Office of the Principal Scientific Adviser to the Government of India

1999-2024 Years of Impact through Science Advice

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Concept Document

Inclusivity in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) in the Indian Context

(Background Document for draft Inclusivity-STEMM-SARF)

Preamble

This concept document envisions highlighting different aspects of inclusivity that need emphasis or a renewed impetus from an institutional and policy viewpoint. It also serves as a background document for the draft Self Assessment and Reporting Framework (SARF) on inclusivity in STEMM being conceptualised by the Office of the Principal Scientific Adviser to the Government of India. The document can inform diverse stakeholders including policymakers, academic institutions, research bodies, industry, civil society, and the public on incorporating considerations of inclusivity in their processes. These considerations include the widely discussed dimensions of inclusivity such as gender, disability, language, etc. alongside some of the less discussed dimensions such as knowledge plurality, diversity of thoughts and experiences, and intersectionality. The first section elaborates on the concept of inclusivity, its interconnectedness with equity and accessibility and its significance in the STEMM ecosystem. The document further contextualises inclusivity for the Indian STEMM ecosystem to break the 'one size fits all' notion. It referred to several best practices globally, keeping in mind the unique requirements of India, based on conceptual as well as contextual understanding. While identifying challenges and opportunity areas in different dimensions of inclusivity in the Indian STEMM ecosystem, the document provides key recommendations to make the STEMM ecosystem more diverse, equitable, inclusive, and accessible. The recommendation section captures aspects such as ensuring gender equity, inclusion of regional and linguistic diversity, leveraging cognitive and knowledge plurality, enabling people with disability, and addressing intersectionalities. The following section suggests pathways to improve inclusive and evidence-driven decision-making and fostering a robust institutional culture for inclusivity in STEMM from a science advice viewpoint. The section emphasises incorporating social and behavioural sciences, science advice, multidisciplinary approach, principles of open science, people's perspective and appropriate feedback mechanisms into decision-making. The final section elaborates on the intent, use case and the way forward for the draft Inclusivity-STEMM-SARF.

I. Inclusivity and its significance in the STEMM Ecosystem

The concept of inclusivity is a hallmark of an evolving society. Diversity, Equity, Inclusion, and Accessibility are the key principles of inclusivity. Diversity is often described as a variety of experiences among the members within a group. It can be multidimensional, including but not limited to diversity of social identity such as gender, age, race, religion, regional identity, language, economic status, disability status, sexual orientation, etc.; diversity of thoughts; and diversity of knowledge. In the field of STEMM, diversity of thoughts, experiences, and knowledge is as important as diversity of social identity. Different kinds of diversities need to be equitably included based on the principles of fairness, justice, and representation. It is also important to understand the difference between equality and equity. While equality considers treating all people the same, equity is more nuanced as it provides a level playing field to those who require it more than others, taking into account their distinct realities. Inclusion refers to an environment where everyone feels valued and respected, irrespective of their identity. Mere diversity becomes meaningless unless people feel equitably included in processes and decisions. Accessibility makes the quality of any intervention, information, product, institution, or environment to be mindful of and usable by as many people as possible. Diversity, Equity, Inclusion, and Accessibility are interconnected and work best when viewed in unison.

Multiple layers of disparities affect the STEMM ecosystem by excluding a certain population, systems of thought, and streams of knowledge based on both explicit and implicit biases and stereotypes. Along with explicit biases, people from underrepresented communities also face microaggressions, meaning indirect and subtle discrimination through statements, actions, or incidents reflective of implicit abuse, insult, and invalidation. The plurality of knowledge, thoughts, and experience also holds significance in STEMM. The overall experience and mental well-being of individuals with marginalised identities are important attributes of equity and inclusion. Hence any institutional and policy decision aimed to facilitate ‘doing science’ should always pay due consideration to the social, cultural, knowledge, and other identities of those doing science.

To optimally realise and utilise the enabling prospects that are inherent to scientific discoveries, technological advancements, and their application, it is essential to view science as a common good and develop a cadre of trained human resources that represents the entire population[1].

[1] 2017, UNESCO Recommendation on Science and Scientific Researchers

II. Considerations of Inclusivity in STEMM specific to India

Diversity of socio-economic, cultural, and knowledge identities: India is a diverse country. Along with the globally relevant identities, Indian society has historically created various other kinds of social and knowledge identities. In India, the social identity of individuals, such as gender, geography, language, etc., directly impacts their education and career choices. This is especially true for higher education and careers in STEMM. For instance, the disproportionate burden on women to act as caregivers of the family, both for children and elderly people, acts as an impediment to their educational and professional progress.

Accessibility: Accessibility is another aspect that needs serious consideration in the field of technology and innovation. India's digital transformation is facilitating the accessibility and affordability of certain technologies. Due consideration for accessibility based on geography, disability, and language can make this technological transformation truly inclusive. Sections of STEMM promote the participation of people with disabilities by making institutions accessible to people in terms of their infrastructure. National Education Policy 2020 emphasised rethinking various aspects of education from the inclusion and accessibility viewpoint, especially for people with disabilities. However, we still have a long way to go in ensuring their equitable participation.

Linguistic and regional disparities: From inclusion and accessibility viewpoints, despite several efforts to bridge the technology-oriented language gap across the country, the language barrier in education and the job market persists. A similar can be witnessed in the innovation ecosystem where non-English speaking innovators face difficulties participating in mainstream innovation activities including learning modern subjects, raising investments, accessing markets, etc. Alongside and intertwined with language-related disparities, regional disparities are prominent in India, especially concerning the STEMM infrastructure. Evidence also suggests that educational and career outcomes in India can be attributed to a lack of provisions to pursue education in the mother tongue (Karla and Dutt, 2019). Indigenous groups and linguistically underrepresented groups are highly affected due to the unavailability of the curriculum and teachers in tribal languages.

Plurality of knowledge: Along with social identities, India has a cultural identity distinct from the rest of the world. Hundreds of cultures coexist in the country. Diverse knowledge systems have emerged and thrived in India through generations that are distinct from mainstream knowledge systems. Traditional and indigenous knowledge systems in India are gaining due recognition, and policies are being devised to speed up this process. Initiatives and policies promoting indigenous development of technology, tech indigenisation, and promotion of grassroots and frugal technologies, are bringing local knowledge and actors to the mainstream. However, their sectoral application is skewed.

Diversity of thoughts and experiences: For a country like India, diversity based on thoughts and experiences is also critical for expanding the horizons of scientific research. For example, individuals with multidisciplinary expertise can contribute meaningfully to the ethical practice of science and ensure its

connection with society. India is both a demographically and cognitively diverse country. Cognitive diversity implies educational and functional diversity, as well as diversity in the mental frameworks that people use to solve problems. Cognitive diversity brings different perspectives and perceptions at the workplace, universities, and other institutions. However, the recognition of cognitive diversity and neurodiversity in the overall diversity narrative seems lacking. Barring a few efforts to bring such individuals into the mainstream, the cognitively diverse population remains a highly untapped talent pool globally.

Intersectionality of diversities and disparities: In India, linguistic and cultural multiplicities coexisting with diverse knowledge systems make the intersectionality lens more critical and complex. Gender is a key aspect that intersects with other social and knowledge identities. The siloed discussions around inclusivity in STEMM often fail to capture the intersectionality in disparities. One of the reasons behind this could be the lack of a comprehensive framework derived from contextual understanding.

In India, these diversities coexist with several implicit biases. These issues are systemic and a true commitment to systemic change in the STEMM culture is essential for addressing them. Given its unique socio-cultural context and distinct pace of development, India requires inclusivity policies that are tailored to its needs and demands.

III. Ensuring Inclusivity in the Indian STEMM Ecosystem

Ensuring gender equity in STEMM: Policies with a sociological and behavioural lens

The efforts to ensure gender equity must stem not just from economic development needs but also from moral and sociological standpoints. Policy and public discourse around gender equity should include all genders. **To achieve gender equity, every policy, especially STEMM-oriented policies, should be framed with also a gender lens**. The persistence of leaky pipelines for women in STEMM education and careers, skewed sectoral participation, and tokenism in representation at leadership levels are some of the widely acknowledged issues in the STEMM policy. However, systemic barriers such as implicit biases, microaggressions, lack of conducive infrastructure, and lack of awareness and sensitisation make it difficult for women and other marginalised genders to find their 'Science identity'. **The STEMM ecosystem needs to carefully consider both explicit and implicit issues**. The development of a **quality, accessible, and affordable care economy** is also necessary to support women who are primary caregivers of the family.

Inclusion of regional and linguistic diversity from the position of strength:

As regional and linguistic disparities are often linked to each other, our **policies and institutions may approach these disparities together.** At the level of education, **institutions in both urban and rural areas can act as a conduit for change**. However, alongside these institutional efforts, a more **behavioural shift** is required. An individual's creative expression must not be hindered because they do not speak a certain language. Similarly, their capabilities must not be assessed based on the language they speak. This is especially important in the fields of science and innovation. Furthermore, **technology, innovation and design thinking can be leveraged to turn this linguistic plurality into an asset**.

Leveraging cognitive diversity (diversity of thoughts, experiences, and expressions)

There is a large scope for the scientific enterprise to leverage and thrive from the diversity that comes with the uniqueness of every individual. Several development-oriented studies have substantiated the role of diversity of thoughts, experiences, and expressions in organisational as well as national development (Tsimpli et al, 2020). However, sheer development is a very narrow purview of an individual's ability to contribute to any domain. **Hence, the role of conducive policies and institutional environment becomes critical in enabling people with different skill sets, different ways of thinking, different perspectives, different ways of communicating, different ways of learning and processing information, and different intellectual abilities to be able to participate in STEMM activities**.

Plurality of knowledge: Due recognition of diverse systems of knowledge

Plurality of knowledge implies plurality in the production, sharing, and validation of knowledge. Taking into account diverse systems of knowledge alongside mainstream knowledge through appropriate validation can

anchor robust, inclusive, and sustainable development of the STEMM field. Knowledge systems that are different from contemporary systems followed globally should not be misconstrued as pseudoscience and their validations should be a collective process. **Policies and institutions should emphasise the recognition of multiple systems of knowledge or ways of knowing and showcase openness to different forms of knowledge sharing, not only restricted to academic formats but also encompassing other forms.** Having said that, validation of any system of knowledge is critical in understanding its reliability. Globally, the validation processes such as peer-to-peer validation and collaborative validation are used. **There are instances where local and indigenous knowledge has successfully been gathered and integrated into the policies with the support and agreement of the carriers of knowledge**[2].

Removing barriers for people with disabilities

People with physical, developmental, behavioural and sensory disabilities face several socioeconomic, physiological and psychological barriers. Participation of disabled students is less than 1% of the total students enrolled in Indian Higher Education Institutions[3]. It becomes even less as we explore the diverse streams of STEMM (All India Survey on Higher Education (AISHE), 2021-22). The same is reflected in both the general and the STEMM workforce. Students and STEMM professionals with disabilities recount several instances of being constrained from carrying out activities such as lab tasks, outdoor experiments, peer interactions, etc. **Interventions for people with disabilities are often focused on rehabilitation as opposed to accessibility and addressing marginalisation**. To remove barriers for people with disabilities in STEMM concerted efforts are needed to **a) equip our institutions with accessible infrastructure, scientific and otherwise, b) sensitise the individuals and the environment surrounding people with disabilities and c) begin this at the early stage of their education to prepare them for higher education and employment.**

Acknowledging and addressing intersectionality:

The demographic diversity in India has birthed several intersectionalities, both positive and negative. The very first step is to **acknowledge that individual diversities and disparities intersect with each other to create an effect that is larger than the sum of its parts**. **Efforts need to be placed to address them simultaneously**. **An example of positive intersectionality is** linguistic diversity in India, which is a potential factor affecting cognitive skills. Evidence suggests that a socio-culturally diverse environment enhances cognitive functions in children (Karla and Dutt, 2019). **In the case of negative intersectionality**, a study found that the under-represented groups with low-income status and first-generation college status

[2] Carriers of knowledge can be individuals, institutions, or the knowledge itself (in the form of different formats such as books, manuscripts, visuals, etc.). These carriers can be knowledge workers as well, meaning those who apply this knowledge management, innovation, problem solving, etc. Some of the knowledge carriers can simply be the transferers of that knowledge

[3] As per the AISHE 2021-22 report, the total enrolment of students in higher education was ~4 crores, out of which only ~88000 students were people with disabilities. Making their representation only 0.22%

faced additional disadvantages in terms of educational outcomes (Whitcomb, et.al, 2021). In India, gender together with regional disparity creates a critical intersectionality.

It is equally important to inculcate a culture that values people's distinct experiences alongside their shared realities.

Along with the above aspects, there are several other important opportunity areas that can emerge in this discourse. The purpose of this document is to also have more such opportunity areas and intersectionalities recognised by stakeholders based on context and relevance.

IV. Pathways to improve inclusive and evidence-driven policymaking in STEMM: Science advice aspect of inclusivity in STEMM

It is important to integrate Science Advice into policymaking**.** Science advice acts as an interface between science and policy and is equipped with the expertise to use scientific and technical knowledge in a specific social, political, and economic context. Science advice possesses a distinct position in the policy landscape as it is driven by expertise, experience, and a degree of independence from policymaking institutions and processes. The sector-agnostic and multidisciplinary nature of science advice can aid in making policies that are more responsive yet proactive regarding the needs of society and science.

1. **Integrating scientific evidence, technical expertise and contextual understanding while making policies**: A two-fold approach of policy making incorporating empirical evidence while also giving relevant weightage to other forms of knowledge, technical expertise and contextual understanding of the ecosystem.

2. **A multidisciplinary approach to policy making:** Instead of being seen as additional processes, Social[4] and Behavioural[5] Science evidence can be seamlessly integrated into science policy. Social and behavioural science expertise should be included at the early stage of the policymaking process. Similarly, methods such as qualitative analysis, Focus Group Discussions (FGDs), Natural experiments, Randomised Controlled Trials (RCTs), etc. that social and behavioural sciences deploy to understand any issue and to devise a solution need to be adopted to facilitate policy-making.

3. **Policies based on the principles of open science:** Policies around science and scientific knowledge should be based on the principles of open science. This means that the policies should promote not just production but also the dissemination and application of scientific knowledge based on openness, inclusivity, accessibility, and sustainability.

4. **Building institutional and policy capacities:** To be able to form both responsive and proactive policies around inclusivity in STEMM, it is necessary to build individual, institutional, and policy capacities. A capacity-building module can be developed on inclusivity in STEMM for all STEMM policymaking bodies to demonstrate how every policy measure can effectively incorporate the inclusivity lens.

5. **Identifying and building synergies:** It is widely recognised that any transition requires a whole-of-system approach. Hence, it is critical to build synergies between different institutions,

[4] E.g., the physical, economic, social, cultural, and policy environments
[5] E.g., behaviours, knowledge, attitudes, beliefs, motivations, perceptions, cognitions, and emotions

policies and programs in the quest to achieve a common goal. Multidisciplinary, multi-stakeholder, and representative approach can be essential in this regard.

6. **Engaging the public in policy-making:** It is critical to ensure that policymakers take as full a purview as possible of how any policy intervention or measure impacts different people, ideas, and ideologies. However, public participation in decision-making should not stem from the 'Deficit Model' of understanding[6]. The decision-making for scientific policies should be based on the goal of democratisation of science[7].

7. **Developing a database for inclusivity in STEMM:** The lack of data that is disaggregated based on different inclusivity-related indicators keeps several issues from coming to the mainstream. Collection, collation, and analysis of such disaggregated data based on a comprehensive list of indicators can aid evidence-driven policymaking.

8. **A dynamic monitoring, evaluation, and revision mechanism:** The constantly evolving demography and socio-political conditions in India call for dynamic monitoring, evaluation, reflection and reconceptualisation of policies to effectively incorporate the emerging evidence. A strong foresight capacity can be developed at the institutional level to anticipate emerging challenges and the potential impact of existing interventions on society.

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[6] The deficit model of scientific understanding perceives the public to be "blank slates" where their knowledge of scientific discourse and research is almost non-existent (Gregory, Jane and Miller, Steve, 2000)
[7] In addition to being rigorous, science should also be participatory, popular, and relevant. (Guston, 2004)

Inclusivity in STEMM: Self Assessment and Reporting Framework

A Self Assessment and Reporting Framework (SARF) is developed to identify and assess institutional efforts on key aspects of inclusivity, including

1. Ensuring Gender-based equity
2. Promoting other historically underserved groups (underrepresented groups, persons with disabilities, individuals from less advantaged economic backgrounds, people from less advantaged territories, people with linguistic barriers, etc.)
3. Ensuring diversity of thoughts, disciplines, perspectives and experiences
4. Ensuring plurality of knowledge and languages
5. Fostering just, ethical, and open science

This Self-Assessment and Reporting Framework can help

a. Institutions and policymakers to assess priorities and existing efforts around different aspects of inclusivity.
b. Institutions to assess their performance and priorities concerning specific areas of inclusivity.
c. Decision-makers to identify assets, gap areas, priorities, and opportunity areas for different institutions.
d. Institutions and policymakers to revise the existing instruments and deploy new ones.

Upon self-assessment and reporting by diverse institutions including government, industry, academia, R&D bodies, etc. An asset-gap analysis can be conducted to further shape inclusivity in STEMM initiatives in the country. Best practices will also be shared with the wider ecosystem.

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References:

- All India Survey on Higher Education (AISHE) Report 2021-22, Department of Higher Education, Government of India. https://cdnbbsr.s3waas.gov.in/s392049debbe566ca5782a3045cf300a3c/uploads/2024/02/20240719952688509.pdf
- BhashaNet Portal, Ministry of Electronics and Information Technology (MeitY), Government of India. https://bhashanet.in/home
- Bilimoria, D. and Singer, L.T. (2019), "Institutions Developing Excellence in Academic Leadership (IDEAL): A partnership to advance gender equity, diversity, and inclusion in academic STEM", Equality, Diversity and Inclusion, Vol. 38 No. 3, pp. 362-381. https://doi.org/10.1108/EDI-10-2017-0209
- Chowdhury, Fahmida & Marinova, Galia & Ciupercă, Ella & Bhattacharya, Basabdatta & Doyle-Kent, Mary. (2021). The State of Play in Diversity and Inclusion in STEM–A Review of Empirical Evidence, Focusing on Gender. https://www.researchgate.net/publication/356180427_The_State_of_Play_in_Diversity_and_Inclusion_in_STEM-A_Review_of_Empirical_Evidence_Focusing_on_Gender/citations .
- Council of Scientific & Industrial Research (CSIR) Traditional Knowledge Digital Library (TKDL) Unit https://tkdl.res.in/tkdl/langdefault/common/Home.asp?GL=Eng
- Abigail J. Lynch, Álvaro Fernández-Llamazares, Ignacio Palomo, Pedro Jaureguiberry, Tatsuya Amano, Zeenatul Basher, Michelle Lim, Tuyeni Heita Mwampamba, Aibek Samakov, Odirilwe Selomane (2021). Culturally diverse expert teams have yet to bring comprehensive linguistic diversity to intergovernmental ecosystem assessments, One Earth, Volume 4, Issue 2, 2021, Pages 269-278, ISSN 2590-3322, https://doi.org/10.1016/j.oneear.2021.01.002.
- Deloitte Review, 2018, the Diversity and Inclusion Revolution. https://www2.deloitte.com/content/dam/insights/us/articles/4209_Diversity-and-inclusion-revolution/DI_Diversity-and-inclusion-revolution.pdf
- Digital India Bhashini, Ministry of Electronics and Information Technology (MeitY), Government of India. https://bhashini.gov.in/about-bhashini
- Kalra, R., Dutt, A.K. (2019). Exploring Linguistic Diversity in India: A Spatial Analysis. In: Brunn, S., Kehrein, R. (eds) Handbook of the Changing World Language Map. Springer, Cham. https://doi.org/10.1007/978-3-319-73400-2_202-1
- Marshman, Emily & Kalender, Z. Yasemin & Nokes-Malach, Timothy & Schunn, Christian & Singh, Chandralekha. (2018). Female students with A's have similar physics self-efficacy as male students with C's in introductory courses: A cause for alarm?. Physical Review, Physics Education Research. https://journals.aps.org/prper/abstract/10.1103/PhysRevPhysEducRes.14.020123
- David H. Guston (2004). Forget Politicizing Science. Let's Democratize Science! Issues in Science and Technology. https://issues.org/p_guston-3/
- Kenneth Gibbs, Jr. (2024) Diversity in STEM: What It Is and Why It Matters, 2024. Scientific American. https://blogs.scientificamerican.com/voices/diversity-in-stem-what-it-is-and-why-it-matters/
- Global Gender Gap Report, 2023, World Economic Forum. https://www.weforum.org/publications/global-gender-gap-report-2023/in-full/benchmarking-gender-gaps-2023/
- Gregory, J., & Miller, S. (2000). Science in Public. Communication, Culture, and Credibility (294 p.). Cambridge, MA: Basic Books. https://dokumen.pub/science-in-public-communication-culture-and-credibility-9780738203577-0738203572.html
- Ankur Paliwal (2023). How India's caste system limits diversity in science — in six charts. Nature. https://www.nature.com/immersive/d41586-023-00015-2/index.html
- I-STEM (Indian Science, Technology, and Engineering facilities Map) Women in Engineering, Science, and Technology (WEST), Office of the Principal Scientific Adviser to the GoI.

https://www.istem.gov.in/west

- Gratani, M., Butler, J. R. A., Royee, F., Valentine, P., Burrows, D., Canendo, W. I., & Anderson, A. S. (2011). Is Validation of Indigenous Ecological Knowledge a Disrespectful Process? A Case Study of Traditional Fishing Poisons and Invasive Fish Management from the Wet Tropics, Australia. Ecology and Society, 16(3). http://www.jstor.org/stable/26268947
- Tsimpli, Ianthi Maria, Margreet Vogelzang, Anusha Balasubramanian, Theodoros Marinis, Suvarna Alladi, Abhigna Reddy, and Minati Panda. (2020). "Linguistic Diversity, Multilingualism, and Cognitive Skills: A Study of Disadvantaged Children in India" Languages 5, no. 1: 10. https://doi.org/10.3390/languages5010010
- Moss-Racusin, C. A., Pietri, E. S., van der Toorn, J., & Ashburn-Nardo, L. (2021). Boosting the Sustainable Representation of Women in STEM With Evidence-Based Policy Initiatives. Policy Insights from the Behavioral and Brain Sciences, 8(1), 50-58. https://doi.org/10.1177/2372732220980092
- Women Wizards Rule Tech (W2RT). National Association of Software and Services Companies (NASSCOM). https://www.nasscom.in/press/nassscom-launches-women-wizards-rule-tech-program-women-technologists
- Austin, Robert D., and Gary P. Pisano. (2017). Neurodiversity as a Competitive Advantage. Harvard Business Review 95, no. 3 (2017): 96–103.https://www.hbs.edu/faculty/Pages/item.aspx?num=52624
- Whitcomb, K. M., Cwik, S., & Singh, C. (2021). Not All Disadvantages Are Equal: Racial/Ethnic Minority Students Have Largest Disadvantage Among Demographic Groups in Both STEM and Non-STEM GPA. AERA Open, 7. https://doi.org/10.1177/23328584211059823
- Olzmann JA. (2020). Diversity through equity and inclusion: The responsibility belongs to all of us. ascb MBoC, Vol. 31, No. 24. https://www.molbiolcell.org/doi/full/10.1091/mbc.E20-09-0575
- Maries, A., Singh, C. (2024) Towards meaningful diversity, equity and inclusion in physics learning environments. Nat. Phys. 20, 367–375. https://doi.org/10.1038/s41567-024-02391-6
- Vernacular Innovation Program (VIP), Atal Innovation Mission (AIM), Government of India 2021. https://aim.gov.in/Vernacular-Innovation-Program.php
- The United Nations Educational, Scientific and Cultural Organization (UNESCO) Recommendation on Open Science, 2021 https://unesdoc.unesco.org/ark:/48223/pf0000379949
- The United Nations Educational, Scientific and Cultural Organization (UNESCO) Recommendation on Science and Scientific Researchers, 2018 https://unesdoc.unesco.org/ark:/48223/pf0000263618
- Gary S. Weissmann, Roberto A. Ibarra, Michael Howland-Davis & Machienvee V. Lammey (2019) The multicontext path to redefining how we access and think about diversity, equity, and inclusion in STEM, Journal of Geoscience Education, 67:4, 320-329. https://doi.org/10.1080/10899995.2019.1620527
- Women in Science and Engineering-KIRAN (WISE-KIRAN), Department of Science and Technology, Government of India. https://dst.gov.in/scientific-programmes/wise-kiran#:~:text=Vigyan%20Jyoti%3A,gender%20ratio%20across%20the%20streams