2

Industrial Revolution 4 and Indian Women in STEM : Challenges and Prospects

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Technological progresses induced by innovations and inventions marked its impact on the production and social relations of the society. The advancement in Science, Technology, Engineering and Mathematics (henceforth 'STEM') has critical role in the spread of IR4 and building the modern society. The STEM remained to be a male dominated field for the centauries despite the perception that knowledge remained to be gender neutral. This paper investigates the trends in women's participation in STEM fields in India. The paper finds convergence in the gap between participation of women in STEM in the recent past on account of the sincere efforts by the government and non-governmental organizations in the recent times.

[**Keywords :** STEM, Industrial revolution 4, Cyber-Physical system, Convergence]

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1. Introduction

Industry 4.0 also known as the 'Fourth Industrial Revolution' (Henceforth 'IR4') refers to the current trend of automation and data exchange in manufacturing technologies, including cyber-physical systems, the Internet of Things (IoT), cloud computing, and cognitive computing (Klaus, 2017). IR4 is characterized by the integration of advanced technologies to streamline and optimize manufacturing processes, resulting in increased productivity, efficiency, and cost savings. It also involves the use of big data analytics and artificial intelligence to make informed decisions and identify new opportunities for growth and innovation. IR4 is expected to transform various industries, including manufacturing, healthcare, transportation, and energy, among others.

2. Industrial Revolution 4 and Women's Education : Opportunities and Threats

The fourth industrial revolution requires the convergence of digital, physical, and biological technologies that could change the existing system of science education which might end the silos in the different streams of science education, especially in higher education in India. The success of IR 4 would depend on how fast countries adopt the multi-disciplinary and cross-disciplinary integrated approach in science education. The literature and experiences both suggest that the fourth industrial revolution has the potential to do both. It may have a positive and negative impact on the gender gap in terms of participation in education and work. Under the new regime, a metamorphosis is expected in the dynamics of the current and future education and markets. The new technologies and digital platforms of Industry 4.0 can provide opportunities for women to access new types of jobs, increase their skills and knowledge and participate in new industries as digital platforms facilitate flexible work arrangements. It also allows women to balance work and family responsibilities, especially in urban and peri-urban areas. To participate and lead in industry 4.0, in-depth knowledge of the STEM course is a must especially in the field of higher education. There are ample shreds of evidence which finds that engineering and computer science, mathematics, and other core science areas remained to be male-dominated for centuries around the world on account of various socio-economic reasons.

In the hindsight, there are concerns that Industry 4.0 could perpetuate or even exacerbate gender inequalities in the workforce. For instance, many of the jobs that are expected to be created by Industry 4.0 may reinforce existing gender stereotypes and barriers to women's participation in these fields. The risk is that Industry 4.0 technologies could be developed with biases that disadvantage women such as facial recognition algorithms that struggle to recognize faces of darker skin tones of women, or voice assistance that respond more accurately to male voices than female ones.

To overcome these issues, it becomes pertinent to invest in education and training for women in STEM fields and also addresses the biases in algorithmic systems, and promote greater diversity and inclusion in the technology industry. Additionally, policymakers, educators, and businesses need to be aware of the potential challenges and must take proactive steps to ensure that women are not left behind in the digital era. This could involve investing in infrastructure and digital resources to ensure that women have equal access to education and training opportunities, promoting gender diversity and inclusivity in the technology industry, and encouraging girls and women to pursue careers in STEM fields (UNESCO, 2020).

From the above discussion, it has emerged that not only do women struggle for access to education in general but also their access to STEM courses remains even more cumbersome and difficult. The research paper is aimed at analyzing the trends in the gap between men and women in STEM participation. The paper also investigates the impact of the policy intervention on the trends in gender disparity at the national level.

3. Hypothesis

The null hypothesis of the paper is that policy intervention was secular and gender-neutral in terms of access to education at the national level.

4. Research Methodology and Data Source

The paper investigates the trends in gender disparity in STEM courses. This research paper is based on the secondary data taken from the All India Survey of Higher Education (AISHE), World Development Indicators, and UNESCO.

5. Industrial Revolution and Women's Participation in STEM

Women's participation in industries was low during the adept of the first industrial revolution in the earth 17th century owing to the feudal social structure in Europe. The situation began to change during the second industrial revolution[1], yet female participation in STEM was far below their share in the population. The third industrial revolution, which began in the mid-20th century with the widespread use of electronics and information technology brought both opportunities and challenges for women's education. During the advent of the fourth industrial revolution, the widespread use of information and communication technologies made it easier for women to access educational resources and pursue learning opportunities from anywhere in the world. Women have been able to take advantage of online courses, digital resources, and e-learning platforms to gain new skills and knowledge, regardless of their location or socio-economic status. Moreover, the growth of the service sector and knowledge economy has created new opportunities for women in fields such as education, healthcare, and business services. Women have been able to enter these fields and advance their careers by acquiring new skills through education and training.

However, there are also challenges that women have faced in accessing education and training opportunities in the third industrial revolution. Women have been under-represented in STEM (Science, Technology, Engineering, and Mathematics) fields, which have been the driving force of technological innovation in this era. This has limited women's access to high-paying, high-tech jobs. Besides, traditional gender roles and stereotypes have persisted especially in developing countries where a lack of support and opportunities for women in pursuing careers in STEM fields are common. There persists ample evidence which shows that the culture and structure of some educational institutions and workplaces have not been supportive of women, leading to lower rates of retention and advancement. According to a report by UNESCO, less than 30% of researchers worldwide are women, and only around 30% of female students choose STEM-related fields in higher education (UNESCO, 2020). Moreover, women are under-represented in many high-tech and emerging fields, such as computer science, engineering, and artificial intelligence. The reasons for the under-representation of

women in STEM are complex and multifaceted (Dasgupta and Stout, 2014). Factors that have been cited include cultural and social stereotypes, a lack of role models and mentors, and systemic biases and discrimination within educational and workplace environments. This report welcomed the steps taken by the various government in recent years that suggest progress is being made towards increasing women's participation in STEM fields. For example, many countries have launched initiatives and programs aimed at promoting girls' interest in STEM fields and encouraging women to pursue STEM-related careers. In addition, many companies and organizations have recognized the importance of diversity and inclusivity in the workforce and have made efforts to increase the representation of women and other under-represented groups in STEM fields (UNESCO, 2020). According to a report published by the Ministry of Education in 2019, women now make up over 40% of students studying science and engineering in Chinese universities. The percentage of women enrolled in undergraduate science and engineering programs has significantly increased from 24% in 1999 to 42% in 2018 (MOE, 2019). Despite this, women still face challenges in pursuing STEM careers in China on account of the persistence of gender stereotypes and biases and the hostile or unwelcoming environment for women in STEM fields. Another challenge is the lack of female role models in these fields, which can make it difficult for young women to envision themselves succeeding in STEM careers.

6. Women's Participation in STEM Fields in India

The role of women in the STEM field in ancient India has not been well documented. However, there are a few examples of women who made significant contributions to the fields of mathematics and astronomy during this period. One notable example is the mathematician and astronomer Lilavati, who lived in the 12th century. She was the daughter of the mathematician Bhaskara II, who was one of the leading scholars of his time. Lilavati herself was a highly skilled mathematician and astronomer, and she wrote a book called "Lilavati" that became a classic in Indian mathematics. The book covered a wide range of mathematical topics, including arithmetic, algebra, geometry, and trigonometry, and it was widely used as a textbook in schools throughout India. Similarly, Gargi Vachaknavi, who lived in the 6th century BCE was a prominent scholar in the field of astronomy and was known for her expertise in

the Vedas, the ancient Hindu scriptures. She is also credited with making important contributions to the development of Indian philosophy.

After independence, the literacy rate for women in India was very low, with only about 8% of women being able to read and write (Census, 2021). Although significant progress has been recorded in literacy rates for both genders the notable gap persists in this regard. As per the National Statistical Office (NSO), In the year 2017-18, the female literacy rate was 70.3%, compared to the male literacy rate of 84.7% in India. The government of India recognized the importance of education for women and made efforts to improve access to education through various policies and programs. Women's participation in STEM fields in India has been increasing in recent years, but there is still a significant gender gap in these fields. According to a report published by the Indian government in 2020, women make up only 14% of the total workforce in STEM fields in India. Several factors contribute to this gender gap. One issue is the lack of opportunities for girls to receive a quality education in STEM subjects, especially in rural areas. Another issue is the persistence of gender stereotypes and biases, which can create a hostile or unwelcoming environment for women in STEM fields. Additionally, many women face societal pressure to prioritize marriage and family over their careers.

To address these challenges, various initiatives have been launched to encourage and support women in STEM in India. Besides, scholarships and mentorship programs for girls and women interested in STEM fields by many organizations the government has made several provisions to correct the gender biases in the schemes such as *Beti Bachao, Beti Padhao* (Save the Girl Child, Educate the Girl Child) scheme.

The government of India has launched several initiatives especially to promote STEM education and research in the country. Here are some examples :

1. **Atal Innovation Mission (AIM) :** It was launched in 2016. AIM is a flagship initiative of the Indian government to promote innovation and entrepreneurship among students, especially in the fields of science and technology. Under AIM, the government has set up Atal Tinkering Labs (ATLs) in schools across the country to provide students with access to tools and resources for hands-on learning and innovation.

2. **Rashtriya Avishkar Abhiyan (RAA) :** Launched in 2015, RAA is an initiative to promote scientific temper among students and encourage them to take up careers in science and technology. Under RAA, the government has set up science clubs in schools and organized science exhibitions, workshops, and other events to encourage students to explore and innovate.
3. **Prime Minister's Research Fellowship (PMRF) :** Launched in 2018, PMRF is a scheme to encourage research in cutting-edge areas of science and technology. Under PMRF, selected students are provided with a fellowship of Rs. 70,000 to Rs. 80,000 per month for a period of five years to pursue research in premier institutions in India.
4. **IMPRINT India :** Launched in 2015, IMPRINT India is a joint initiative of the Indian government and the Indian Institutes of Technology (IITs) to address the major engineering challenges facing the country. Under IMPRINT India, the government has allocated funds to support research in areas such as healthcare, energy, and security.
5. **Uchhatar Avishkar Yojana (UAY) :** Launched in 2015, UAY is a scheme to promote industry-academia collaboration in the field of engineering and technology. Under UAY, selected engineering colleges are provided with funds to set up Centers of Excellence in emerging areas of engineering and technology, and to collaborate with industries to develop innovative solutions to real-world problems. These initiatives are aimed at promoting STEM education, research, and innovation in India and encouraging more students to pursue careers in these fields.
6. **I-STEM (Indian Science Technology and Engineering facilities Map) :** Women in Engineering, Science, and Technology (WEST), a new I-STEM (Indian Science Technology and Engineering facilities Map) initiative called "Women in Engineering, Science, and Technology (WEST)" was launched by the Government of India on 5th September 2022. The WEST program will cater to women with a STEM background and empower them to contribute to the science, technology, and innovation ecosystem. I-STEM is a national web portal for sharing research equipment/facilities and is the umbrella under which many programs for promoting collaborations in R&D and

technological innovation among and between academia and industry, especially startups, are underway. Through the WEST initiative, I-STEM shall provide a separate platform to scientifically inclined women researchers, scientists, and technologists for pursuing research in basic or applied sciences in frontier areas of science and engineering. Women may join the WEST program and explore opportunities to become stakeholders in various domains and pursue careers in R&D at various levels: technicians, technologists, scientists, and entrepreneurs. Opportunities range from operating scientific equipment and maintaining them to designing and manufacturing them. The Skill Development programs under the WEST initiative will provide training for women with S&T backgrounds to brush up on their abilities and become engaged "in the field" as lab technicians and maintenance engineers, filling crucial gaps in the R&D infrastructure of the country. This initiative will also help bring women back into S&T domains after a career break. With this experience, women can become entrepreneurs to serve as consultants for the operation and maintenance of sophisticated equipment/instruments through the I-STEM platform. This would go a long way towards filling a "skills gap", and putting publicly-funded equipment to good use. Under the WEST initiative, the current support being provided to S&T startups by women entrepreneurs by I-STEM will be enhanced. The access to R&D facilities and R&D software platforms (COMSOL, MATLAB, LABVIEW, AUTOCAD) available through the I-STEM portal will form a strong support network for women entrepreneurs in S&T. I-STEM shall provide a platform/forum for women researchers to deliberate on achievements, issues, and exchange ideas on taking the country forward through advances in science, technology, and innovation. In addition, a digital consortium "Connect Quickly" for an online discussion and immediate support has also been established through the I-STEM WhatsApp and Telegram platforms. A dedicated team of women will ensure the successful implementation of the WEST initiative.

7. Analysis and Results

Given the above analysis, it becomes pertinent to assess the impacts of the policies on the ground. For this, I have compiled and

calculated the share of women in the total enrollment in STEM from 2016-17 to 2020-21 from AISHE data.

Table -1 : Women's Participation in Stem (in %)

Period	Engineering and Technology	Science	STEM
2016-17	28.9	49.0	39.9
2017-18	29.0	50.0	40.9
2018-19	29.3	52.4	42.4
2019-20	29.5	53.1	43.2
2020-21	29.3	53.1	43.2

Note : Authors' own calculation from the AISHE data (AISHE, 2021)

It is evident from the data presented in above table that women's share in STEM enrollment has shown increasing trends in the last six years. However, despite improvement in enrollment, engineering and technology remained to be male-dominated field while the share of women in science enrollment has surpassed their male counterparts, particularly during and after the COVID pandemic. Findings are against the common perceptions that it was the women group which suffered most during the pandemic owing to the inaccessibility of the technology. Our finding suggests that women have made better use of technology such as online lecture, material, and classes. The schemes launched in the recent past seem to be successful in bridging the gender gap in STEM enrollment. This trend also indicates that women have accepted the challenges of Industrial revolution 4 and see their future in the STEM fields.

8. Conclusion

Pranab Mukherjee had rightly observed that real empowerment of women would be possible only through education, encouragement of economic self-dependence and provisional of opportunities enabling the unfolding of one's full potential. The 21st century is perceived to be a knowledge society in which technology would play an important role in the lives of the masses. Indeed, the success of the industrial revolution four would depend on the preparation of the infrastructure including labor force for adopting and leading the changes in which institutions would have to play a critical role. Certainly, the participation of women in STEM cannot

be ignored. Nonetheless, women have broken the glass of the barriers and increasingly participating in cutting-edge technology and STEM courses. However, policymakers, educators, and industry leaders continue to prioritize efforts to increase women's participation in STEM fields and address the barriers that have historically limited women's access to these fields.

Footnote

The Second Industrial Revolution, which took place from the late 19th century to the early 20th century, was a period of significant technological advancement that led to the widespread adoption of electricity, the development of new communication technologies, and the rise of industrial giants. This period also saw a significant increase in the participation of women in STEM (science, technology, engineering, and mathematics) fields.

References

Crawford, M., "Engineering still needs more women", ***American Society of Mechanical Engineers***, September 12, 2012. Available at http://www.asme.andorg/career-education/articles/undergraduate-students/engineering-still-needs-more-women.

Crosnoe, R., Riegle-Crumb, C., Frank, K., Field, S. & Muller, C., "Peer group contexts of girls' and boys' academic experience", ***Child Development***, 79(1), 2008, 139-155.

Dasgupta, N. and Stout, J. G., "Girls and women in science, technology, engineering, and mathematics : STEMing the tide and broadening participation in STEM careers", ***Policy Insights from the Behavioral and Brain Sciences***, 1(1), 2014, 21-29.

Eccles, J. S., (2014). "Gendered socialization of STEM interests in the family", ***2nd Network Gender & STEM Conference***, Berlin, Germany. Retrieved from file:///C:/Users/anreink/Downloads/419-29 43-1-PB.pdf.

"India has more women STEM grads than US, UK or France", ***Times of India***, July 20, 2022. Available at https://timesofindia.indiatimes.com/india/india-has-more-women-stem-grads-than-us-uk-or-france/articleshow/84571128.cms

PIB, "Women in Engineering, Science, and Technology (WEST) : Launching of a new I-STEM initiative". (5th September, 2022). Available at https://pib.gov.in/PressReleasePage.aspx?PRID=1857175#:~:text=Through%20the%20WEST%20initiative%2C%20I,areas%20of%20science%20and%20engineering

Reinking, Anni K. and Barbara Martin, "The Gender Gap in STEM Fields: Theories, Movements, and Ideas to Engage Girls in STEM", ***Journal of New Approaches in Educational Research***, 7(2). July 2018, 148-153.

Schwab, Klaus, ***The Fourth Industrial Revolution***, London : Penguin Books Ltd, 2017.

Shapiro, J. R. and Williams, A. M., "The role of stereotype threats in undermining girls' and women's performance and interest in STEM fields", ***Sex Roles***, 66, doi:10.1007/s11199-011-0051-0

UNICEF, "Towards an equal future: Reimagining girls' education through STEM". (2020) Available at https://www.reimagining-girls-education-through-stem-2020.pdf ★

Article Received on February 18, 2023; Accepted on March 08, 2023