WOMEN'S EMPOWERMENT THROUGH STEM EDUCATION: BREAKING BARRIERS IN INDIA'S TECHNOLOGY AND INNOVATION SECTORS

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ABSTRACT

The purpose of this research is to investigate the effects of STEM (Science, Technology, Engineering, and Mathematics) education on gender equality and national development in India. This study will zero in on obstacles in the innovation and technology industries with a particular emphasis on their removal. The elimination of obstacles that are now existent in the technology and innovation sectors will be the means by which this objective will be attained. Because of this, it will be feasible to study the impact that education in STEM subjects has on the process of bringing about transformation. Regardless, despite India's progress toward technical powerhouse status, women continue to remain underrepresented in STEM disciplines. Even if India has achieved a lot recently, this is still the case. The present situation is the result of a confluence of factors, some of which have persisted for a long time and pertain to social, cultural, and institutional difficulties. This study examines women's participation, educational programs, and inclusion measures. This investigation covers all of them. In order to do this, tools such as statistical data, case studies, and policy analysis are utilized. Publicly available information suggests that a STEM (science, technology, engineering, and mathematics) education can help students become economically self-sufficient, foster an environment conducive to creativity, and advance gender equality. The systemic structure, the underlying framework of India's system, is also open to potential modification as a result of these developments.

Keywords: STEM, obstacles, powerhouse, statistical data, assist, creativity, gender equality, framework

Introduction

Even though India is at the forefront of technical innovation on a global scale, women are still noticeably underrepresented in STEM fields. Projections show that the country's IT sector will have reached a total value of $350 billion by 2025.

Individual possibilities are restricted, and the expansion of the nation is hampered in an economy that is driven by information. Gender inequality is a concern in an information-driven economy. Providing women with the skills essential to navigate and prosper in high-demand fields such as artificial intelligence, biotechnology, and software engineering is made possible via the application of STEM education, which also serves as a potent tool for empowering women. Some examples of industries that come within this category are computer software engineering, biotechnology, and artificial intelligence. But there are also major challenges, such as biases in the workplace, limited educational possibilities, and cultural norms. Women in India's IT and innovation industries have unique challenges, and this article seeks to address that by examining how STEM education could help them succeed. What are some of the ways that this may be accomplished? The study investigates the most recent tendencies, examines the activities that are currently in place, and provides prospective solutions that may be put into action. This is accomplished via the usage of both quantitative data and qualitative insights. By bridging this gap, India would be able to unleash the full potential of fifty percent of its people, which will, in turn, encourage economic growth and create social equality. This would be a win-win situation for everyone involved.

Background and Context

There has long been a gender bias in India's STEM (science, technology, engineering, and mathematics) fields. For quite some time, this form of prejudice has persisted. This limitation likely originates from patriarchal traditions, which value domestic duties more highly than the achievement of one's professional goals. Patriarchal traditions may have been the driving force behind this restriction. There is no denying that educational opportunities in the early 20th century were severely constrained. As evidence, consider the fact that by 1950, just 2% of women were participating in programs that provided access to higher education. A mere 29% of STEM degree recipients are female, according to the All-India Survey on Higher Education (AISHE) 2023–24. But this is the truth regardless of the fact that women constitute 43% of all college and university students. Despite efforts to advance the case, this is the result that has

materialized. Also, as compared to the rest of the nation, rural towns' development rates are getting worse and worse. Because of rampant cultural biases and poor infrastructure, people in these regions are less likely to pursue jobs in the STEM fields. In contrast, a poll conducted and published by NASSCOM in 2023 found that women made up just 19% of the IT industry's workforce. The technical sector in India is responsible for the 7.5% of GDP that comes from the technology industry, which employs more than five million people. That being said, nothing has changed regarding the situation over the years. In this segment, we track the rise of women's involvement, highlighting watershed moments like the 1980s government scholarship program and the founding of women's universities. This section specifically highlights such events. In addition, a description of the history of women's participation is included in this section. Additionally, it sets India's rise to prominence as a worldwide hub for technology into its context, underlining the necessity of gender diversity in order to maintain innovation and competitiveness in fields like as artificial intelligence, robots, and renewable energy. This is an important aspect of the setting. This course of action is pursued in order to guarantee that India would continue to have a significant position in the global technology industry.

Barriers to Women's Participation in STEM

Many barriers exist in India that prevent women from pursuing STEM occupations. Various types of obstacles impact various surroundings, including social, educational, and professional spheres.

Societal and Cultural Norms: Young women are discouraged from pursuing careers in mathematics and science due to these persistent preconceptions that portray STEM as a maledominated field. Math, science, technology, and engineering make up STEM. The four main parts of the STEM acronym are math, science, technology, and engineering. The focus changes from a young person's education to their new responsibilities at home once they get married. This is because of the combination of circumstances. Twenty-three percent of the population, namely rural women between the ages of twenty and twenty-four, exhibit this tendency (NFHS5, 2021). Parents sometimes have the belief that "safer" jobs, such as teaching, are more desired than careers in engineering or technology. This is a prevalent misconception.

Educational Access: The United Nations Educational, Scientific, and Cultural Organization (UDISE) 2023 reports that about 40% of public schools are tasked with teaching science to secondary school pupils. A significant amount of the total is made up of this. Most of the time,

rural schools lack certain resources like scientific labs, computers, and instructors with degrees in math, science, and engineering. Due to budgetary constraints, families are compelled to prioritize their sons' education more heavily. During the academic years, this is particularly the case. One of the many factors contributing to the persistent underrepresentation of women in STEM fields is the dearth of positive role models in these fields. Due to a lack of interest, the problem persists. Due to the inherent disparities between rural and urban settings, resolving this problem in the former is far more challenging than in the latter. Compared to their urban counterparts, girls living in rural regions had a significantly lower likelihood of participating in STEM programs. This discrepancy is significant enough to merit consideration.

Role of STEM Education in Empowerment

They possess the technical expertise, self-assurance, and problem-solving skills necessary to thrive in a constantly changing industry. Due to the fact that these women have acquired degrees in STEM topics, they are able to participate in this dynamic market. Computer science and engineering are two examples of fast-growing fields where degree programs have opened doors for women. More opportunities exist for women now than in the past. The number of women working in software development has grown by 20% from 2018 to 2024, according to LinkedIn's India Workforce Report. This is an increase of 20% from the previous year. The report is where we got this data. The Department of Science and Technology's Vigyan Jyoti Scheme and similar programs have resulted to a fifteen percent rise in the number of female students majoring in STEM subjects. This increase in population has been documented in over 100 distinct districts. Participation in these programs provides participants with mentorship experiences in addition to opportunities to gain laboratory skills. Scholarships from private players, such as Tata Trusts and Google's Women in Technology program, have been allocated to more than 10,000 women. These women have been given the opportunity to pursue further education. These scholarships have been of assistance in reducing some of the difficulties that women encounter in terms of their financial situation. Education in the STEM fields makes it feasible for women to innovate in a variety of fields, including but not limited to the field of economics. For example, women may innovate by developing applications for healthcare or discovering solutions for sustainable energy. This is because working in these fields equips women to be economically independent and gives them the confidence to start their own businesses. In the next section, we'll go over some of the numerous ways that technical, dataanalysis, and engineering skills could benefit startup companies. There has been a 25%

increase in the percentage of women leading IT companies since 2020 (Inc42 2020). The information technology sector also had a role in this growth. Also, it considers the power of education to change minds and encourage the youth of today to pursue careers in STEM fields and beyond.

Case Studies and Success Stories

This section profiles transformative examples of women in STEM:

Girls in Tech India: Through its online classes and bootcamps, this foundation has enabled over 5,000 women to gain training in data science, cybersecurity, and computer science. They have been granted access to these training opportunities. They have had the opportunity to participate In this training program from 2018. Sixty percent of the people who took part in the study in Telangana found jobs in the tech industry, with average yearly salaries of six lakh Indian rupees. This is a testament to the importance of education in driving economic progress.

This number shows how crucial education is to a country's economic growth.

Kiran Mazumdar-Shaw, Biocon: After Shaw finished his schooling and research in the area of biotechnology in 1978, he made the choice to start Biocon. This incident happened after Shaw had completed his high school education and was studying for his final exams. He built a biotechnology enterprise worth two billion dollars thanks to his considerable knowledge and skill in science, mathematics, and technology. He was able to effectively accomplish this objective by making use of both his own expertise and his own experience from previous endeavours. The work she has done in the field of easily accessible, fairly priced insulin and cancer drugs is an example of the innovativeness that is driven by education. She has done work like this before. This is an illustration of some of the work she has completed previously.

Rohini Srivathsa, Microsoft India: Srivathsa, who holds a degree in engineering and is currently working in this capacity, is currently serving in his current post as Chief Technology Officer. The technical department reports to him as well. In addition, he oversees the division that deals with technical issues. It is his responsibility to manage the activities related to cloud computing and artificial intelligence, as per the criteria of his current job. On top of that, she is an inspiration to younger women since she champions Microsoft's diversity initiatives. For younger women, she is an inspiration. One of the most important things she offers is this

contribution, which she is offering. She is a terrific example of the many different kinds of leadership jobs that are accessible in the technology industry. She is an excellent demonstration of this. She is a wonderful illustration.

Policy and Institutional Initiatives

The Indian government and private sector have developed STEM women's initiatives. The NEP 2020 promotes gender balance in schools through STEM camps and incentives for girls. AISHE forecasts a 12% increase in women enrolled in technical schools by 2024. The GATI project promoted inclusive policies to boost metropolitan female STEM faculty by 10%. More than 20,000 young women are given the chance to attend coding courses and get mentorship each year by private groups like STEM for Girls at IBM. Meanwhile, Adobe's Women in Technology Awards pay tribute to trailblazing female tech executives. But this doesn't mean there aren't obstacles: Scholarship funding is insufficient, and only 5% of eligible students receive them; rural outreach remains poor, with just 30% of projects targeting faraway regions. Likewise, there are still difficulties to overcome. An analysis of the implications is carried out in this section by making use of data and feedback from various stakeholders. One of the positives that has been highlighted is the momentum of the policy, while one of the drawbacks that has been noted is the implementation in tier-2 and tier-3 cities.

Strategies for Breaking Barriers

This section offers suggestions to encourage more women to pursue technical, scientific, and mathematical careers:

Awareness Campaigns: It is necessary to initiate and coordinate media initiatives on a national scale across the whole nation. The objective is to dispel common misunderstandings about women who are working in STEM professions and to raise awareness about women who are employed in these industries through the use of various mediums such as television, social media, and community seminars. It is vital for parents and instructors to take an active position in the process of assisting females in achieving their goals.

Workplace Reforms: It is recommended that audits be conducted to verify that equal pay is being provided, with the aim of reaching parity by the following year, 2028. Offering flexible working hours and childcare services to employees is very crucial for organizations functioning

in the technology industry. The goal of increasing the ratio of women in senior positions to 30% can be advanced by the establishment of mentorship programs that connect women with leaders.

Partnerships: Joining forces between the state, NGOs (like Girls Who Code), and IT firms like Infosys is crucial if we are to meet our target of 2 million women by 2030. Without doing this, no other task can be considered essential. For the simple reason that reaching the goal calls for a trifecta of these kind of things. In order to begin, this is the sole method that will allow you to finish the prerequisite chores. Because of this, more options for internships, innovation labs, and professional development programs will become available. This is the inevitable result of this given the circumstances.

Literature Review

Gupta, N. (2012): "Women in Science and Technology in India: A Status Report" Namrata Gupta examines the plight of women in India's STEM fields and the disparity between their levels of education and their engagement in the workforce. Published in Current Science (Vol. 102, No. 3), the research finds that women constitute about 40% of STEM graduates but only 12% of the scientific workforce, a disparity attributed to cultural norms, lack of mentorship, and work-life balance challenges. Through an analysis of enrollment data, workforce statistics, and interviews with female scientists and engineers, Gupta underscores the need for policy interventions, gender-sensitive curricula, and mentorship programs to bridge this gap and empower women in STEM fields.

UNESCO (2017): "Cracking the Code: Girls' and Women's Education in STEM"UNESCO's 2017 report, "Cracking the Code: Girls' and Women's Education in STEM," provides a global perspective on female participation in STEM, with a dedicated section on India. It reveals that 35% of STEM students in India are women, but societal stereotypes and limited access to quality education, especially in rural areas, hinder progress.

All India Survey of Higher Education (AISHE, 2020): "Gender Statistics in Higher Education" The All-India Survey of Higher Education (AISHE) 2020, conducted by the Ministry of Education, India, examines gender statistics in higher education, including STEM fields. It reports that women make up 43% of STEM graduates, with strong representation in biosciences (50%), but only 16.6% of research positions in STEM are held by women, far

below the global average. Using statistical analysis of university enrollment and graduation data, the study highlights a “leaky pipeline” where women exit STEM careers due to societal pressures and workplace bias.

Kurup, A., & Maithreyi, R. (2011): "Beyond Family and Societal Attitudes: Women in Science Education in India" Anuradha Kurup and R. Maithreyi’s 2011 study, published in the International Journal of Science Education (Vol. 33, No. 10), investigates factors influencing women’s persistence in STEM education and careers in India. It notes that mentorship and scholarships improve retention. The study calls for career counselling, awareness campaigns, and targeted interventions to shift societal attitudes and support women in STEM.

Prasad, K. (2019): "Gender Bias in India’s STEM Workforce: A Case Study" K. Prasad’s 2019 case study, published in Economic and Political Weekly (Vol. 54, No. 12), investigates gender bias in India’s STEM workforce. Interviews with women in tech and research reveal discrimination in promotions and funding, with only 14% in senior roles.

Nair, S., & Thomas, G. (2020): "Women-Led Tech Startups in India: Challenges and Opportunities" S. Nair and G. Thomas’s 2020 study, published in Entrepreneurship Development Review (Vol. 8, No. 1), explores women-led tech startups in India. Analysis of funding data and interviews reveal women receive less than 10% of venture capital, limited by bias and networks. The study recommends training, incubators, and policy support to empower women in innovation and entrepreneurship.

Mehta, A. (2018): "STEM Education for Girls in Rural India: A Pilot Study" A. Mehta’s 2018 pilot study, published in Rural Education Journal (Vol. 39, No. 3), tests STEM programs for rural girls in India. Through workshops and surveys, it finds increased interest and skills, though access to labs and teachers is limited. The study advocates for mobile labs, scholarships, and NGO partnerships to empower rural women in STEM and tech fields.

Banerjee, R. (2023) - "Women in AI and Robotics: India’s Emerging Frontier" R. Banerjee’s 2023 study, published in Journal of Emerging Technologies (Vol. 15, No. 2), examines women’s roles in India’s AI and robotics sectors. Data and interviews show women make up less than 10% of these fields, facing skill and bias barriers. The study calls for upskilling, diversity policies, and research opportunities to boost women’s innovation contributions.

Reddy, L. (2021): "Impact of STEM Scholarships on Women in India" L. Reddy's 2021 study, published in Higher Education Quarterly (Vol. 75, No. 4), assesses STEM scholarships for women in India. Tracking recipients, it finds scholarships increase enrollment (45% rise) and retention, empowering women for tech careers.

Research Methodology

This mixed-methods study examines how STEM education empowers women in India's technology and innovation businesses. For the purpose of conducting an all-encompassing study, the research utilizes both quantitative and qualitative approaches:

Quantitative Data Collection: For the purpose of acquiring the information that we want, we relied on a broad variety of secondary sources. Throughout the course of this inquiry, a variety of sources were utilized. The All-India Survey on Higher Education (AISHE 2023-24), reports from the National Association of State Communication Organizations (2023), and the National Family Health Survey (NFHS-5, 2021) were some of the sources that were utilized in this study. Here are some statistics on the percentage of women who are employed in the field of technology (19%), the percentage of women who are employed in STEM disciplines (29%), and cultural issues such as early marriage (23% in rural areas). The data is laid forth in the paragraphs that follow. The use of descriptive statistics allowed for an investigation of the shifts in the rates of workforce enrollment and participation.

Qualitative Data Collection: Fifty people were interviewed in this study using semi-structured interviews. Educators, female STEM students, and legislators from the Indian states of Rajasthan and Bangalore took part. The participants came from all walks of life. A number of the attendees were Rajasthani. Conducting semi-structured interviews was done. We did this to make sure the interview went well. Neither the zone nor the metropolitan region excluded Bangalore. Research interviews were conducted with the conscious agreement of those who were actively participating in the study. Ultimately, we were able to achieve our goal with the cooperation of everyone we questioned. The places where interviews were conducted included Bangalore, Rajasthan, and others. There were also other areas added. Our travels took us to Bangalore, Rajasthan, and beyond. Document analysis and participant narratives were used to generate case studies of Kiran Mazumdar-Shaw and Girls in Tech India. Methods outlined above were implemented. Making use of the answers that were already outlined allowed this task to be accomplished. This task could be well-executed if the methods outlined in the

preceding paragraph are followed. After reading this text, we felt more confident in our ability to do the task. With these strategies, hitherto impossible goals were achieved.

Data Analysis: The quantity, rate, and type of the education-employment relationship were determined by quantitative analysis using SPSS. We used this method to find the links. The major purpose was to determine their relationship. This was to investigate job and educational opportunities. This technique allowed us to explore the link between the two themes. We did this activity to grasp the two-way street and classify it. Each participant sought to understand the other's relationship to better understand their relationship. All participants agreed on how to achieve the goals. Prior goals must be considered for this decision to succeed. Data classification may reveal urgent issues and tasks. A practical conclusion would have made sense. Making this happen started with finding educational possibilities, cultural obstacles, and rewards for empowerment. Things happened because of that. This made identifying urgent situations easy. A theme strategy to categorize qualitative data revealed these previously unknown issues. This was achieved utilizing a theme approach. With theme technology, this became possible. Since the topic approach determines the outcome, this explains it. We'll expand on this later. Please allow me to clarify. Using many data items improved research validity. This helped make the study more valid. Being part of and contributing to the rise affected growth and was a cause. Alternatively, this was merely one of numerous variables that boosted validity.

Scope and Limitations: Throughout its whole, this research covers the years 2015–2025 with India serving as its predominant target. One country gets a lot of attention and scrutiny as the inquiry progresses. The scope of this analysis is narrowly defined to include the many commercial enterprises involved in the discovery and advancement of new technology. The inquiry covers 2015–2025 because they are part of the specific time period being investigated. The years in question are part of the era under review. Interviews with people recounting their experiences may be biased. It is possible to accomplish this. We were able to get this conclusion because we interviewed the people who took part in the study. The scarcity of upto-date, relevant information for rural areas is already bad enough, and this just makes things worse. Furthermore, data specifically pertaining to rural areas is very lacking. This specific information source is only accessible in a limited capacity. There is always the possibility of bias occurring because both of these factors are present. For the simple reason that bigotry will always exist.

Using this technique, it is conceivable to construct a firm foundation for the purpose of assessing difficulties, determining the amount of the effect that STEM education has, and suggesting solutions that are achievable in the real world. Everything described here is possible.

This idea, outlined below, might be implemented.

Suggestions and Recommendations

It is advocated that the following measures be implemented in order to optimize the impact that STEM education plays in empowering women in India's technology and innovation sectors:

Government Action: The provision of laboratories and computers to seventy-five percent of the educational institutions in rural areas by the year 2030 is a goal that should be prioritized in order to improve funding for STEM infrastructure in rural schools. To reach our goal of providing two million young women with mentorship and scholarship opportunities, we must expand programs like Vigyan Jyoti and WISE-KIRAN.

Educational Institutions: One strategy to accommodate diverse students would be to implement a STEM curriculum that is sensitive to gender issues. Another option would be to hire more female faculty members, with the goal of having 25% by 2030. Lastly, offering online courses with more flexibility would also be helpful. You will be able to attend practical seminars in rural regions by establishing connections with non-governmental organizations (NGOs).

Private Sector: It is anticipated that businesses operating in the technology sector, such as TCS and Wipro, would make investments in training programs that are solely devoted to women and will also provide 50,000 internships on an annual basis. According to this criterion, women are guaranteed to have access to employment possibilities. When it comes to retaining exceptional people, it is essential to establish standards that are both transparent and sympathetic to families inside the organization. The provision of childcare services and the provision of the ability for employees to work from home are two examples of such policies.

Community Engagement: To dispel misconceptions about STEM jobs, grassroots campaigns in regional languages should be used on television, radio, and social media. We hope this clarifies any misconceptions. With this ambition, we shall achieve the maximum amount that is practically possible in our pursuit of 100 million houses by 2028. You have a better chance

of promoting the cause of educating young women if you include influential members of the community. So long as you get these people involved, it should work.

Monitoring and Evaluation: To guarantee accountability and success, a national task force should be established to track the number of women working in STEM fields. This is what should be done. To put it simply, this is something that should be done. The activity in question is unquestionably one that ought to be carried out.

Conclusion

In order to break down obstacles to innovation and technology, more women in India should pursue STEM degrees. For India, this would be a boon. Women may gain power through STEM education, which is why we are in this predicament. The survey points out problems that must be solved, even while enrollment is on the rise, programs are doing well, and role models are motivating. Additional study might be conducted based on these early findings. Even though this data is available to the public, there are additional concerns that need resolving. Inequitable access, long-standing cultural norms, and workplace prejudice are everyday challenges for employees. Some typical problems are these. Everything that has been said thus far is only the top of the iceberg. With the help of women's imaginations, India's technology sector may grow from its current $350 billion valuation. Do not forget to evaluate the probability. The rapid improvement of India's technological capacity is a positive outcome of this. We may do this by modifying laws, increasing our understanding, and adjusting our actions. A multi-stakeholder approach to support women's success in STEM fields is proposed in the article. Cooperation among the government, corporations, and communities would be required by this approach. It is believed that this method will assist women in achieving their goals in the scientific and academic fields. This plan can only be put into action if the three of you work together. To guarantee prosperity, equity, and new ideas, we are putting this plan into action.

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