opportunities make careers associated with computers more lucrative for females. However, to ensure an equal opportunity for a female to choose both academics and a career in the field of her choice without worrying about patriarchal gendered roles assigned to females, all stakeholders should fulfil their responsibilities. Family and society should be encouraging; educational institutes and workplaces should be sensitive to the needs of females; and females themselves should be bold to take up the challenges on a day-to-day basis by adapting to the requirements for an education and a career in engineering. Ultimately, the unequal participation of females in engineering education and subsequent careers is not only a gender issue. It is also a concern for the nation that it fails to provide females, who comprise almost half of the population, with an equal opportunity to participate in the nation's growth. It is not only a concern for sabotaging female rights, but also, in the process, affects the economic growth of a nation undesirably. In contrast, greater participation opportunities for females in engineering education and careers are both economically beneficial and societally equitable, and hence highly desirable for a nation's welfare.

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