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Prescriptive Analysis of STEM based activity on Student Awareness Engagement and Equity in Education

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Abstract: During an era of widespread focus on how important STEM is, there has persisted a gender imbalance that prevents women from fully coming into their own in scientific endeavors, a shortfall that can slow outstanding research. This study attempts to overcome these obstacles by spreading awareness to children from varied age groups and backgrounds, through interactive seminars that bring to the front the outstanding yet historically repressed work of women in STEM. This methodology distinctly administers questionnaires to gauge the students' perceptions, enabling seminar material to be dynamically adjusted to promote participation and comprehension of gender roles. The most significant findings indicate that students' economic status and family background greatly influence their attitude in favor of boys' access to education. Additionally, rural students have other challenges which lead to reduced exposure to technology in comparison to urban students. Keeping in mind the magnitude of this problem, this research emphasizes the critical role of higher authorities, especially government institutions, in augmenting these activities. Although policies such as the NEP 2020 seek to increase access, drawbacks and failures in their implementation indicate that increased government intervention is needed to augment technology exposure and establish true equal educational settings. In conclusion, this study promotes pro-active, responsive pedagogical approaches and systemic interventions to tackle socio-economic and spatial inequalities in promoting inclusivity of STEM from early schooling.

Index Terms - STEM education, Gender disparity, Technological awareness, Student engagement, Rural-Urban divide, Women in STEM.

I. INTRODUCTION

The disciplines of Science, Technology, Engineering, and Mathematics (STEM) are crucial to India's emergence as a superpower globally. Yet, even though the fields are critical, we notice a stark contrast in who occupies these sectors.

Though increasing number of women are enrolling in STEM courses, their numbers decline when considering higher engineering degrees and positions of leadership. This implies that mere opening of education doors will not do. We need to examine the social problems, teaching practices, and employment obstacles keeping girls and women from being able to take part in and thrive in STEM professions. This paper will discuss these issues briefly, emphasizing the need of uncovering the ways that girls and women are both encouraged and discouraged to pursue STEM from their earliest years at school through to their careers.

Most of this issue starts in schools, where the way subjects such as math and science are taught could be holding girls back. Our existing education system tends to be too based on theory, with little room for practical learning. It also tends to commonly highlight men's accomplishments in science and fails to represent the work of women and men equally. This has the effect of making these topics less engaging or more difficult to relate to, particularly girls, who lose interest by high school. Losing students so early in the process means that we are missing out on a great deal of potential talent. Outside of schools, the scarcity of women role models in higher academic ranks and absence of infrastructure of professional colleges designed solely for women exacerbates the problem. This forms a cycle whereby women do not represent themselves in STEM, and thus it becomes more difficult for them to imagine themselves working in the field and receiving the support.

Lastly, even for women who do enter STEM careers, the path is frequently made up of special challenges. Reports indicate that women in scientific and technical careers are promoted more slowly and have felt compelled to work far harder than their male counterparts in order to achieve the same level of reward and establish their competence. This underscores an imbalance between their academic achievements and the opportunities they get in the career world. To balance these disparities, our actions must transcend simply pushing more girls to pursue STEM. We need to make the environment conducive with support, provide good mentorship, bring out the successes of women, and treat them equally throughout their schooling and working lives. Only by addressing these challenges is India able to tap the potential and engagement of all its people in the critical STEM fields.

II. LITERATURE REVIEW

2.1 Female Enrollment Trends in Higher Education STEM Fields

It has been observed that there are changing pattern in women’s enrollment in STEM fields at both undergraduate and postgraduate roles by an analysis of All India Survey on Higher Education (AISHE) data. Female enrollment in B.Sc. and M.Sc. programs has consistently been on the rise across all categories, often comprising over half of the students. On the other hand, enrollment in B.Tech., M.Tech., and B.E. programs has been low, with slow and incoherent growth patterns. However, M.E. programs have recently seen a surge in female enrollment, though women are still underrepresented in most STEM fields [1].

2.2 Factors Influencing Girls' Engagement and Success in STEM

Several studies have highlighted the most important factors influencing girls' involvement and achievements in STEM. A trial conducted on students over a span of two years lead to Boys have showing greater willingness in supporting their sisters and other female family members’ education, while the program slightly increased girls' likelihood of applying for college scholarships [2].

A survey of secondary school students in West Bengal found that female students scored much higher compared to males in most personal values, indicating strong association to values relevant to success in STEM fields. The overall personal value score was higher for girls, suggesting they possess key personal qualities for STEM [3].

It was also found that the academic achievements of girls can be influenced by their geographical locations. While location doesn't impact the academic achievements of their male peers at the secondary level, rural girls tend to lag behind their urban counterparts [5]. Despite this, a study in Meghalaya found no significant difference in academic achievements between high and average achievers in rural and urban areas; interestingly, low achievers in rural areas significantly outperformed their urban peers [4]. For higher education students, self-efficacy plays a very important role, with urban girls in Aurangabad, Maharashtra, exhibiting higher self-confidence that can be leveraged to encourage their participation in STEM fields [6].

2.3 Classroom Environment, Faculty Representation, and Persistence in STEM

The classroom environment greatly impacts the students' academic performance. A survey conducted of STEM students from three universities of varied backgrounds concluded that a positive, inclusive classroom climate improves the engagement
of students. On the other hand, discriminatory environments especially harm the female's motivation and self-esteem [8].

Faculty representation also plays a crucial role. Professional colleges for women are scarce, making up only about 5% of women's institutes. There's a strong co-relation between the percentage of women teachers and women's enrollment, indicating that female faculty help encourage participation. Despite this, women are underrepresented in senior academic positions, holding only 15.64% of higher roles [7]. A multi-institutional study across U.S. colleges found that a higher percentage of women faculty was associated with a smaller GPA gap between male and female students, suggesting faculty representation can influence performance differences [9].

2.4 Challenges and Strategies for Encouraging Women in STEM Careers

The current Indian education system seems overly theoretical with limited experiential learning, which leads many students (especially girls) to lose interest in math and science by high school [13]. This highlights a critical need for early and sustained support for girls in STEM. Reaching out to them at a young age could help broaden thinking and guide them onto a STEM pathway [10]. A role model, strong mentor or support system plays a vital role in sustaining girls' interest in STEM fields.

Within professional settings, women remain underrepresented. In CSIR labs, women make up just 18% of scientists and 15% of technical staff, with very few in leadership positions.

Despite demonstrating strong research productivity seen in publications, patents, awards, and expert lectures, women S&T staff report delayed promotions, lack of recognition, and the need to work harder than male peers to prove themselves. Nearly two-thirds felt they had to work harder than men, and about 60% attributed missed opportunities to a lack of networking [11]. This reflects a disconnect between women's academic achievements and their representation and equity in STEM careers.

For women in STEM, particularly in educational and early career stages, supportive environments are vital for integrating their identities authentically. This reduces pressure to constantly adapt and improves persistence in STEM pathways [12].

2.5 The Impact of STEM Pedagogies on Academic Engagement and Achievement

The adoption of STEM (Science, Technology, Engineering, Mathematics) pedagogies shows promise in improving student engagement and achievement. The differences in academic outcomes of students when using a STEM-based education model were clearly visible, as the students were significantly more engaged in subjects that historically garnered less interest. Foreign studies, such as [15] were conducted in which students were divided into experimental and control groups and taught the same subject, with the experimental group using STEM activities and the control group using traditional teaching methods. The outcome was that the experimental group enjoyed the subject more, while the control group did not.

Various research studies showed that using STEM activities as the bridge between traditional teaching and the learning process of an average student could enhance academic performance. As shown in a recently conducted study [17], which had a research methodology similar to our research model, the conclusion was that STEM education, if used widely, could have an extensive and far-reaching positive influence on the accomplishments of secondary school students [18]. This is in line with other researches which show that STEM based learning environments are more effective than the curriculum-based ones in helping improve student's academic achievement [17].

For women in STEM, interdisciplinary STEAM principles offer inclusive and collaborative learning environments that can help bridge gender gaps. These approaches foster confidence, creativity, and leadership skills among girls, preparing them for future success [14].

III. RESEARCH METHODOLOGY

The methodology section outline the plan and method that how the study is conducted. This includes Universe of the study, sample of the study,Data and Sources of Data, study's variables and analytical framework. The detailsare as follows;

3.1 School Connect

To understand women's contribution in STEM and educate the school students about it, a qualitative research approach was adopted. It involved direct interaction with students from 2 rural and 2 urban schools across parts of Mumbai.

1. Vikas High School, Vikhroli.
2. Sandesh School, Vikhroli.
3. Adarsh Vidyalaya, Goregaon (W).
4. JVM's New English School, Kalwa (W)

Figure 1. An Image of urban school survey conducted

3.2 Formation of questionnaire

The students were asked to respond to a questionnaire which was designed to evaluate their prior knowledge and opinion of gender role in STEM. The questionnaire assessed their perceptions about women's participation in STEM and tested basic awareness of related issues. It included ten questions-seven multiple choice and three opinion-based question covering gender disparity, opportunity gaps, recognition of societal roles, expectations and social support mechanisms. Four out of the seven multiple choice questions, were based on gender related issues, while the remaining three questions focused on setbacks faced by women in STEM fields.

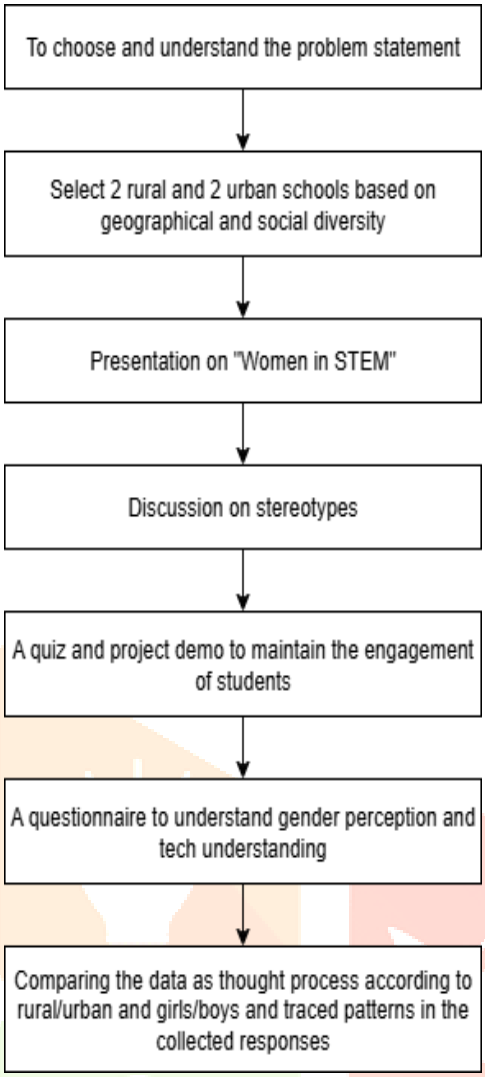

Figure 2. Flow of questionnaire formation

IV. RESULTS AND DISCUSSION

4.1 Response analysis

Table 4.1: Statistics

Question Criteria	Question no	Correct answer selected by students (in %)							
		Rural				Urban			
		School no. 1		School no. 2		School no. 3		School no. 4	
		Male	Female	Male	Female	Male	Female	Male	Female
Gender based	Q1	30.2	43.1	35.6	59.4	42.6	64.2	47.7	67.5
	Q4	77.9	84.3	72.3	88.9	85.1	91.3	87.8	94.5
	Q5	45.3	84.5	61.7	78.5	68.9	88.6	72.3	91.2
	Q6	70.9	52.8	80.3	49.7	76.5	66.4	80.1	69.7
Tech	Q2	51.2	41.7	40.3	38.4	59.2	51.7	62.6	55.1
	Q3	38.4	48.6	53.8	53.2	57.4	61.3	60.1	64.5
	Q7	62.8	69.4	73.9	71.2	79.4	84.2	82.8	87.3

The responses were analyzed to identify patterns based on their gender as well as age and how the students' background-whether rural or urban affected their perception. The last question asked the students whether they believed scientific contributions came primarily from men, women or both equally. It was insightful to understand their pre conditioning and influence the students had from society. A total of 811 students from all the four schools were involved in the session.

A comparison across all four schools- rural (school 1 & 2) and urban (school 3 & 4) based on the percentage of students who selected the correct answers in the questionnaire. The analysis was also categorized by gender to highlight how boys and girls differ in their understanding of women in STEM and related tech awareness.
In Q1, based on the reason for fewer women involved in STEM, urban females had the highest accuracy (67.5% in school 4 and 64.2% in school 3), while rural males performed lowest (30.2% in school 1).

In Q2, based on companies promoting women in technology, urban students, especially males, scored higher, with school 4 males at 62.6%. In Q3 (identifying stereotypes as barriers), urban girls led the scores (64.5% in school 4 and 61.3% in school 3).

Q4 and Q5 were about equal opportunities and societal support. It showed high accuracy, especially among urban females (above 90% in both schools), reflecting stronger awareness.

For Q6, referencing barriers like family responsibilities, males from rural school 2 (80.3%) and urban males (above 76%) showed strong understanding, while rural females had notably lower scores (52.8% and 49.7%).
From the opinion-based question, it was noticed that majority of the students' thoughts aligned with contributions of men and women in STEM being equal. The lowest correct perception was seen in rural school males (62.8%). This indicated traces of stereotypes in some regions.

4.2 Practical Learning

As part of this study, an IoT-based, women safety prototype was developed and demonstrated during the school sessions. The device was a buzzer system which responded to different click patterns.

1. Single click: Green light glows with low intensity beep indicating a mild security concern or the button being pressed mistakenly. This setting was added to ensure that the device would not immediately escalate in the case of accidental clicks.
2. Double click: Blue light glows with medium intensity beep indicating alert situation. This setting represents a scenario when a person does not feel safe in their surroundings, but does not wish to escalate to the highest level.
3. Triple click: Red light glows emitting a high intensity beep intended to alert people in emergency. This mode of operation is only intended to be used in absolutely critical situations where the person is in active danger and needs immediate assistance and is intended to provide the details of the person to their close ones, and to the required authorities.

This system was built with basic components like an Arduino board, buzzers, LEDs, breadboard and connecting wires making it easy to replicate as well as cost effective. This basic prototype was made for demonstration purposes on how fun science projects can be, once inculcated in our life at an early age. At greater stages, the system can be scaled to include a feature which can dial emergency services or send real-time notifications to closed ones. The circuit can also be embedded into smartwatches. It was meant to illustrate how STEM and IoT technology can be used to solve real world challenges; ensuring personal safety in vulnerable situations, in this case.

This demonstration sparked the interest of the students (especially girls) who found the idea practical and something they could start building themselves.

One of the students, in a rural school that was visited, had already represented the school and bagged first place in a robotics competition. This discovery highlighted a crucial point that rural students possess talent and passion in STEM, but lack exposure, guidance or a good platform to enhance their skills. The teachers expressed appreciation for the guidance that the students received and were enthusiastic for more such seminars in future.

4.3 Conclusion

Last but not least, this research stresses the necessity of making students aware of women's roles in STEM and introducing profound changes in their attitudes toward gender roles in STEM. Our use of tailored questionnaires has turned out to be helpful in pointing to the ways in which the National Education Policy (NEP) 2020 may be adjusted in order to address different student profiles, specifically by considering gender and economic diversity.

It is evident that a single system cannot guarantee well-rounded development of students; rather, interventions must be sensitive and adaptive to multiple behaviors and learning needs. While schools are also crucial locations for the spread of gender-sensitive STEM education, the broader socio-environmental context, specifically rural-urban variations play a highly contributory role in shaping students' perspectives and ambitions. Our study reveals that city students are more likely to have progressive attitudes than their rural counterparts, the kind that prove the unequal access to technology and social support systems can be a recipe for entrenched disparities.

In addition, the study recognizes the dormant potential among all students, including rural ones, who are deprived of good opportunities and platforms to fulfill their STEM potential.

This requires higher government and institutional involvement to ensure more access to technological resources and gender-mixed STEM projects in different regions.

Lastly, this research encourages comprehensive, region-sensitive education policies and implementations that recognize and address the varied barriers to women advancing in STEM. In doing so, we can establish an environment that will be fair to all students and enable them to grow and empower so that society can reap the best out of women's contributions to science and technology.

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