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From Pages to Pixels: Women's Evolving Engagement with Science and Technology

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Abstract: Active participation of women in science and technology has progressed gradually over several decades from print-based knowledge systems to digital platforms, described as a movement from pages to pixels. This progress is shaped by changing social structures, educational access, policy initiatives and technological development. Increased access to knowledge and information both quantitatively and qualitatively has played a key role in facilitating the greater participation of women. This paper examines the visibility of women scientists in India and also compares it to the global scenario over the past century as an evidence for bridging of the gender divide in science and technology. It also explores the challenges and opportunities through which women have evolved to the forefront as players in science and technology. In the backdrop of social reformations and restructuring, supported by inclusive education systems and institutional policies, emergence of digital technologies has provided a thrust to the pace of evolution of women from being the benefactors of technology to being the creators.

Keywords: *Women in science, gender and technology, digital transformation; STEM education, digital divide*

Introduction

The role of women in science and technology has evolved alongside changes in society, education systems, and modes of knowledge dissemination. In the early twentieth century, scientific knowledge was largely confined to printed journals, books, and institutional archives. These systems were often inaccessible to women due to social restrictions, limited educational opportunities, and institutional gatekeeping. The transition to digital age has transformed this landscape to a great extent enabling greater access, visibility, and participation. The evolutionary trajectory of women in science and technology (S&T) is characterized by a transition from structural invisibility in the era of "pages" to digital agency in the era of "pixels." While the 20th century was defined by gatekeeping and limited physical access to knowledge, the 21st century has leveraged digital technologies to democratize information and amplify the visibility of women scientists (IWWAGE, 2024).

Global Nobel Trends (1901–1960s)

During the early decades of the twentieth century, women's participation in science was limited by structural and cultural barriers. Scientific institutions, universities, and journals were predominantly male spaces. The Matilda Effect, where women's scientific contributions were overlooked or credited to male colleagues, further reduced recognition (ResearchGate, 2025). Globally, Nobel Prize data show that women constituted less than 3% of science awardees before 1960. During the first half of the 20th century, female representation was statistically negligible. Physics saw only two women (Marie Curie and Maria Goeppert Mayer) in 60 years.Statistical data from the Nobel Foundation illustrates this "page-bound" exclusion: between 1901 and 1960, only a handful of women, such as Marie Curie and Gerty Cori, broke through the global scientific glass ceiling (NobelPrize.org, 2025). Analysis of Nobel Prizes in Physics, Chemistry, and Physiology or Medicine from 1901 to 2025 reveals a slow but steady increase in female representation. The majority of female Nobel laureates have emerged after the year 2000, reflecting improved access to education, research networks, and digital visibility.

Major STEM Awards Globally and Gender Representation

Award	Scope	Female Winners / % Female	Notes on Male vs Female
Nobel Prizes (STEM)	Global	~6.6% women (1901–2025)	Detailed gender analysis available
Breakthrough Prizes (STEM)	Global	~16+ women (2013–2024)	Women are a minority; no complete gender dataset
L'Oréal-UNESCO For Women in Science	Global	100% women	Award designed exclusively for women
Rosalind Franklin Award	UK	100% women	Award recognises women in STEM
Irène Joliot-Curie Prize	France	100% women	Award for women scientists and technologists

Women have been historically under-represented among Nobel laureates in science since the prize's establishment in 1901. Following are the women who have won Nobel Prizes in STEM fields (Physics, Chemistry, Physiology or Medicine, and the Prize in Economic Sciences, which is also considered a science/social-science award), along with their country and year of award.

Male vs Female Nobel Laureates in STEM (1901–2025)

Category	Total Laureates (Individuals)	Women Laureates	Men Laureates
Physics	~229	5	~224
Chemistry	~200	8	~192
Physiology or Medicine	~232	14	~218
Total (STEM)	~661	27	~634

Note: Totals are approximate due to shared prizes and multiple laureates in a single year. Figures reflect individual awardees in Physics, Chemistry, and Physiology or Medicine.

Nobel Prize Winners (Women) in STEM Areas (1901–2025)

Physics

Name	Year	Country	Award Area
Marie Skłodowska-Curie	1903	Poland / France	Radioactivity research
Maria Goeppert Mayer	1963	Germany / USA	Nuclear shell structure
Donna Strickland	2018	Canada	Ultra-short optical pulses
Andrea Ghez	2020	USA	Supermassive compact object discovery
Anne L'Huillier	2023	Sweden / France	Attosecond light pulses

Chemistry

Name	Year	Country	Award Area
Marie Skłodowska-Curie	1911	Poland / France	Radium and polonium
Irène Joliot-Curie	1935	France	Artificial radioactive elements
Dorothy Crowfoot Hodgkin	1964	UK	X-ray crystallography of biomolecules
Ada E. Yonath	2009	Israel	Ribosome structure
Frances H. Arnold	2018	USA	Enzyme directed evolution
Emmanuelle Charpentier	2020	France	CRISPR genome editing
Jennifer A. Doudna	2020	USA	CRISPR genome editing
Carolyn Bertozzi	2022	USA	Click & bioorthogonal chemistry

Physiology or Medicine

Name	Year	Country	Award Area
Gerty Theresa Cori	1947	USA	Glycogen metabolism
Rosalyn Yalow	1977	USA	Radioimmunoassay
Barbara McClintock	1983	USA	Mobile genetic elements
Rita Levi-Montalcini	1986	Italy	Nerve growth factor
Gertrude B. Elion	1988	USA	Principles of drug treatment
Christiane Nüsslein-Volhard	1995	Germany	Embryonic development genetics
Linda B. Buck	2004	USA	Olfactory receptors
Françoise Barré-Sinoussi	2008	France	HIV discovery
Elizabeth H. Blackburn	2009	Australia / USA	Telomeres and telomerase
Carol W. Greider	2009	USA	Telomeres and telomerase
May-Britt Moser	2014	Norway	Brain navigation cells
Tu Youyou	2015	China	Malaria therapy
Katalin Karikó	2023	Hungary /	mRNA vaccine research

		USA	
Mary E. Brunkow	2025	USA	Peripheral immune tolerance

Economic Sciences (STEM-related)

Name	Year	Country	Award Area
Elinor Ostrom	2009	USA	Governance of commons
Esther Duflo	2019	France / USA	Experimental poverty economics
Claudia Goldin	2023	USA	Labour market & gender economics

Indian Evidence: Shanti Swarup Bhatnagar Prize

The Shanti Swarup Bhatnagar Prize for Science and Technology, instituted in 1958, is India's most prestigious science award. Since its inception, women awardees have remained a small minority. Decade-wise analysis shows that female representation remained negligible until the 1980s, with a noticeable increase only after 2010. Despite improvement, women constitute less than 10% of total awardees, highlighting persistent gender gaps in recognition. Until the 1970s, less than 3% of all global science awards were given to women. In India, female participation in R&D was below 5%. In India, early pioneers like Anandi Gopal Joshi (the first female MD in 1886) and Janaki Ammal (the first Indian woman to receive a D.Sc. in 1931) had to travel abroad to access higher education, as local print-based knowledge systems were heavily guarded by patriarchal institutional structures (India Bioscience, 2025).

Pioneers like Janaki Ammal (Botany) and Asima Chatterjee (Chemistry) navigated a double hurdle: colonial-era restrictions and gender bias. In the "Pages" era, an Indian woman scientist's work was often buried in local registers or credited to male supervisors.

From Pages to Pixels: The Digital Thrust

The transition to digital platforms has acted as a major catalyst for change. Open-access journals, online databases, and digital collaboration tools have reduced traditional gatekeeping. The "Matilda Effect"—the systematic under-recognition of female scientists—was facilitated by the lack of direct publishing avenues for women (ResearchGate, 2025) was overcome by digital platforms such as ResearchGate, LinkedIn, and online conferences which have enhanced visibility and networking opportunities for women scientists. Recent studies show that while male scientists traditionally dominated the press, female computer scientists are increasingly active on social media to disseminate their work, thus challenging gender stereotypes in academia (MDPI, 2025).

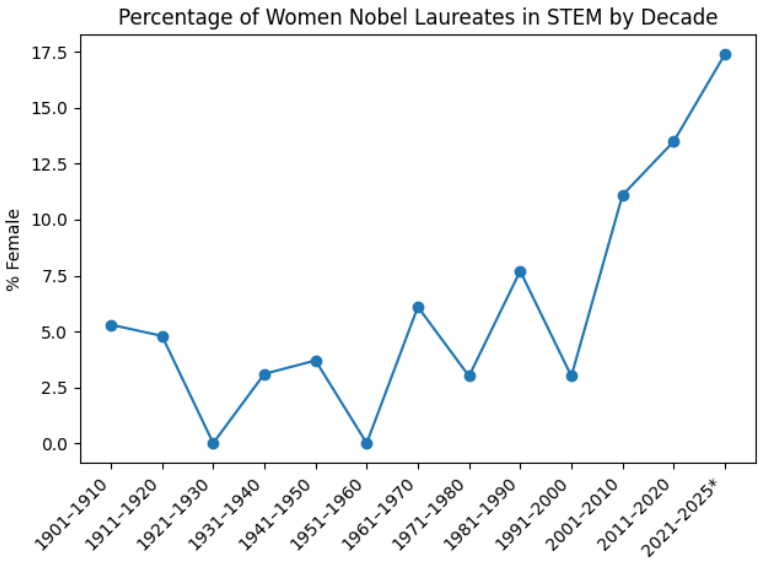
In India, digital missions in space science and biotechnology have showcased women scientists to a global audience. The global data shows a sharp upward curve in the last two decades. More Nobel Prizes were awarded to women in the 2000s and 2010s than in the entire 20th century combined (e.g., Jennifer Doudna and Emmanuelle Charpentier in 2020) and with recent laureates like Anne L'Huillier and Katalin Karikó (2023) benefiting from a more connected, digital scientific community (NobelPrize.org, 2025).

Decadal trend in female representation among Nobel STEM laureates

Nobel Prize in STEM (1901–2025): Men vs Women by Decade

Decade	Women	Men	Total	% Female
1901–1910	1	18	19	5.3
1911–1920	1	20	21	4.8
1921–1930	0	27	27	0.0
1931–1940	1	31	32	3.1
1941–1950	1	26	27	3.7
1951–1960	0	28	28	0.0
1961–1970	2	31	33	6.1
1971–1980	1	32	33	3.0
1981–1990	3	36	39	7.7
1991–2000	1	32	33	3.0
2001–2010	5	40	45	11.1
2011–2020	7	45	52	13.5
2021–2025*	4	19	23	17.4

*2021–2025 represents a partial decade.



In the domain of space and defense tech in India, the Mars Orbiter Mission (Mangalyaan) showcased women scientists (Ritu Karidhal, Nandini Harinath) to a global digital audience, which has had a new "role model" effect that is more pronounced in the age of digital media as compared to print media.

The progress of women in STEM has followed different velocities across the globe.

Region	Key Milestone (20th Century)	Current Status (21st Century)
Global (West)	Suffrage and wartime labor needs (WWII) pushed women into technical roles.	High participation in life sciences; persistent gaps in Engineering/CS.
India	Post-independence focus on nation-building; social reforms led by pioneers like Janaki Ammal.	Significant rise in STEM graduates (approx. 43%), though the "leaky pipeline" remains a challenge.

Education, Enrollment, and the Leaky Pipeline

India has one of the highest proportions of female STEM graduates globally, with women constituting approximately 43% of STEM enrollment.According to the All India Survey on Higher Education (AISHE) 2021-22, women now comprise 43% of STEM graduates in India, a significant leap from the 5% participation rate observed in 1950 (IAS, 2013; JICE IAS, 2025).

However, this representation declines sharply at the workforce and leadership levels. Only about 27% of researchers in India are women. Only 27% of the STEM workforce in India consists of women (PMF IAS, 2025). This disparity suggests that while digital access has opened the "pages" of education,

social "pixels"—such as workplace culture and domestic responsibilities—still filter women out of long-term careers.

This leaky pipeline reflects the continued influence of social expectations, career breaks, and lack of institutional flexibility.

Parameter	Global Scenario	Indian Scenario
Nobel Laureates	6.6% (Historical Total)	0% (Science categories)
STEM Enrollment	~35% (UNESCO average)	43% (World Leader)
Workforce Participation	~30% (Global average)	~14-15% (Lagging)
Growth Catalyst	Institutional DEI Policies	Government schemes (KIRAN, GATI, Vigyan Jyoti)

Policy Interventions and Institutional Support

Government initiatives such as the WISE-KIRAN scheme and the Gender Advancement for Transforming Institutions (GATI) framework aim to address systemic barriers. These policies support career continuity, leadership development, and institutional accountability.

WISE-KIRAN Scheme: Launched by the Department of Science and Technology (DST), this initiative addresses the "career break" common among women due to family responsibilities. By 2023, women's participation in extramural R&D projects rose to **18.6%**, up from 13% in 2000 (PIB, 2025).

GATI (Gender Advancement for Transforming Institutions): This framework pushes for systemic change within universities, moving beyond individual merit to institutional accountability (DST, 2025).

Such initiatives represent essential structural support to sustain progress enabled by digital access.

Challenges in the Pixel Era

Despite technological advancement, challenges remain. The digital gender divide persists, particularly in rural and marginalized communities where access to high-speed internet and digital tools is limited. While the transition to pixels offers opportunities, it introduces a new gender digital divide. In India, only 33% of women use the internet compared to 57% of men (NFHS-5; Triumph IAS, 2025). This gap threatens to create a "second-tier" of exclusion where women in rural or marginalized areas are left behind in the move toward creator-based roles in AI and high-end technology.

Additionally, work-from-home models can reinforce the double burden of professional and domestic responsibilities for women.

Conclusion

The transition from pages to pixels marks a significant shift in the participation and visibility of women in science and technology. While digital technologies have democratized access to knowledge and improved representation, structural and cultural barriers continue to limit recognition and leadership. Bridging the gender divide requires sustained policy support, institutional reform, and social change to ensure women are not only participants but leaders and creators in science and technology.

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