CODING CHANGE: THE SOCIAL IMPACT OF STEM EDUCATION IN EMPOWERING WOMEN

Maria Boaler
Research Scholar RRC, Department of Management Studies,
Centre for PG Studies, VTU & Assistant Professor,
School of Management Studies, REVA University,
maria.boaler@reva.edu.in

Dr. Pankajakshi. R
Associate Professor, Department of Management Studies,
Centre for PG Studies, VTU
pankajavtubng@gmail.com

Abstract
In an era defined by technological innovation, the inclusion of women in Science, Technology, Engineering, and Mathematics (STEM) has emerged as a cornerstone for achieving gender equality and driving sustainable development. This chapter explores the transformative power of STEM education as a tool for social impact, with a particular focus on empowering women from marginalized and underrepresented communities. By examining grassroots initiatives, policy frameworks, public-private partnerships, and community-driven approaches, the chapter highlights how targeted STEM programs have not only enhanced educational outcomes for women but also contributed to broader social change. Through case studies and impact assessments, the chapter identifies key success factors and challenges in leveraging STEM education for gender empowerment. It underscores the importance of culturally sensitive curricula, mentorship opportunities, and access to resources in creating inclusive pathways for women in STEM. Ultimately, this chapter advocates for a holistic, equity-focused approach that recognizes the socio-cultural contexts in which STEM education operates and aligns technological advancement with social justice.

Keywords: *STEM education, gender empowerment, social impact, women in technology, inclusive education, equity in STEM, digital inclusion, community engagement, education policy, sustainable development.*

1. Introduction

The 21st century has witnessed a remarkable acceleration in technological advancements, reshaping industries, economies, and societies. However, despite this progress, the gender gap in STEM fields remains a persistent barrier to equitable participation in innovation. Women, particularly in developing nations and underserved communities, continue to face systemic obstacles to accessing quality STEM education and related career opportunities. Globally, women account for only 28% of the workforce in science and engineering roles, according to UNESCO's 2023 Science Report. The disparity is even more pronounced in leadership and advanced research positions. In developing nations, the challenges are amplified by structural inequalities, limited access to quality education, cultural norms, and socioeconomic constraints. For instance, in Sub-Saharan Africa, less than 30% of STEM researchers are women, and the gender digital divide remains a critical issue, with women being 20% less likely to use mobile internet compared to men (GSMA, 2022). According to a

UNESCO report, only 35% of STEM students in higher education globally are women, and differences are observed within STEM disciplines. According to a report by the National Science Foundation, women make up only 14% of the total workforce in STEM fields in India. Furthermore, a study conducted by UNESCO found that only 35% of STEM students in higher education in India are women. These statistics highlight the urgent need for greater efforts to promote and support women's participation in STEM.

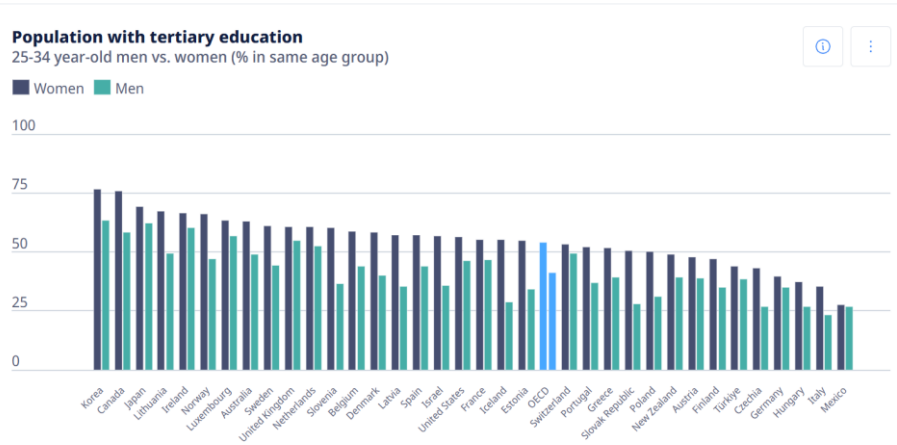

Fig 1: "Population with tertiary education: 25–34 year-old men vs. women (% in same age group)"

Source: OECD (2023), Education at a Glance 2023: OECD Indicators, OECD Publishing, Paris.

The chart titled "Population with Tertiary Education: 25–34 Year-Old Men vs. Women" highlights the percentage of young adults across various countries who have attained tertiary education, categorized by gender. It reveals a consistent trend: women aged 25–34 is more likely than men to hold a university or college degree in nearly all countries. This gender gap is especially pronounced in nations like Estonia, Latvia, and Lithuania. Countries such as South Korea and Canada show the highest overall attainment among women, while Mexico, Italy, and Hungary report the lowest for both genders. The OECD average reflects this global pattern, with roughly half of women and fewer than 40% of men holding tertiary qualifications, indicating progress for women but also signalling the need to address male educational attainment.

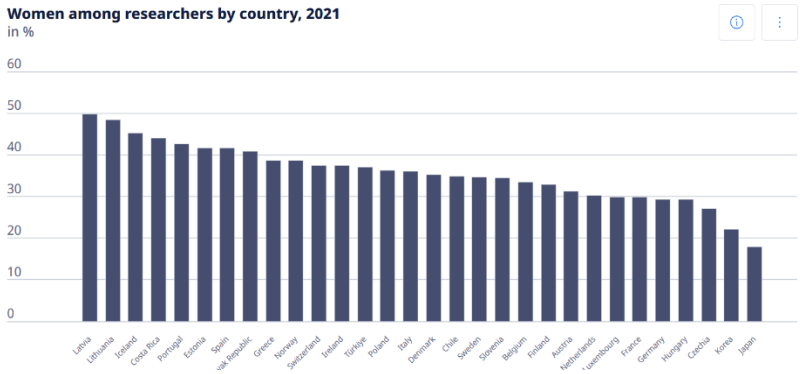

Fig 2: Women Among Researchers by Country, 2021

Source: OECD (2023), Education at a Glance 2023: OECD Indicators, OECD Publishing, Paris.

ISBN: 978-93-6163-902-9

The bar chart illustrates the percentage of women researchers across countries in 2021, highlighting global gender disparities in research careers. Latvia, Lithuania, and Iceland report the highest female representation, nearing 50%, while countries like Costa Rica and Portugal also exceed 40%. In contrast, nations such as France, Germany, and Hungary show more moderate female participation at around 30%. The lowest proportions are seen in Czechia, Korea, and Japan—where women comprise just about 20% of researchers. The data underscores the ongoing need to enhance gender diversity in research, especially in countries with significant gender imbalances.

These figures highlight the urgent need to reimagine STEM education as more than a pipeline to technical careers—it must also be viewed as a transformative tool for social change. This chapter contends that when STEM education is delivered through a social impact lens, it can serve as a powerful catalyst for women's empowerment, economic mobility, and the broader transformation of underserved communities. By integrating real-world challenges, community engagement, and inclusive pedagogies, STEM initiatives can foster not only technical skills but also leadership, resilience, and civic responsibility among women and girls. This chapter contends that STEM education—when applied through a social impact lens—can serve as a powerful catalyst for women's empowerment and community transformation.

2. Theoretical Framework

Empowerment theory and social constructivist learning models form the foundation of this chapter. Empowerment theory emphasizes enhancing individuals' control over their lives through access to knowledge, resources, and decision-making capabilities. Meanwhile, social constructivism views learning as a collaborative, context-driven process, which is particularly relevant when considering how women interact with STEM education in different cultural settings.

Together, these frameworks suggest that STEM education must not only deliver technical skills but also foster critical thinking, agency, and a sense of social responsibility among female learners.

3. Barriers to Women's Participation in STEM

Women's participation in STEM fields continues to be hindered by a range of structural and societal barriers that begin early and persist throughout their educational and professional journeys. One of the most pervasive challenges is the prevalence of gender stereotypes that subtly, yet powerfully, discourage girls from exploring STEM subjects from a young age. These stereotypes often portray STEM as a male-dominated domain, leading girls to internalize doubts about their abilities and potential in science, technology, engineering, and mathematics. Compounding this issue is the visible lack of female role models in STEM careers, which limits the aspirations of young girls who struggle to see themselves represented in these fields. Additionally, disparities in access to technology and quality STEM education—especially in rural, marginalized, or low-income communities—further restrict opportunities for girls to develop relevant skills and confidence. Cultural and societal

expectations also play a significant role, often emphasizing traditional roles and responsibilities for women over their professional ambitions, thereby reinforcing the gender gap. Effectively addressing these barriers requires a multifaceted approach that blends educational innovation with proactive community engagement and comprehensive policy reform. This includes integrating gender-sensitive pedagogy, creating mentorship opportunities, investing in equitable STEM infrastructure, and promoting inclusive narratives that empower girls to pursue and thrive in STEM pathways.

4. STEM Education for Social Impact: Models and Approaches

STEM Education works as an Empowerment Tool. This section explores different models where STEM education has been harnessed for social impact and women's empowerment:

4.1 Community-Based Programs

Community-based programs have emerged as powerful tools for bridging the gender gap in STEM by making science and technology education more accessible, inclusive, and relevant to local contexts. These initiatives are grounded in the idea that empowering women in STEM begins with meeting them where they are—both geographically and culturally. For instance, mobile STEM labs in rural India bring hands-on science experiments and interactive learning experiences directly to under-resourced villages, allowing girls who may not have access to formal laboratories or digital tools to engage with STEM in meaningful ways. These labs often collaborate with local schools and educators, fostering a supportive learning environment and sparking interest in science from a young age.

Similarly, robotics workshops in African townships aim to dismantle the notion that technology is only for urban elites. By involving young women in the design, construction, and programming of robots, these workshops provide practical skills and boost confidence, all while challenging traditional gender roles. In Latin America, localized coding bootcamps specifically tailored for women offer an intensive, skills-based approach to digital literacy and career readiness. These bootcamps often incorporate mentorship from female tech professionals and promote peer learning, creating a strong support network that extends beyond the classroom.

What unites these diverse programs is their commitment to accessibility, contextual relevance, and community ownership. Rather than imposing a one-size-fits-all solution, they adapt to the unique needs and challenges of the communities they serve, ensuring that STEM education is not only available but also empowering. These initiatives prove that when education is localized and inclusive, it has the potential to ignite lasting change and open doors for women and girls to participate fully in the digital and scientific future.

4.2 Public-Private Partnerships

Collaborations between governments, NGOs, and tech companies have produced scalable STEM initiatives such as Google's "Women Techmakers," UNESCO's "Girls Can Code," and Microsoft's "DigiGirlz" program.

ISBN: 978-93-6163-902-9

VIVO has also launched a digital campaign on International Women's Day that emphasizes the need to create a diverse workforce in STEM, showcasing the inspiring journeys of young women across India, determined to overcome challenges and pursue careers in STEM

As the gender gap in STEM fields remains a pressing challenge, especially for young women from underserved communities in India who lack access to opportunities and support. Recognizing this urgent need, VIVO India proudly launched project 'VIVO KanyaGyaan', a nationwide initiative dedicated to empowering Indian women for a future in STEM career.

4.3 Policy and Advocacy

Policy and advocacy play a critical role in creating systemic change to support and sustain women's participation in STEM fields. National education policies that explicitly mandate the inclusion of girls in STEM curricula have been instrumental in breaking down institutional barriers and promoting gender equity from early education onward. These policies often include measures such as curriculum reforms that challenge gender stereotypes, the integration of STEM subjects into primary and secondary education, and the inclusion of real-world applications to engage students, particularly girls, in science and technology.

Scholarship programs targeted at women in tech and other STEM disciplines are another effective policy tool. By removing financial barriers, these scholarships open doors for women who might otherwise be excluded from higher education or specialized training. In addition to covering tuition, many of these programs offer mentorship opportunities, internships, and networking platforms, which are crucial for career development and retention in male-dominated sectors.

Gender-sensitive teacher training is also essential. Educators play a pivotal role in shaping attitudes toward STEM, and when teachers are trained to recognize and address unconscious bias, they can foster a more inclusive classroom environment.

5. Case Studies of Successful Interventions

Several impactful initiatives around the world have successfully addressed gender disparities in STEM by focusing on mentorship, skill development, and inclusive access to education. These case studies offer valuable insights into scalable and sustainable strategies for empowering women in science and technology fields.

Case Study 1: **STEMinism in India: Empowering Rural Girls through STEM Education**

STEMinism in India is a grassroots initiative aimed at bridging the gender and geographical divide in STEM education by bringing coding and science learning opportunities to girls in rural and underserved communities. The program organizes STEM camps and workshops in rural areas, offering hands-on training in coding, robotics, and digital literacy. It partners with local schools to train female teachers as facilitators, ensuring cultural relevance and community support. Many participants report increased interest in science subjects, improved academic performance, and aspirations to pursue

ISBN: 978-93-6163-902-9

STEM careers. The program not only enhances education but also challenges traditional gender roles within conservative communities. The key outcomes of this program were it reached over 5,000 girls across five states, increased girls' enrolment in science subjects by 30% and developed peer mentorship models within villages.

Case Study 2: UNESCO – Girls' Digital Literacy Campaign

UNESCO has launched numerous initiatives to promote gender equality in STEM, including campaigns to improve digital literacy among girls and women in developing nations. One flagship program involves community-based digital skills training in Africa and Asia.By focusing on accessible technology and basic digital skills (like internet navigation, coding, and mobile literacy), UNESCO has empowered thousands of girls, especially in remote or conflict-affected regions. The training often includes modules on online safety, critical thinking, and career pathways in STEM. The key outcomes of this program were it trained over 50,000 girls in basic and intermediate digital skills,partnered with governments to integrate gender-sensitive STEM education policies and increased school retention rates among adolescent girls in target areas.

Case Study 3: Global Engineer Girls (GEG)

Fostering Women Engineers Across the Middle East and Balkans GEG is a global program launched by the Limak Foundation, supported by institutions like the World Bank and UNDP, to encourage girls to pursue careers in engineering. Active in countries like Turkey, Kosovo, and North Macedonia, GEG provides scholarships, mentorship, and internship opportunities to female engineering students.

The program selects high-achieving girls and supports them throughout their university studies. GEG also offers leadership and entrepreneurship training, connecting participants with female engineers and role models in the industry. It helps combat cultural biases that discourage women from entering engineering fields.The key outcomes of this program were it provided scholarships to over 200 engineering students.,achieved 95% program completion rate and increased job placement among graduates in engineering roles.

Case Study 4: Girls Who Code (USA): Bridging the Gender Gap in Computer Science:

Founded in the United States, Girls Who Code is a nonprofit organization dedicated to closing the gender gap in technology by equipping young women with the skills, resources, and confidence needed to pursue careers in computer science. Through free summer immersion programs, after-school clubs, and college-level initiatives, Girls Who Code reaches thousands of girls from diverse backgrounds across the U.S. The curriculum combines hands-on coding instruction with exposure to female role models in the tech industry, fostering both technical competency and a strong sense of community. The program has demonstrated measurable success, with many alumni continuing into STEM majors and careers, thus contributing to a more gender-diverse tech workforce.

ISBN: 978-93-6163-902-9

Case Study 5: AnitaB.org (Global): Supporting Women in Tech through Mentorship

AnitaB.org is a global organization that supports women and non-binary individuals in technology through advocacy, community building, and career development. One of its most influential programs is the annual Grace Hopper Celebration, the world's largest gathering of women technologists, which connects attendees with employers, mentors, and cutting-edge innovations. The organization also runs year-round initiatives focused on mentorship, professional training, and policy advocacy, helping women advance in tech-related fields. By combining research, grassroots efforts, and partnerships with academic and corporate institutions, AnitaB.org plays a central role in transforming the landscape for women in technology around the world.

Case Study 6: She Codes (Africa & Middle East): Upskilling Women for Digital Careers

She Codes is a rapidly growing movement in Africa and the Middle East aimed at empowering women through digital literacy and coding skills. The program offers intensive bootcamps, workshops, and online courses tailored to women with little to no prior experience in tech. She Codes focuses not only on technical training but also on creating safe, supportive learning environments that address the unique challenges faced by women in these regions, including societal norms and limited access to education. The initiative has helped thousands of women gain employment in tech, start entrepreneurial ventures, or pursue further education, thereby promoting economic independence and gender equity in digital industries.

Case Study 7 TechSHEro – Kenya

TechSHEro, a Kenyan NGO, runs mentorship programs and coding bootcamps in Nairobi's informal settlements. By pairing young women with female software engineers, they've seen a 60% enrollment increase in tech-based higher education programs among participants.

Global initiatives like Girls Who Code, STEMinism in India, UNESCO, and Global Engineer Girls (GEG) are leading efforts to make STEM education more accessible and inclusive, proving that with the right support, women can lead and shape the future through science and technology.

These case studies collectively underscore the importance of targeted, community-centered interventions that combine skills training with mentorship and advocacy. They demonstrate how well-designed programs can not only equip women with technical abilities but also foster networks of support and pathways to long-term success in STEM.

6. Recommendations:

STEM education—particularly in coding and technology—plays a transformative role in empowering women by opening doors to high-paying careers, fostering critical thinking, and promoting innovation. Economically, it enables women to gain financial independence and bridge the gender gap in male-dominated industries. It also equips them with future-ready skills essential in today's tech-driven world. To ensure sustainable progress in STEM

ISBN: 978-93-6163-902-9

education, several key strategies are recommended. Introducing STEM education early—particularly in primary schools—can help cultivate interest and confidence among young girls, laying the foundation for future engagement. Corporations must also be held accountable for promoting gender diversity through transparent hiring practices, equal opportunities for advancement, and inclusive workplace policies. Strengthening public-private partnerships is essential to increase funding and resources for women-focused tech initiatives. Finally, creating robust mentorship networks and professional development opportunities can connect aspiring female technologists with role models, providing guidance, support, and pathways to leadership. These strategies, when combined, can pave the way for a more inclusive and equitable future in STEM.

7. Conclusion

STEM education it is a powerful catalyst for social transformation. Empowering women through STEM opens pathways to innovation, economic growth, and greater gender equality. However, achieving true impact requires more than isolated programs. A systemic, inclusive, and context-aware approach is essential.

Future efforts must prioritize women's voices in program design, support grassroots initiatives with scalable models, and promote mentorship and leadership development. Connecting education to equity and innovation to inclusion will foster a global movement where women are not just participants but leaders in shaping the digital future. By aligning STEM education with social impact, we can build a world where all women can lead, innovate, and transform their communities.

References:

1. African Girls Can Code Initiative (UN Women & ITU, 2022).
2. AnitaB.org (2021). The State of Women in Tech.
3. Beede, D. N., Julian, T. A., Langdon, D., McKittrick, G., Khan, B., & Doms, M. E. (2011). Women in STEM: A gender gap to innovation (ESA Issue Brief No. 04-11). U.S. Department of Commerce. https://www.commerce.gov
4. Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural stereotypes as gatekeepers: Increasing girls' interest in computer science and engineering by diversifying stereotypes. Frontiers in Psychology, 6, 49.
5. Dasgupta, N., & Stout, J. G. (2014). 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), 21–29. https://doi.org/10.1177/2372732214549471
6. Girls Who Code (2022). Impact Report.
7. Google. (2023). Women Techmakers. https://www.womentechmakers.com
8. https://www.asee.org/papers-and-publications/publications/college-profiles
9. https://www.oecd.org/education/education-at-a-glance
10. https://www.oecd.org/education/education-at-a-glance/

11. Margolis, J., & Fisher, A. (2002). Unlocking the Clubhouse: Women in Computing. MIT Press.
12. Microsoft. (2022). DigiGirlz: Encouraging girls to pursue STEM. https://www.microsoft.com/en-us/diversity/programs/digigirlz.aspx
13. Sax, L. J., et al. (2017). Anatomy of an enduring gender gap: The evolution of women's participation in computer science. The Journal of Higher Education, 88(2), 258-293.
14. She Codes Africa (2020). Empowering African Women in Tech.
15. Technovation Girls (2023). Impact Study.
16. UN Women. (2021). Gender equality: Women's empowerment in STEM. https://www.unwomen.org/en/digital-library/publications
17. UNESCO & EQUALS (2019). I'd Blush if I Could: Closing Gender Divides in Digital Skills.
18. UNESCO (2017). Cracking the Code: Girls' and Women's Education in STEM.
19. UNESCO (2021). To Be Smart, the Digital Revolution Will Need to Be Inclusive.
20. UNESCO. (2017). Cracking the code: Girls' and women's education in STEM. United Nations Educational, Scientific and Cultural Organization. https://unesdoc.unesco.org/ark:/48223/pf0000253479
21. Wang, M. T., & Degol, J. L. (2017). Gender gap in STEM: Current knowledge, implications for practice, policy, and future directions. Educational Psychology Review, 29(1), 119-140.
22. Wang, M. T., Degol, J. L., & Ye, F. (2015). Gender differences in motivational profiles across mathematics and science courses. Journal of Educational Psychology, 107(4), 1056–1074. https://doi.org/10.1037/edu0000024
23. World Bank (2019). Missed Opportunities: The High Cost of Not Educating Girls.
24. World Bank (2020). Women, Business, and the Law.
25. World Bank Group (2021). The Equality Equation: Advancing the Participation of Women and Girls in STEM.
26. World Bank. (2020). Women and girls in STEM: A bright future in the digital economy. https://www.worldbank.org/en/topic/girlseducation/publication/women-in-stem
27. Yoder, B. L. (2017). Engineering by the numbers. American Society for Engineering Education.

ISBN: 978-93-6163-902-9