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Research Paper

Status of Scheduled Tribe Students in Science, Technology, Engineering and Mathematics (STEM) at the Level of Higher Education in India

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Abstract

STEM fields play a pivotal role in driving innovation and economic growth. Ensuring equitable access for all students, including those from disadvantaged backgrounds, is crucial for fostering diversity and inclusivity. This study examines the enrollment status of Scheduled Tribe (ST) students in Science, Technology, and Engineering at higher education levels in India, focusing on their participation in STEM fields. This study explores the barriers that ST students face in accessing and persisting in STEM education and provides suggestions to enhance their participation and success. This study is qualitative and documentary in nature. All-India Survey on Higher Education Reports AISHE reports (2011-12 to 2021-22), Department of Higher Education, Ministry of Education, Govt. of India. The study revealed that in Bachelor of Science (B.Sc.) programs, male ST student enrollment was higher than females from 2011-2012 to 2018-2019, but this trend reversed from 2018-2019 to 2021-2022, with female enrollment surpassing males. Similarly, in Master of Science (M.Sc.) programs, male enrollment was higher until 2013-2014, after which female enrollment exceeded males from 2014-2015 to 2021-2022. However, in the engineering and technology fields (B.E., M.E., B.Tech., M.Tech.), male students consistently maintained higher enrollment rates than female students at both undergraduate and postgraduate levels.

Keywords: *Status, Scheduled Tribe, Higher Education, Science, Technology, Engineering*

INTRODUCTION

India's higher education is a turning point for the international economy. One cannot over-emphasize the role of higher education as a key catalyst for promoting socio-economic mobility and preparing citizens for a knowledge society. Tertiary education facilitates the absorption of the positive effects of globalization and enabling India to develop a trillion-plus economy through a highly qualified and broad national talent base. The progress of any country and nation depends on the education of its citizens. Therefore, every citizen of the country, regardless of caste or religion, receives higher education to improve the economic development of the country (Seth, 2024). STEM education is important to promote innovation. With economic growth and global competitiveness, disparities in access to and participation by under-represented students in STEM fields continue. STEM education is critical to global growth. Promoting social and economic reform. Innovation and technological progress, but equal access remains a key issue. Especially for underprivileged students (Why is STEM Education so Important?, 2024; Team Bricks 4 Kidz, 2023). STEM education has the potential to significantly uplift Scheduled Tribes (STs) by providing them with skills critical for modern employment opportunities that can help bridge educational and economic gaps, empowering tribal communities to participate in diverse industries, promote inclusivity, and foster sustainable development for ST communities. The status of Scheduled Tribe (ST) students in STEM (Science, Technology, Engineering, and Mathematics) education at the higher

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education level in India represents a critical area of inquiry, with significant implications for social equity and national development. Scheduled Tribes constitute a significant section of the populace, yet they face considerable barriers to accessing and completing higher education, especially in STEM disciplines. Historically, Scheduled Tribe (ST) communities in India have faced systemic barriers to education, including socioeconomic challenges, cultural discrimination, and inadequate infrastructure in educational institutions (Prajapati, 2023). This study holds potential significance by generating insights that can inform policymakers and educational institutions in their efforts to implement effective strategies aimed at promoting inclusive STEM education practices for ST students, thereby facilitating their academic success and professional opportunities. The demand for STEM professionals is increasing worldwide and in India. The participation of all social groups, especially marginalized communities, in these sectors is critical to promoting innovation, economic growth, and social equity (Sharma & Gupta, 2021).

The objectives of this study were to examine the enrollment status of Scheduled Tribe (ST) students in Science, Technology, and Engineering at higher education levels in India and to investigate the overall trends in their participation across these critical fields. Additionally, this study aims to analyze the barriers encountered by Scheduled Tribe students in accessing and succeeding in STEM higher education, thereby identifying the challenges that hinder their academic persistence. Additionally, the research will provide possible solutions to increase SC student participation and STEM success, ultimately promoting an inclusive educational environment. Three key research questions guide this research:

1. What is the enrollment status of the Scheduled Tribe (ST) students in Science (B.Sc. & M.Sc.) at higher education levels in India?
2. What is the enrollment status of the Scheduled Tribe (ST) students in Technology (B.Tech. & M.Tech.) at higher education levels in India?
3. What is the enrollment status of the Scheduled Tribe (ST) students of Engineering (B.E. & M.E. at higher education levels in India?

LITERATURE REVIEW

About the Scheduled Tribe in India

Scheduled Tribes (STs) in India are grounded in historical, sociological, and constitutional frameworks. The concept of Scheduled Tribes emerged from the need to identify and protect indigenous communities marginalized by centuries of socioeconomic deprivation. Theoretical perspectives such as social exclusion and marginalization theories explain historical discrimination, land alienation, and the lack of access to resources that have contributed to their socioeconomic backwardness. Constitutional provisions, especially Articles 342, 15(4), and 46, provide the legal foundation for affirmative action, safeguarding rights, and promoting socioeconomic and educational advancement. Tribal studies also emphasize the preservation of cultural identity and sustainable development within the broader context of national integration**.**

Demographic characteristics of Scheduled Tribe students in India

India has a diverse population of Scheduled Tribes (STs), constituting 8.6% of the total population. Equivalent to approximately 104.28 million people according to the 2011 census, more than half are concentrated in Madhya Pradesh, Chhattisgarh, Maharashtra, Orissa, Jharkhand, and Gujrat. Almost 90% of them reside in rural areas, particularly in difficult terrains, interiors of forests, or remote hilly areas, which are normally less accessible to the mainstream population (Suresh & Cheerean, 2014).

Conceptualization of STEM

The term STEM is used for refer to subjects in the fields of science, technology, engineering, and mathematics. Although these subjects have been taught for a long time, the US National Science Foundation (NSF) officially introduced the abbreviation in 2001 (Chute, 2009). The term serves as an umbrella term for many fields, such as information technology, software development, computer network architecture, data security, and so on. STEM education can be viewed from a broad perspective. From this perspective, each STEM field of study includes education, science, technology, and engineering. and mathematics, as well as a combination of these disciplines or an interdisciplinary one (Li, 2014). The theoretical foundation of STEM (Science, Technology, Engineering, and Mathematics) is rooted in interdisciplinary learning that integrates knowledge across these four domains to solve real-world problems. STEM education is based on constructivist theories, where learners actively engage in hands-on, inquiry-based learning, fostering critical thinking, creativity, and problem-solving skills. The approach draws on Vygotsky's social constructivism, emphasizing collaborative learning, and Piaget's cognitive development theory, which stresses the importance of experiential learning. STEM also aligns with Dewey's philosophy of learning by doing, encouraging students to apply knowledge practically to bridge the gap between theory and application.

Different related studies on Enrollment Status in ST Students in STEM Education

The enrollment status of Scheduled Tribe (ST) students in STEM education has been the focus of various studies, highlighting significant disparities and systemic barriers they face. Research indicates that ST students are often underrepresented in STEM fields due to socioeconomic challenges, cultural stigma, and educational inequities (Reardon, 2018). For instance, studies have revealed that while overall enrollment in STEM programs has increased, the percentage of ST students remains disproportionately low compared to their peers (Shah & Shobha, 2024; Sud & Ramanujam, 2024). Additionally, gender disparities within this group are pronounced, with female ST students facing even greater challenges to participation and retention in STEM disciplines (UNESCO, 2017; Rainey et. al, 2018). Recent initiatives aimed at improving access and equity, such as targeted scholarship and support programs, have shown promise in enhancing enrollment and persistence among ST students in STEM education. Despite these efforts, the ongoing need for comprehensive policies and community engagement remains critical to ensure that ST students can thrive in STEM environments. Nandi et al. (2023) found that the enrollment trend of female students among Others Backward Classes (OBC) in STEM was comparatively higher than general SC and ST female students in six years. Enrollment in engineering and technology is not hopeful; the enrollment growth rate is very low and discontinuous, and a gender gap exists.

RESEARCH METHOD

This study is qualitative and documentary in nature. Document review is a method of qualitative research (Yildirim & Simsek, 2005; O'Leary, 2017; Prior, 2003). Documentary analysis is a systematic and rigorous procedure for reviewing or evaluating textual and electronic documents (Bowen, 2009). Qualitative research is best when exploring a problem or topic in depth (Creswell, 2013). The documentary analysis method followed by the content analysis technique was conducted to study the enrollment status of Scheduled Tribe (ST) students in Science, Technology, and Engineering at higher education levels in India collated from the All-India Survey on Higher Education Reports AISHE reports 2011-12 to 2021-22), Department of Higher Education, Ministry of Education, Govt. of India. The researchers systematically gathered data through content analysis, employing a meticulous approach. They conducted a thorough examination of the document, scrutinizing each page, as stated by Collado and Atxurra (2006). The primary focus was on identifying data related to enrollment status of the Scheduled Tribe (ST) students in Science, Technology, and Engineering at higher education levels. The analysis proceeds in multiple steps.

Step 1: All data related to the enrollment status of Scheduled Tribe (ST) students were collected.

Step 2: Categories the data of enrollment into Science, Technology, and Engineering at UG & PG level separately.

Step 3: The researchers then provided detailed descriptions, offering insights into the observed patterns because detailed descriptions are necessary for interpreting patterns in visual data and provide a basis for deeper analysis (Ball & Smith,1992; Prosser, 2005).

Step 4: Finally, the researchers concluded the study, culminating in the preparation of the comprehensive final report (Davis & Lee, 2021).

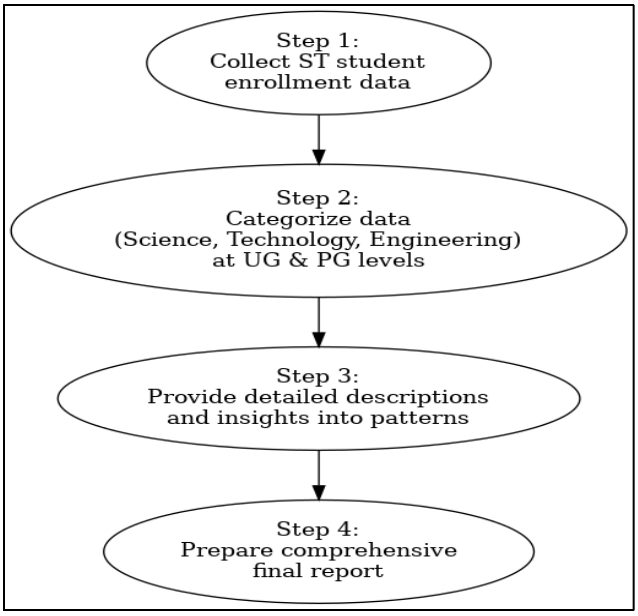

Figure 1. Flowchart of content analysis

FINDINGS AND DISCUSSION

Objective 1: To examine the enrollment status of the Scheduled Tribe (ST) students in Science at higher education levels in India.

Table 1. Enrollment status of the Scheduled Tribe (ST) students in Bachelor of Science (B.Sc.)

Year	Bachelor of Science (B.Sc.)					
	Total number of (Male & Female)	Total number of Male	Total number of Female	Percentage (%) of Male	Percentage (%) of Female	Gender gap
2011-2012	85562	47576	37986	55.60	44.39	11.21
2012-2013	103907	57426	46481	55.26	44.73	10.53
2013-2014	130109	72510	58914	55.73	45.28	10.45
2014-2015	164311	90435	73876	55.03	44.96	10.07
2015-2016	175727	94444	81283	53.74	46.25	7.49
2016-2017	194170	102930	91240	53.01	46.98	6.03
2017-2018	204432	106009	98423	51.85	48.14	3.71
2018-2019	218151	109880	108271	50.36	49.63	0.73

Year	Bachelor of Science (B.Sc.)					
	Total number of (Male & Female)	Total number of Male	Total number of Female	Percentage (%) of Male	Percentage (%) of Female	Gender gap
2019-2020	225245	110076	115169	48.86	51.13	2.27
2020-2021	253945	122241	131704	48.13	51.86	3.73
2021-2022	284015	138238	145777	48.67	51.32	2.65

Source: All India Survey on Higher Education (AISHE), (2010-11 to 2021-22)

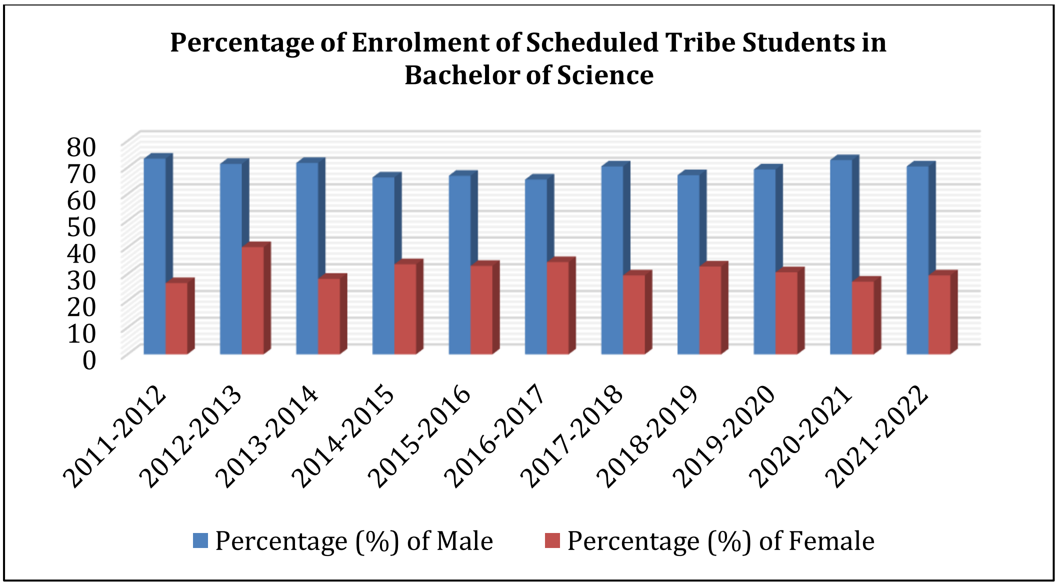

Figure 2. Enrollment status of the Scheduled Tribe (ST) students in Bachelor of Science (B.Sc.)

Table no 1. represents a comprehensive overview of the enrollment status of Schedule Tribe (ST) students at the Higher Education Level in Bachelor of Science (B.Sc.) programs over a decade, from 2011 to 2022. The enrollment of Scheduled Tribe (ST) students in Bachelor of Science (B.Sc.) programs saw a significant increase from 85,562 in 2011-2012 to 284,015 in 2021-2022. Notable growth occurred between 2012 and 2013 and 2013-2014, with enrollment rising by 26,202, and approximately 2014-2015 and 2015-2016, with an increase of 11,416. The enrollment of female students steadily increased, surpassing that of male students from 2019-2020 onwards, reaching 51.86% in 2020-2021. The gender gap decreased sharply, narrowing from 11.21% in 2011-2012 to just 0.73% in 2018-2019, followed by slight fluctuations, ending at 2.65% in 2021-2022.

Table 2. Enrollment status of the Scheduled Tribe (ST) students in Masters of Science (M.Sc.)

Year	Masters of Science (M.Sc.)					
	Total number of (Male & Female)	Total number of Male	Total number of Female	Percentage (%) of Male	Percentage (%) of Female	Gender gap
2011-2012	13536	7497	6039	55.38	44.61	10.77
2012-2013	14266	7533	6733	52.80	47.19	5.61
2013-2014	16531	8573	8133	51.86	49.19	2.67
2014-2015	19684	9726	9958	49.41	50.58	1.17

Year	Masters of Science (M.Sc.)					
	Total number of (Male & Female)	**Total number of Male**	**Total number of Female**	**Percentage (%) of Male**	**Percentage (%) of Female**	**Gender gap**
2015-2016	22299	10663	11636	47.81	52.18	4.37
2016-2017	25545	11955	13590	46.79	53.20	6.41
2017-2018	29074	13041	16033	44.85	55.14	10.29
2018-2019	29084	12979	16105	44.62	55.37	10.75
2019-2020	34266	14791	19475	43.16	56.83	13.67
2020-2021	40607	17750	22857	43.71	56.28	12.57
2021-2022	50261	22191	28070	44.15	55.84	11.69

Source: All India Survey on Higher Education (AISHE), (2010-11 to 2021-22)

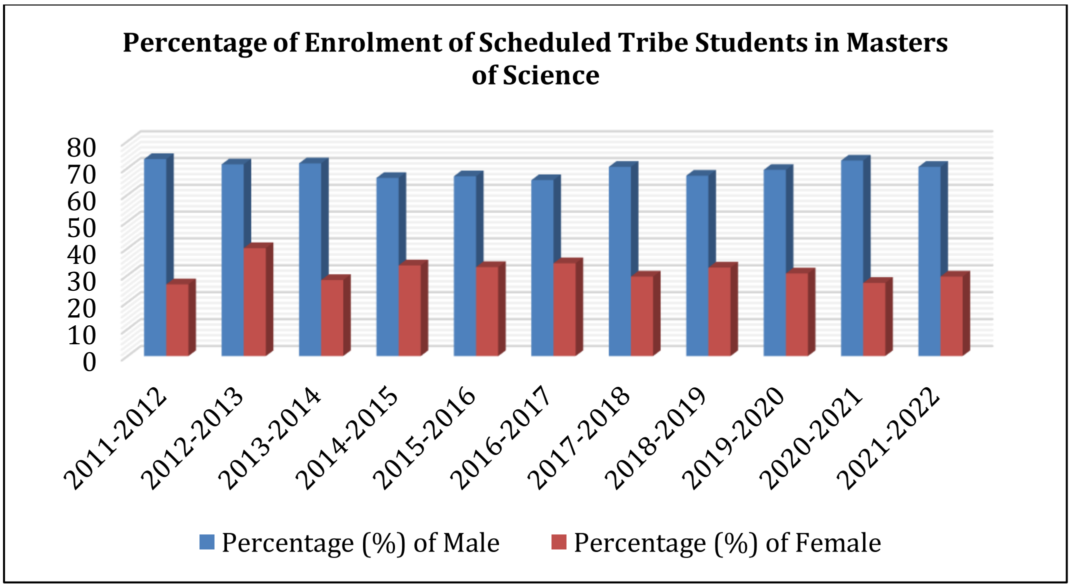

Figure 3. Enrollment status of the Scheduled Tribe (ST) students in Masters of Science (M.Sc.)

Table no 2. represents a comprehensive overview of the enrollment status of Schedule Tribe (ST) students at the Higher Education Level in Masters of Science (M.Sc.) programs over a decade, from 2011 to 2022. Enrollment steadily increased from 13,536 in 2011-2012 to 50,261 in 2021-2022. Particularly significant increments were observed in 2013-2014 (16,531) and 2020-2021 (40,607). Gender gap trends narrow from 10.77% in 2011-2012 to just 1.17% in 2014-2015, indicating improved gender parity during that period. However, from 2015-2016 onwards, the gap widened again, reaching 13.67% in 2019-2020 before slightly reducing to 11.69% in 2021-2022. Overall, female enrollment grew significantly, surpassing male enrollment recently.

Objective 2: To investigate the enrollment status of the Scheduled Tribe (ST) students in Technology at higher education levels in India.

Table 3. Enrollment status of the Scheduled Tribe (ST) students in the Bachelor of Technology (B.Tech.)

Year	Bachelor of Technology (B.Tech.)					
	Total number of (Male & Female)	**Total number of Male**	**Total number of Female**	**Percentage (%) of Male**	**Percentage (%) of Female**	**Gender gap**
2011-2012	40344	30299	10045	75.10	24.89	50.21
2012-2013	44075	33651	10424	76.34	23.65	52.69
2013-2014	55980	43992	13338	78.58	23.82	54.76
2014-2015	63951	48932	15019	76.51	23.48	53.03
2015-2016	63137	48274	14863	76.45	23.54	52.91
2016-2017	67218	51440	15778	76.52	23.47	53.05
2017-2018	66397	50523	15874	76.09	23.90	52.19
2018-2019	68082	51022	17060	74.94	25.05	49.89
2019-2020	68635	51075	17560	74.41	25.58	48.83
2020-2021	77610	56841	20769	73.23	26.76	46.47
2021-2022	91447	66465	24982	72.68	27.31	45.37

Source: All India Survey on Higher Education (AISHE), (2010-11 to 2021-22)

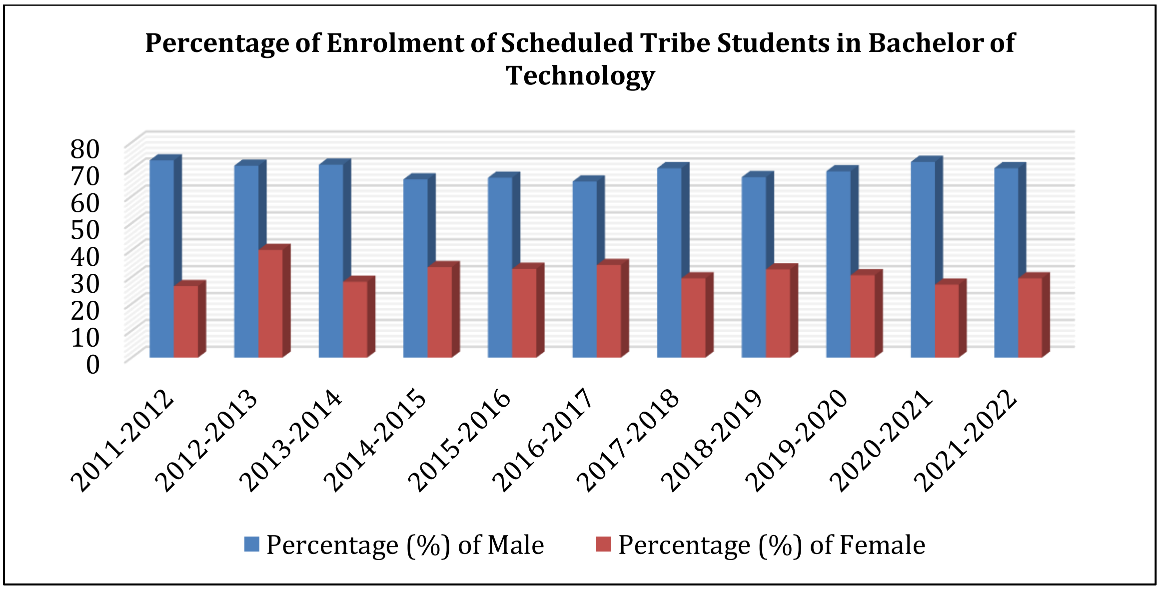

Figure 4. Enrollment status of the Scheduled Tribe (ST) students in the Bachelor of Technology (B.Tech.)

Table no 3. represents a comprehensive overview of the enrollment status of Schedule Tribe (ST) students at the Higher Education Level in Bachelor of Technology (B.Tech.) programs over a decade, from 2011 to 2022. Saw notable growth between 2011 and 2022, rising from 40,344 in 2011-2012 to 91,447 in 2021-2022. A significant increase is observed particularly in the last two years, with enrollment jumping from 68,635 in 2019-2020 to 77,610 in 2020-2021, and further to 91,447 in 2021-2022. However, the gender gap in enrollment saw a gradual decrease over time. In 2011-2012, the gap was 50.21%, which narrowed down to 45.37% by 2021-2022, indicating an increase in female representation in B.Tech. programs, as their percentage rose from 24.89% to 27.31%.

Table 4. Enrollment status of the Scheduled Tribe (ST) students in the Masters of Technology (M.Tech.)

Year	Masters of Technology (M.Tech.)					
	Total number of (Male & Female)	**Total number of Male**	**Total number of Female**	**Percentage (%) of Male**	**Percentage (%) of Female**	**Gender gap**
2011-2012	2330	1707	623	73.26	26.73	46.53
2012-2013	2794	2051	743	73.40	26.59	46.81
2013-2014	4550	3308	1311	72.70	28.81	43.89
2014-2015	6401	4624	1777	72.23	27.76	44.47
2015-2016	6253	4396	1857	70.30	29.69	40.61
2016-2017	4954	3372	1582	68.06	31.93	36.13
2017-2018	4305	2938	1367	68.24	31.75	36.49
2018-2019	4196	2911	1285	69.37	30.62	38.75
2019-2020	4294	3044	1250	70.88	29.11	41.77
2020-2021	4911	3508	1403	71.43	28.56	42.87
2021-2022	5685	4066	1619	71.52	28.47	43.05

Source: All India Survey on Higher Education (AISHE), (2010-11 to 2021-22)

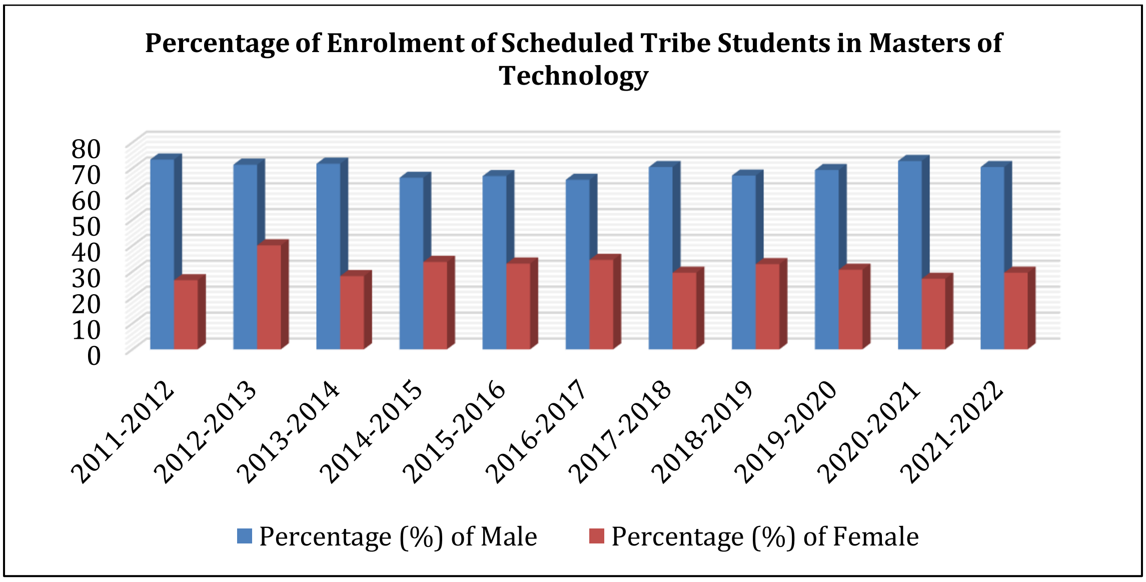

Figure 5. Enrollment status of the Scheduled Tribe (ST) students in the Masters of Technology (M.Tech.)

Table no 4. represents a comprehensive overview of the enrollment status of Schedule Tribe (ST) students at the Higher Education Level in Masters of Technology (M.Tech.) programs over a decade, from 2011 to 2022. The total enrollment rose significantly from 2,330 in 2011-2012 to a peak of 6,401 in 2014-2015 before gradually declining to 4,305 in 2017-2018. A subsequent increase saw enrollment reach 5,685 by 2021-2022. The gender gap also witnessed notable changes, narrowing from 46.53% in 2011-2012 to a low of 36.13% in 2016-2017, followed by a slight increase, with the gap reaching 43.05% in 2021-2022.

Objective 3: To study the enrollment status of the Scheduled Tribe (ST) students of Engineering at higher education levels in India.

Table 5. Enrollment status of the Scheduled Tribe (ST) students in the Bachelor of Engineering (B.E.)

Year	Bachelor of Engineering (B.E.)					
	Total number of (Male & Female)	Total number of Male	Total number of Female	Percentage (%) of Male	Percentage (%) of Female	Gender gap
2011-2012	22499	16239	6250	72.17	27.77	44.4
2012-2013	27985	20742	7243	74.11	25.88	48.23
2013-2014	36564	26831	9866	73.37	26.98	46.39
2014-2015	40407	29940	10467	74.09	25.90	48.19
2015-2016	43519	32224	11295	74.04	25.95	48.09
2016-2017	44845	32736	12109	72.99	27	45.99
2017-2018	42828	30847	11981	72.02	27.97	44.05
2018-2019	40071	28675	11396	71.56	28.43	43.13
2019-2020	35568	25163	10405	70.74	29.25	41.49
2020-2021	34190	24142	10048	70.61	29.38	41.23
2021-2022	34940	24999	9941	71.54	28.45	43.09

Source: All India Survey on Higher Education (AISHE), (2010-11 to 2021-22)

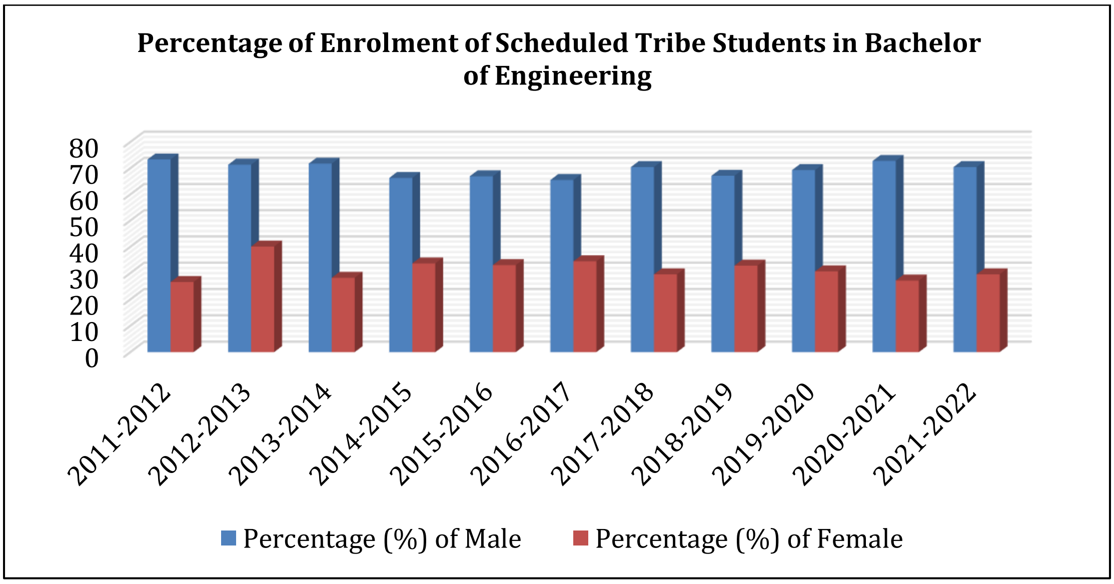

Figure 6. Enrollment status of the Scheduled Tribe (ST) students in the Bachelor of Engineering (B.E.)

Table no 5. represents a comprehensive overview of the enrollment status of Schedule Tribe (ST) students at the Higher Education Level in Bachelor of Engineering (B.E.) programs over a decade, from 2011 to 2022. Showed a notable increase approximately 2011-2012 and 2015-2016, with enrollments rising from 22,499 to 43,519. However, from 2017-2018 onwards, there was a steady decline, with enrollments falling to 34,940 by 2021-2022. Regarding gender gaps, the widest gap occurred in 2012-2013 with a 48.23% difference, while the smallest gap was in 2019-2020, at 41.49%. The percentage of female enrollment gradually increased, peaking at 29.38% in 2020-2021, reflecting a reduction in the gender gap over time.

Table 6. Enrollment status of the Scheduled Tribe (ST) students in Masters of Engineering (M.E.)

Year	Masters of Engineering (M.E.)					
	Total number of (Male & Female)	Total number of Male	Total number of Female	Percentage (%) of Male	Percentage (%) of Female	Gender gap
2011-2012	728	534	194	73.35	26.64	46.71
2012-2013	723	516	207	71.36	40.11	31.25
2013-2014	963	691	272	71.75	28.24	43.51
2014-2015	1012	671	341	66.30	33.69	32.61
2015-2016	1007	674	333	66.93	33.06	33.87
2016-2017	948	621	327	65.50	34.49	31.01
2017-2018	1144	806	338	70.45	29.54	40.91
2018-2019	779	523	256	67.13	32.86	34.27
2019-2020	821	569	252	69.30	30.69	38.61
2020-2021	1026	747	279	72.80	27.19	45.61
2021-2022	1144	806	338	70.45	29.54	40.91

Source: All India Survey on Higher Education (AISHE), (2010-11 to 2021-22)

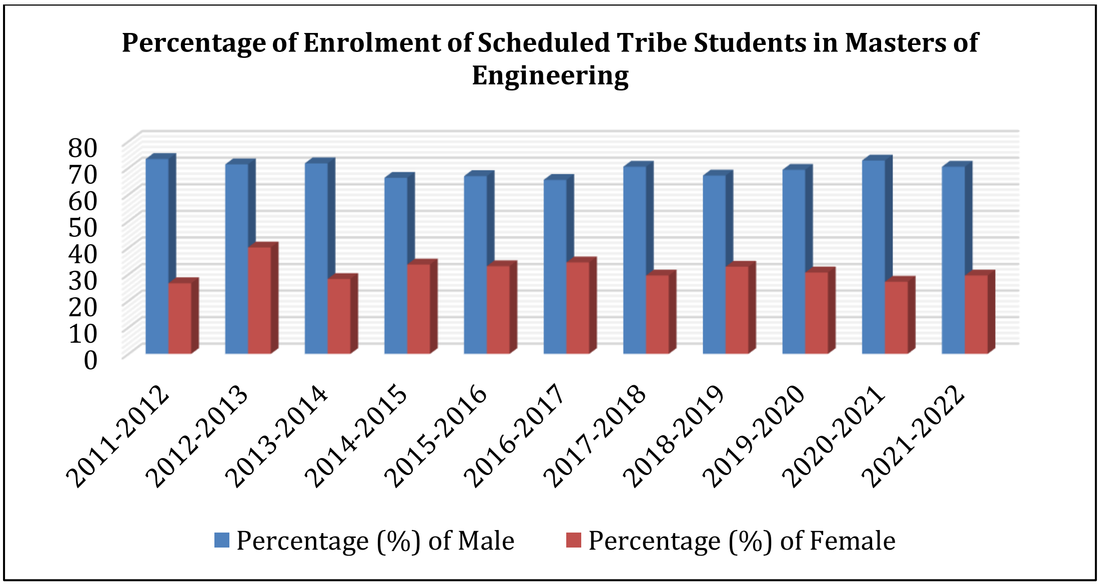

Figure 7. Enrollment status of the Scheduled Tribe (ST) students in Masters of Engineering (M.E.)

Table no 6. represents a comprehensive overview of the enrollment status of Schedule Tribe (ST) students at the Higher Education Level in Masters of Engineering (M.E.) programs over a decade, from 2011 to 2022. Notable increases in total enrollment were observed in 2014-2015 (1,012) and 2017-2018 (1,144), while 2018-2019 marked a significant decline (779). In terms of gender representation, male enrollment consistently remained higher, with percentages ranging from 65.50% to 73.35%. Female enrollment peaked in 2014-2015 (33.69%) and 2016-2017 (34.49%) but showed declines in other years, especially in 2011-2012 (26.64%) and 2020-2021 (27.19%). The gender gap fluctuated, with the widest gap in 2011-2012 (46.71%) and 2020-2021 (45.61%), while the smallest gap was in 2012-2013 (31.25%) and 2016-2017 (31.01%).

Discussion

Enrollment status of the Scheduled Tribe (ST) students in Science at higher education levels

Findings from this study indicate a significant change in the enrollment pattern of Scheduled Tribe (ST) students in Bachelor of Science (BSc) programs in India between the 2011-2012 and 2021-2022 academic sessions. Initially, the enrollment of male ST students exceeded that of female students. However, there was a notable reversal between the 2018-2019 and 2021-2022 academic years, with female enrollment in B.Sc. programs exceeding male enrollment. This trend not only highlights the changing dynamics in gender participation in STEM education; But it also reflects broader societal shifts in gender roles: educational inspiration and policy implications. The growth in female B.Sc. enrollment among SC students indicates a broader trend observed in STEM education, where female representation is gradually improving. The rapid increase in female enrollment has several causes. This includes government initiatives focused on empowering women in higher education. and increased visibility of women's role models in science (Kumar & Sahoo, 2024). Moreover, fluctuations in enrollment numbers can be contextualized within national policy frameworks that promote education among marginalized groups. In line with this, increasing the potential of female students who wish to pursue higher education in STEM fields. Social and political changes positively impact female students' STEM education ambitions, especially among historically disadvantaged groups. Another factor that has helped increase female enrollment in B.Sc. courses is that more support programs, especially scholarships for women, Scheduled Tribe women, and other related schemes, are now more available.

Enrollment status of the Scheduled Tribe (ST) students in Technology and Engineering at higher education levels

Research shows that in Engineering and Technology programs, including B.E., M.E., B.Tech., and M.Tech., more ST male students enroll than ST female students at both undergraduate and graduate levels. Despite growing numbers of women pursuing STEM, the representation of women in engineering remained disproportionately low, especially among marginalized groups, including Scheduled Tribes and Scheduled Castes (Bhagat & Vijayaraghavan, 2019). Factors contributing to these disparities include societal expectations, financial constraints, and inadequate support systems for women in technical fields, which collectively discourage female students from enrolling in or persisting in engineering programs. Research shows that issues like gender bias and the absence of female role models in engineering play a major part in why fewer women sign up for these programs compared to men. A World Economic Forum (2023) highlighted that women constitute just 27% of the STEM workforce in India, even though many enroll in related educational courses. This "leaky pipeline" problem shows that educating women to join engineering programs is not enough to keep them in the field or help them succeed in their careers. Many women face system-wide obstacles that limit their progress. Moreover, the results can also be understood when considering wider social and cultural factors that shape ST students' educational choices. Studies indicate that cultural expectations often determine what academic paths and careers women aspire to, which can prevent them from entering fields dominated by men, like engineering. Initiatives that focus on getting more women into STEM, such as providing mentors and financial aid for female ST students, have shown promise in reducing the gender divide. However, these programs still do not match up to the scale of what is needed. Moreover, discrepancies in enrollment rates point to the need for policy interventions that not only focus on increasing the representation of women in engineering programs. It also focuses on creating an inclusive academic environment. This is even though regulatory bodies like the All-India Council of Technical Education (AICTE) have launched scholarships and schemes. To support women in technical education, a more comprehensive strategy is needed to address the root causes of gender inequality in enrollment and retention

(Kumar, 2024).

Barriers faced by the Scheduled Tribes students in STEM in Higher Education

Gender bias plays a significant role in the adoption of STEM education among students (Glass et al., 2013). Gender, a social construct, has been the focus of recent studies exploring bias in STEM, particularly among college students (Seyranian et al., 2018). Gender discrimination remains a key barrier, with cultural norms reinforcing the idea that STEM is more suitable for men, which discourages female students (UNESCO, 2017). Race and gender influence students' decisions to pursue STEM (Rainey et al., 2018), and female students often face bias from peers and teachers, deterring them from STEM careers. Additionally, female students from OBC and SC groups face "double jeopardy" due to gender and caste. Barriers such as lack of family support and infrastructure, especially in poor countries, prevent many girls from accessing education, with 44% of girls dropping out or never attending school (Marcus, 2020).

Research has revealed that racial identity negatively impacts students' likelihood of choosing a science major in high school. Compared with their peers in the general caste group, SC, ST, and ST students are less likely to study these subjects. The difference is up to 18% for SC and 12% for ST students. This difference persists even after considering socioeconomic factors. When combined with the challenge This issue highlights how racial bias limits equal access to STEM education (Sud & Ramanujam, 2024). Caste-based discrimination is a major barrier to entry and success for backward students in STEM education in India. The entrenched caste system affects educational opportunities and outcomes. This leads to disproportionate participation in science and technology (Shah & Shobha, 2024). Caste-based discrimination is a major barrier to STEM education for backward class students. These students often face discrimination from their peers. Faculty bias and limited access to opportunities such as internships or research projects. Racial bias manifests in various ways, including exclusion from academic groups, prejudicial treatment of educators, and limited resources and opportunities necessary for academic success. These systematic differences not only impede students' ability to thrive in STEM fields (Thorat & Newman, 2010). In many cases, racial bias undermines students' confidence and academic performance. The negative impact of racial disparities on educational attainment. This highlights how bias undermines student confidence and academic performance. This creates a permanent gap in access to STEM education. Addressing these issues requires comprehensive reforms that eliminate discriminatory practices. Furthermore, promote equal access to educational resources and support. The National Education Policy (NEP) recognizes these differences and emphasizes the need for research-based policies tailored to the unique challenges these communities face. The goal is to close the gap in educational outcomes. This results in decreased ability to continue to participate in STEM programs.

A student's socioeconomic status (SES) is a key factor in educational success, with low SES students often facing poor quality education, inadequate infrastructure, and limited resources critical to STEM success (Reardon, 2018). They also lack access to extracurricular and support systems, thus widening the STEM opportunity gap. Family background strongly influences STEM career choices, with talented students often struggling because of insufficient support and encouragement. Efforts to support disadvantaged students are vital for breaking the poverty cycle and enabling STEM success (Pushing Poverty Away, 2021). Economic disparities significantly reduce low-income students' representation in higher education STEM programs because financial barriers like tuition and equipment costs, hinder participation (Rozek et al., 2019). Economic stress also impacts academic performance and increases dropout rates (Wang, 2013; Beine, 2019). These challenges force many students into cheaper, non-STEM courses, with family SES playing a critical role in STEM enrollment (Tilak, 2023; Niu, 2017).

Cultural identity greatly influences student engagement with STEM education. Students who feel that their cultural background is not reflected in their content may be less likely to participate. However, cultural integration and local contexts can help increase student interest and performance in STEM subjects (Carlone & Johnson, 2015). Cultural beliefs also play an important role in shaping students' attitudes toward STEM education. In many communities, especially in rural and tribal areas, STEM education is perceived as unrelated or incompatible with local traditions and lifestyles. Local students from these backgrounds may feel pressured to conform to cultural expectations that prioritize immediate financial contributions to the family over long-term educational goals. These cultural beliefs act as barriers that prevent students from pursuing STEM education. Cultural norms often determine what subjects are considered appropriate for different genders. This affects students' self-perceptions and career aspirations in STEM fields (Cheryan et al., 2015) in areas where STEM fields are perceived as more masculine. Girls may feel less supported when following these disciplines. As a result, women's participation rates have decreased (Archer et al., 2012). Where traditional or non-STEM careers are more valuable, students may not perceive STEM education as a possible or desirable path (Gordon, 2014). Family beliefs about education also play an important role in shaping students' attitudes toward STEM. A supportive family environment that values education and displays a positive attitude toward STEM can greatly increase a student's ambition (Bottia et al., 2021).

Teachers' knowledge of STEM education is crucial for student success. They foster interest in STEM and provide essential support for students to excel. Effective STEM education requires a strong teacher expertise (Eckman et al., 2016). However, when teachers lack STEM knowledge, they cannot deliver the quality education students require, especially in rural and under-resourced schools lacking proper training and resources. Studies have confirmed that teachers often lack sufficient understanding to effectively teach integrated STEM education (El-Deghaidy & Mansour, 2015). In India, many teachers lack specialized STEM knowledge, and their methods do not align with STEM's interdisciplinary nature (Sardana et al., 2024). Without proper training, students receive substandard teaching, limiting their participation and STEM success.

Strategies for enhancing the participation of the Scheduled Tribes students in STEM education

Addressing gender issues in accessing and persisting in STEM higher education requires a multifaceted approach that incorporates educational strategies, policy interventions, and community engagement. One effective solution to combating gender bias in STEM education is the implementation of gender-conscious pedagogies. These pedagogies aim to create inclusive learning environments that challenge traditional gender stereotypes and encourage all students to engage with STEM subjects (Kube et al., 2024). Mentorship programs play a crucial role in supporting disadvantaged students in STEM. By pairing students with mentors who understand the unique challenges faced by marginalized groups, these programs can provide valuable guidance and encouragement. Effective mentorship initiatives may include outreach to female role models and professionals in STEM and fostering connections that can inspire and motivate students to pursue their interests. Institutions can tackle gender bias and support disadvantaged students in STEM by implementing policies that include funding opportunities for girls, promoting female recruitment and retention, and providing targeted scholarships or grants. Additionally, fostering an inclusive campus environment through diversity training for staff and students can enhance belonging and engagement (Boyle, 2023). Community engagement and family involvement are also critical in addressing gender bias in STEM education. For instance, family engagement initiatives have been shown to improve students' confidence and interest in STEM, particularly in contexts where families may not traditionally value these disciplines (Kube et al, 2024; Powers et al., 2014).

To combat discrimination in STEM, inclusive curricula that highlight diverse perspectives and contributions are key. Incorporating the histories and achievements of underrepresented racial and ethnic groups validates students' identities and encourages their engagement in STEM. Collaborative research focused on the challenges faced by disadvantaged groups in STEM also helps. By involving students in projects addressing racial identity and caste discrimination, institution foster inclusivity and promote critical scholarship (McGee, 2020). Clear antidiscrimination policies addressing racial and caste-based issues must be communicated and enforced, with faculty and staff trained on diversity, equity, and inclusion (McGee, 2020; Lee et al., 2020). Students from disadvantaged backgrounds often face additional commitments that necessitate flexible learning environments. Offering evening classes, online courses, and experiential learning can help students balance their responsibilities while pursuing education (National Academies of Sciences, Engineering, and Medicine, 2016). The National Science Foundation (NSF) supports inclusivity in STEM through initiatives that increase access for underrepresented communities, with a focus on building research capacity and expanding opportunities (National Science Foundation, 2024).

Implement robust financial support programs. Scholarships, grants, and tuition waivers specifically for low-income students can alleviate the financial burden associated with higher education, making it more accessible. Research indicates that students who receive financial aid are more likely to persist in their studies and graduate, especially in high-cost fields such as STEM (Ajayi et al., 2023; The Importance of STEM Education for K-12 Students in Low-Income School Districts, 2023). Collaborations between educational institutions and industries can provide low-income students with practical experience and financial incentives (Palid, 2023). Mentorship programs that connect low-income students with industry professionals or faculty can foster persistence in STEM education (Ghazzawi et al., 2021). Advocating for state and federal support focused on the equitable distribution of educational resources can help low-income students gain better access to STEM education opportunities (Why do You Think Low-Income Students are Underrepresented in STEM Fields, 2024).

Resource insufficiency includes lack of funding, inadequate facilities, insufficient teaching materials, and a shortage of trained educators, all of which hinder STEM education quality. Schools in low-income areas often face these challenges, limiting their ability to provide effective STEM education (Houston et al., 2022). Geographic factors further affect resource distribution. Addressing these issues requires targeted investments in under-represented communities, as noted by Houston et al. (2022). Insufficient resources not only reduce access to essential tools but also impact student engagement and performance. Schools serving disadvantaged students struggle to support STEM programs, resulting in lower participation in advanced courses (Houston et al., 2022). Partnerships with local industries and mentorship programs can enhance resource and engagement (Houston et al., 2022; Build Community Connections to Break Barriers in STEM, 2024).

CONCLUSIONS

The status of females in science streams seems to be making strides based on information from all angles. However, the progress of the Scheduled Tribe (ST) women into engineering and technology fields is hindered by gender inequality. There is an obvious need for targeted intervention. Creating a supportive educational milieu that helps eliminate such hurdles is essential to enable all SC students, including girls, to excel in higher education, STEM, and beyond.

This study enhances the understanding of disparities in STEM education for Scheduled Tribe (ST) students at the higher education level by providing key data on enrollment, retention, and graduation rates while revealing socioeconomic and cultural barriers. This approach informs policy development by emphasizing the need for targeted interventions such as scholarships, mentorship, and culturally relevant curricula. Additionally, it guides institutions in creating supportive environments through improved infrastructure and faculty training, promoting equitable access to quality STEM education, and better outcomes for marginalized ST communities in India.

LIMITATION AND FURTHER RESEARCH

This study shows the enrollment of Scheduled Tribe (ST) students in Science and Engineering Technology from 2010-11 to 21-22. We were unable to show the enrollment status of the Scheduled Tribe Students (ST) students of Mathematics due to data unavailability. Due to insufficient time, only undergraduate- and postgraduate-level enrollment statuses are shown. The enrollment status of Schedule Tribe (ST) students in STEM studies can be shown in subsequent studies and related to their enrollment status in mathematics.

Further research on the Status of Scheduled Tribe Students in STEM at the Higher Education Level could cover a few areas: First, the socio-economic obstacles that act as barriers in the intake and retention of students from the ST group in the streams of science and technology must be understood about structural inequalities. It would be reasonable to outline future research on how gender disparities work within ST communities in the context of STEM education for policies that might bring more ST women into the field. Third, studies should investigate how effective various initiatives taken by the government and scholarships are in improving the representation of STs in science and technology and their long-term outcomes. Finally, comparative research may investigate regional differences in STEM enrollment and performance among ST students across different states to identify specific local challenges and successes.

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