Women in STEM workforce: Review from Southeast Asian Economies

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Abstract

Science and technology has been considered a male-dominated profession with women holding fewer leadership positions. They are universally under-represented in STEM (Science, Technology, Engineering, Maths) fields. Retaining women in education and, hence, careers in science is essential for an economy's national development. They can bring a different outlook for every sphere by making it more diverse and leading to women's empowerment. A review of the literature has been done to determine the participation of women in the STEM workforce with a particular focus on Southeast Asian economies, which mainly comprise of the developing nations. The study identifies the reasons for women not being able to climb the hierarchical ladder in scientific careers. Furthermore, the initiatives taken by these nations to increase the participation of women in the STEM workforce have been discussed, followed by Interventions by the United Nations on this pertinent issue.

Keywords: Gender Studies, Leadership in STEM, Southeast Asian studies

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1. Introduction

For an economy to progress, Science, technology & innovation (STI), and human development are crucial, women represent almost half of the global population, and they can contribute a major strength to the socioeconomic development of a nation. They are a vital human resource and pillars of the world economy. They have contributed in almost every sphere of life by being powerful agents of change. They are even leading the country (women president, speaker, etc), being a source of inspiration to many. In this context, the far-reaching benefits of diversity and gender parity in leadership and decision-making are increasingly being recognized in all spheres. Women as leaders and decision makers ultimately play a critical role in advancing gender equality and furthering the nation's economic, social and political progress. Therefore, their contribution should not be ignored, and they must be represented in decision-making in businesses, educational institutions, communities, and politics not because of gender parity but because of their merit. Sadly, the S&T sector, which is considered a key element in the economic growth of a nation, is heavily male-skewed. Traditionally, it has remained a male-dominated area in many parts of the world where men still occupy the top positions. The presence of women in higher positions of power in this sector is still an exception. The growth in the fraction of women in S&T has been slow for many decade s (International Day of Women and Girls in Science). We need to understand that building scientific capacity is a shared responsibility and, in this regard, a serious concern has been raised since the 1970's for the inclusion of women and gender parity in S&T under the auspices of UN seminars, conferences being organised nationally and internationally. Delegates drafted the UNDP Beijing Express Declaration for advancing women's equality and opportunities at the Fourth World Conference on Women, Beijing, China, in 1995 where women's empowerment was at the forefront (UN, 1995). Since then, policymakers and planners have recognised the importance of women in leadership positions and efforts are being made. Developing nations that have made commendable progress have done it primarily through empowering women. So, the full involvement of women in scientific and technological endeavors is essential for rapid national development and the sustainable happiness of the people. Because of the persistent efforts by the governments of different nations, the number of women in leadership positions is on the rise from a local to a global level.

Despite some progress, women scientists are paid less, promoted less frequently, and more likely to quit research careers than men of similar qualifications (Inter-Academy Panel on '*Women in Science in India*', 2016). Inclusivity and diversity in leadership positions are important as they bring a fresh perspective to decision-making. Empowering professional women and women at the rural and grassroots levels of developing countries is necessary. Women in rural areas need to be valued as a precious human resource and not a liability as they can change the social stigmas of the society by their upliftment through science

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and technology, thereby, questioning the societal norms of the patriarchal mindset where head of the family is generally perceived to be a male, relationship between work and family which act as hurdles for women in science. They even join the labour market, but their number dwindles as they move up at the organisational ladder. In the engineering sector in many nations, the situation is even worse, where the participation of women in education and employment is low.

2. Review of Literature

Articles were searched from the Google Scholar database with the following search terms used; 'Women in STEM workforce', 'Barriers to women in STEM', Women in STEM workforce in South East Asia', 'Gender inequality in STEM professions in South East Asian economies', etc. Separate searches for this particular topic have been done for the ten members of ASEAN, i.e., Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam.

2.1 Participation of Women in the STEM workforce

Historically, women need to be more adequately represented in Science, Technology, Engineering, and Mathematics (STEM) education, leading to a corresponding underrepresentation in the STEM workforce (Landivar L. C, 2013). As per a 2017 report, women account for just 30% of STEM students in higher education worldwide (UNESCO, 2017). The absence of women in STEM organizations may lead to a lack of diverse perspectives, hindering the generation of innovative ideas. Homogeneous workforce in STEM are less likely to navigate effectively in dynamic and varied environments. Consequently, advocating for educational and career opportunities for women is viewed as a strategy to tap into the full potential of the entire pool of STEM innovators (Pearson et al., 2015). While Western countries have progressed towards more egalitarian social structures, many Asian countries still largely adhere to patriarchal social value systems (Mukhopadhyay & Seymour, 2021). Globally, efforts are underway to boost women's involvement in STEM education, civic engagement, and the STEM workforce. Some Asian countries have witnessed significant strides, with women notably increasing their presence in specific STEM fields, such as computer science and computer engineering (Fan & Li, 2005). Historically, educational opportunities, especially in STEM fields, have favored males over females. While Western countries have shifted towards more egalitarian social structures, many Asian countries still maintain predominantly patriarchal social value systems (Mukhopadhyay & Seymour, 2021). In the face of gendered challenges, numerous Asian women persist in pursuing STEM careers, navigating male-dominated work environments daily. Despite increased representation in specific STEM fields, women in many Asian countries often encounter limited access to leadership positions (Campion & Shrum, 2004). Excluding women from STEM organizations risks overlooking valuable innovative ideas. Homogeneous

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workforces struggle in dynamic, diverse environments. Thus, promoting educational and career opportunities for women is seen as essential to harness the potential of STEM innovators fully (Pearson et al., 2015).

In India, participation of women up to Ph.D. is about 20-25%, but in the positions of Professors or Heads of departments/divisions, it falls to 10-12% (Inter-Academy Panel on '*Women in Science in India*', 2016). Because of the trickle-down effect of few role models for women engineering students, there is a dearth of academic women engineers in visible leadership positions, which is responsible for their under-representation in academia, industry, and government. We need women in science at every level. According to a study on women in leadership, women spend more time contributing to diversity, equity, and inclusion efforts, 07% of men as compared with 11% of women (Forbes, 2021). Encouraging women faculty to consider formal leadership positions and providing structured opportunities to explore those options will likely result in those faculty members' participation as academic leaders (O'Bannon et al., 2020). Working women engineers have found less stress in managing work-life balance, and the gender parity index for women in science is more than one. Very few numbers of women engineers are in the decision-making positions. The employment of women engineers has increased, but they are primarily concentrated in the lower levels because they feel that the workplace is very masculine and they do not feel very comfortable in an organisation.

2.2 Reasons for women remaining in the lower levels of hierarchy in scientific fields

Women scientists face innate prejudice and bias in the workplace. Patriarchal norms contribute to gender discrimination challenges. There is widespread gender insensitivity, which exacerbates workplace issues, and explicit sexual harassment remains a pervasive problem. Gender is embedded in the socio-cultural rules of a workplace, and certain practices are biased towards men, which hinders the chances of women to get to the top (Gupta, 2017a). Women perceive themselves to be more fit in the managerial roles unlike men who consider themselves apt for technical roles because of gender stereotypes (Naukkarinen & Bairoh, 2022). In the case of CSIR laboratories, despite a significant contribution by women scientists in the output, they have not been able to reach the position of a head because of lack of visibility in the organization. (Namrata Gupta, 2014). They do not move up the ladder at the same place as men despite having the same experience as their male colleagues. (Gupta, 2017b) . A possible reason for this is the Indian culture, which requires women to devote time to family, thereby making them less productive in the perception of the males working in research organizations. Also, men remain in the upper posts because sexism exists in the work environment and is ignored by both men and women. (Bevan & Learmonth, 2013) . It was observed that women were more coordinated and the ones who shared

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information with all. They were satiated with their current position with low expectations to move up the ladder, unlike optimistic men (Dhawan, 2000). Another reason why women scientists are at the lowest levels is the inability to protest against wrongdoing and the lack of motivation. (Chakravarthy et al., 1988). Unconscious gender bias existed in institutions when women who were well-accomplished asked for laboratory space, financial resources, and awards to be granted based on merit. (Holliday et al., 2015). Women scientists are rarely appointed as the chairman of various committees in the research institutes and are very few at the top level of the hierarchy. (Namrata Gupta, 2020). They are smaller because of the existence of patrifocal social norms. (Gupta & Sharma, 2003a). Age could be a reason for women in the middle ranks being more productive in research than men because of less burden with grown-up children, and it tends to be even higher after they reach 50's as now they are free to devote time to research.(Gupta & Sharma, 2003b). Because of the belief that women face a dual burden of work and homely responsibilities, they are considered less productive in the workplace. This could be because of the total time devoted, which could be reduced due to family responsibilities or staying back at odd hours, etc. The younger male scientists did support their wives, who were also scientists, in sharing the household responsibilities and taking care of the family, but they did accept that despite their changes in thinking, the stereotypes still existed at the workplace. Apart from this, the social and cultural background of women determines their entry into science. The more educated parents with higher incomes encourage women's entry into male-dominated fields like science, but in the later stages of their careers, it does not affect them in any way. (Kumar, 2001). Many women researchers in STEM distance themselves from other women in the workplace whom they feel are overreactive to gender bias issues or who counter them because these women feel that because of countering the conflicts, it rather leads to their exacerbation and not the resolution of those issues (Rhoton, 2011). In India, unlike other nations, there is a belief that women are equally capable of doing science. In fact, if we look at the no. of publications, women are not behind men, but in spite of this, the workplace is gendered (Gupta, 2016) . In scientific research organizations, the socio-cultural context plays a crucial role in determining the level of gender bias. Because women are unable to socialize and form informal contacts with those in power, they are discriminated against when it comes to their promotions. This has been evident mainly in the case of junior women scientists (Gupta, 2016). Women in academic science are less than men in terms of faculty. There are more women than men in the position of assistant professor, but very few in the post of professors as compared to men as women are considered warmer and more social, whereas men are considered competent and innovative (Kumar, 2001). Because of lower informal networking, women are less engaged in innovation activities (Chatterjee.S,2018) . They are supposed to maintain their professional identity at the workplace and keep their one aside as it can hamper their professional image as one-woman engineers seem to represent all woman engineers. (Carter & Kirkup, 1990). Patronizing

attitudes of men in the workplace act as a hindrance to the progression of women in terms of collaboration and networking (Subramanian, 2007). It is mainly in academia that females get stuck under one specific male chauvinist head, and there is no option of switching. Interorganisational networks can help women scientists and support them to escape the hierarchical setup. (Smith-Doerr, 2004) . Casual odd-hour meetings, which are unproductive according to women scientists, provide an edge to men in having informal interaction with the ones in power (Gupta, 2017b). It is hard for women in academia to contact industry scientists and file patents (Kjersten Bunker Whittington and Laurel Smith-Doerr, 2008). Informal communication is prevalent in the departments of S&T universities. However, it is a matter of the only boy's club, which gives them an edge regarding networking inside and outside the committee. Socialization is a problem because of the culture of segregation of men and women in the workplace (Gupta & Sharma, 2002). Gender segregation in Turkey's R&D sector is less than any other nation like the US because a boost for women's participation in natural sciences and engineering fields via public education and a gender-neutral university entrance exam has led to a surge in women innovators. (Setenay Nil Dogan, 2015) . Apart from the formal and informal structural constraints, lower funding grants to women compared to men are another reason for their higher attrition rates. They have to depend mainly on personal sources for access to financial capital (Lueg, 2020). Grant funding is important for a scientist as it enhances productivity in the sense that a researcher can use it for training students or staff working under it on a project; it helps expand opportunities to collect data and also in forming more networks or collaboration. (Welch, 2014) . Sadly, gender discrimination exists even in grant funding because of the stereotypes.

2.3 Status of women in Southeast Asia

ASEAN aims to foster economic and security cooperation among its ten members: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. Girls in primary and secondary education in numerous ASEAN Member States (AMS) outperform boys in mathematics and science, but this academic advantage does not always result in their pursuing further STEM education or careers. Although more women enroll in higher education in Southeast Asia than men, they are significantly underrepresented in STEM disciplines. Only one in six STEM students are women, highlighting a pronounced gender gap in tertiary education (ILO, 2016). Although women constitute 39 percent of technology majors, a lower percentage compared to the 56 percent seen in other fields of study, their representation in the region's technology sector is 32 percent. This contrasts their overall presence in the workforce, where women make up 38 percent (Vaishali Rastogi et al., 2020).

Table 1: Percentage of Female Tertiary Education Graduates by Field (WEF 2022)

Country	Percentage of Female Tertiary Education Graduates by Field (WEF 2022)		
	Engineering, Manufacturing, & Construction	Information & Communications Technology	Natural Science, Mathematics, & Statistics
Brunei Darussalam	52.26%	-	73.37%
Cambodia	-	8.44%	34.08%
Indonesia	24.92%	34.67%	-
Lao PDR	17.95%	40.82%	55.00%
Malaysia	27.05%	46.00%	70.73%
Myanmar	42.34%	-	66.38%
Philippines	24.48%	48.13%	61.97%
Singapore	-	32.22%	61.72%
Thailand	-	47.85%	70.72%
Vietnam	-	-	50.59%

Source: World Economic Forum 2022

In recent years, Singapore has witnessed heightened efforts from individuals, social organizations, institutions, and private companies advocating for increased representation of women in STEM (science, technology, engineering, and mathematics) fields. During 2014–2016, various local events aimed to promote women in STEM fields, including STEM Week by the National University of Singapore, STEM Workshop for Women by the Singapore University of Technology and Design, a UN Women's Committee panel discussion, and the Women in Engineering, Science, and Technology symposium by Nanyang Technological University. These initiatives respond to the need to expand the labor force, addressing challenges posed by a shrinking and aging population, as per the Ministry of Manpower (2016). Encouraging women's participation was a strategy to mitigate this issue (Singapore Tripartite Forum, 2022) . In Singapore, while the overall gender ratio is nearly equal, the representation of females in engineering programs is less than 20% (Elaine Lee, 2017). The University of Hong Kong (HKU) leads in gender representation with 28.9% of women leaders, predominantly from non-STEM backgrounds, primarily at the departmental level. HKU also excels with 14.3% female institutional leaders. National Taiwan University follows closely, boasting a notable 24.6% representation of women in leadership, showcasing significant progress in gender equality and university management among East Asian world-

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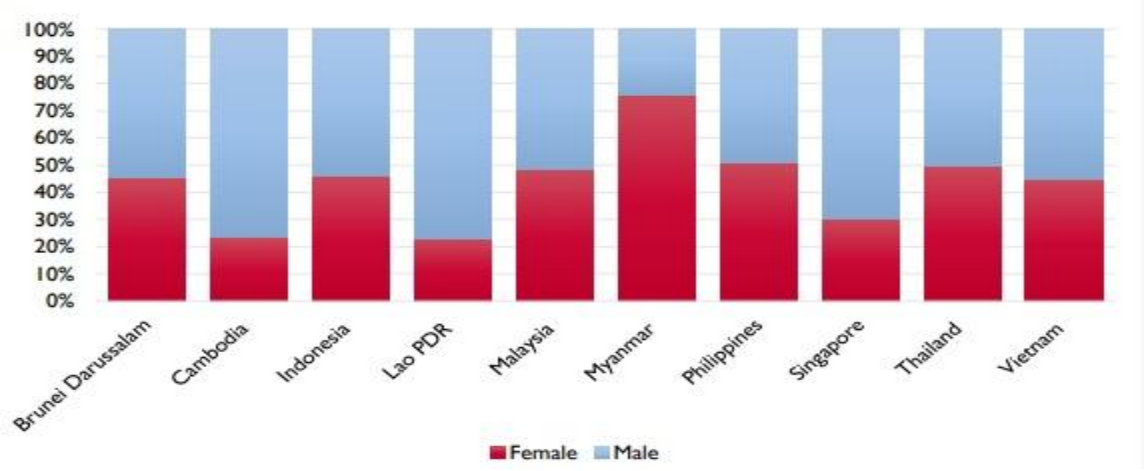
class universities (Hei Hang & Hayes Tang, 2019). Private institutions dominate higher education in Asia (e.g., Japan, South Korea) with up to 80% student enrolment, whereas Latin America, which was historically tied to Catholic-founded private universities, now sees a shift towards for-profit institutions, indicating a growing preference for profit-driven education (Burton Bollag, 2003). Cambodia is amidst an economic transformation amidst the global Industrial Revolution 4.0, creating a heightened demand for STEM graduates. However, the nation encounters challenges in attracting students to STEM fields in higher education. Addressing this requires initiatives not only at the classroom level but also through extracurricular activities in upper secondary schools and broader societal efforts (Jamil et al., 2019) . Cambodian private university academics note the absence of research, citing no institutional requirements. Public universities show limited, locally published research, often diminishing post-masters thesis completion (Heng et al., 2023).

Globally, there is a significant gender disparity among researchers, with men outnumbering women by a ratio of 71:29%. Interestingly, countries with lower research and development expenditures, such as the Philippines and Thailand, have a higher proportion of female researchers, exceeding 45% (UNESCO,2012). Both personal and environmental factors influence academic research engagement and productivity (Kimkong Heng et al., 2020). A conducive environment grants access to essential tools and resources, enhancing productivity (Pfeffer & Langton, 1993) . Management support in Malaysian public universities correlates with increased research engagement (Fauzi, 2023).

The Malaysian higher education landscape has transformed since the 1990s, notably in the public and private sectors. However, persistent gender stereotypes contribute to a notable imbalance among senior staff in public institutions. The private sector has seen slow progress in addressing this gender disparity over the past two decades (Jamil et al., 2019). A Malaysian private university ranked second nationally in the Times Higher Education Ranking 2021, which prompted an exploration of how academics in private institutions connect to Knowledge Sharing (KS) behavior and subsequent research engagement. In a Saudi Arabian public university, 39% of faculty acknowledged engagement in intra-institute research collaborations, but cultural identity emphasizing Islamic values hinders strong motivation for collaborative research with colleagues. As a result, faculty predominantly pursue individual research endeavors (Borg & Alshumaimeri, 2012). In Thailand, women are significantly represented in research across diverse sectors and fields. Within government, higher education institutes, public enterprises, and private nonprofit organizations, they constitute a majority, accounting for 54.2% of researchers. Meanwhile, in the industry sector, women still make up a substantial portion, comprising 47.5% of researchers (UNESCO, 2018). In Myanmar and the Philippines, women are the predominant proportion of science researchers compared to men, as shown in the figure below. Women hold 5.7 percent of the highest research positions (typically director of research or full professor) in Brunei Darussalam, where

representation of women decreases with seniority, which is in line with the global trend. Myanmar is the exception, where women hold 71.6 percent of the highest research positions (UNESCO, 2018)

FFigure 1: Gender Composition of Science Researchers



Source: UNESCO 2020

Brunei's government has prioritized science education, allocating sufficient resources across all schools. Despite well-equipped government schools, there is a concerning trend of declining enrolment in the science stream. Additionally, examination results suggest unsatisfactory outcomes, highlighting the need for further attention to enhance science education effectiveness (Khine, 2002) . Gender inequality in science education is evident in Bruneian textbooks. An analysis of textbook content reveals disparities in the representation of males and females in illustrations and text. This examination paints a picture of how science is portrayed, indicating the extent to which it is presented as a pursuit equally suitable for both boys and girls(Elgar, 2004).

IIn the Brunei civil service, women constitute about 50.4%, with a higher presence in Divisions II, III, and IV. Despite gender gaps in academic achievements favoring women, they remain underrepresented in senior-level civil service positions, where only one in five holds such a position. In STEM fields, female tertiary graduates in Brunei reached 49%, surpassing rates in Singapore and the United States between 2014-2016. However, historical trends show a preference for 'lower level, clerical jobs' among Bruneian women (Dhindsa, 2008) . In Myanmar, a notable gender disparity exists in leadership positions, predominantly filled by males. While there may be some women in senior roles, this presence does not equate to gender equality. Widespread inequalities persist, encompassing areas such as political representation, societal perceptions, gender stereotypes, and access to resources (Khin Khin Mr, 2021)

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While career advancement in Indonesian academia is theoretically nationally regulated to ensure equal opportunities, women in Islamic HEI (Higher Education Institutions) face disparities. They exhibit lower productivity in publications, hold lower academic ranks and leadership positions, and earn significantly less than their male counterparts. The suggestion is for these institutions to specifically empower women by supporting their continuing education, professional development, and career opportunities (Kholis, 2012)

In the UNDP's 2010 Human Development Index, Indonesia ranks 124th out of 187 countries, lower than Brunei (33) and Malaysia (61) but higher than the Philippines (112). Notably, Indonesia outperforms Vietnam (128) and India (134). Despite its overall ranking, Indonesia excels in expected years of schooling (13.2), surpassing most of these countries, except Brunei (14.1), and outperforming Malaysia (12.6) (Priyatna, 2013).

In a study of higher education institutions in Catbalogan City, Philippines, 30 participants shared their experiences through a validated questionnaire. The findings revealed that women respondents encountered gender biases in the workplace, particularly within the institution's regulations and procedures, despite government initiatives promoting gender equality (Irene Evangelista, 2017). In many higher education institutions in the Philippines, women mostly occupy middle and senior-level positions but are less represented in the highest-ranking positions (Morley, 2014). In traditional times in Thailand, the presence of a bilateral and matrilocal kinship system and the high work participation rates among women in the modern, rapidly globalizing economy were sometimes seen as indications of minimal gender discrimination. In the 1990s, the demand for women's studies programs emerged, with both successes and setbacks. Graduates from these programs became leaders and have since played crucial roles in defending women's rights. A notable divide exists in Thailand between the household, where women play pivotal roles in family sustenance, and the public political culture. In the latter, women's internationally renowned 'pleasing personality' is a crucial element in a complex structure that often reflects subservience (Tantiwiramanond, 2007). The 2007-2009 Thai Labor Force Surveys indicate that only one-third of employed STEM graduates work in STEM occupations. While STEM degree holders in STEM fields enjoy a 30% wage premium, those working in non-STEM fields experience only a 2% premium. This suggests that STEM education yields significant returns in STEM occupations but lower, or even negative, returns in non-STEM fields, particularly for women (Jessica Vechbanyongratana & J Vechbanyongratana, 2015) . The International Labour Organization (ILO) estimates that 44% of employment, equivalent to over 17 million jobs, is at risk of automation in Thailand. Women are disproportionately employed in jobs with low STEM skills, making them more susceptible to automation. They are 50% more likely than men to face job loss due to automation. In the industry, 85% of total

female labor holds low-skilled occupations. The ILO program aims to enhance women's acquisition of critical soft and technical STEM-related skills, addressing skills mismatches to boost productivity and enhance competitiveness in the evolving landscape(International Labour Organisation, 2020).

Table 2: Average Monthly Earnings of Employees in Professional, Scientific, and Technical Activities by gender (in US $)

Country	Year	Male	Female
Brunei Darussalam	2014	$2,214.31	$1,840.24
Cambodia	2019	$466.82	$375.74
Lao PDR	2017	$298.40	$203.14
Malaysia	2020	$1,110.27	$799.81
Philippines	2020	$544.08	$488.88
Singapore	2020	$4,769.73	$3,815.93
Thailand	2020	$780.76	$751.25
Vietnam	2021	$422.08	$371.81

Source: International Labour Organisation

Across the professional, scientific, and technical sectors, women generally hold lower representation than men, except Myanmar. There persists a significant gender pay gap. On average, women earn as little as 68 percent of what men earn in these sectors, highlighting substantial disparities in earnings based on gender. Women in STEM leadership across ASEAN are underrepresented but generally outperform global averages. In STEM policy roles, women are still underrepresented across all government levels. For example 2017, women constituted 35% of permanent staff positions in Lao PDR's Ministry of Science and Technology (G. A. Lemarchand, 2018). In Malaysia, women occupied 23.7% of board seats in life sciences and healthcare companies in 2021, surpassing the global average of 21.3%. In technology, media, and communications companies, women held 7.8% of board seats in Indonesia, 20% in Malaysia, and 22% in Singapore in the same year (Deloitte Global, 2022). Women are underrepresented in executive positions, with only 14% holding chief technology officer roles in Singapore and 12% in other ASEAN Member States (AMS). Additionally, companies are recruiting women from Asia-Pacific offices for global roles based elsewhere (Helen Coult, 2020)

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2.4 Barriers to women's participation in STEM institutions in Southeast Asia

Women encounter various barriers in pursuing, staying in, and progressing within STEM professions, ranging from personal and cultural hurdles to structural and systemic obstacles. These challenges lead to low representation of women in STEM fields. Women's active involvement in STEM careers, whether as entrepreneurs, employees, researchers, or leaders, is vital for fostering innovation and driving sustainable economic growth across the ASEAN region. (UNESCO, 2018)

Math achievement was connected with coping mechanisms, study strategies, learning styles, and self-efficacy in a study of Year 13 students in Brunei. Poor arithmetic performance prevents students of both sexes from enrolling in science and technology programs, which are essential to Brunei's industrialization. Particularly, fewer men than women are admitted to Higher Education Institutions (HEIs), which may be related to lower male achievement rates in GCE "A-level" mathematics. There are apparent differences in the ideals of Asian and Western societies. Asian communities encourage collectivism, which includes asking for help from peers, whereas Western cultures emphasize independence. In addition to motivation, socioeconomic situation impacts academic achievement in mathematics and other courses. This element is commonly mentioned in talks on educational outcomes (Mundia & Metussin, 2019).

A self-rating questionnaire survey involving 1281 first-year students across eight higher education institutions in Cambodia explored factors influencing their initial choice of science and engineering major. Findings indicate that individual factors, encompassing personal characteristics and attitude, had the most significant impact compared to family and high school factors (Kao Sovansophal & Kinya Shimizu, 2019). Intrinsic motivation, notably, is a crucial factor empowering academics to excel in their research pursuits (Snowball & Shackleton, 2018).

Women are more likely to major in STEM and computer technology outside the capital in Cambodia. Markers of urbanization and socioeconomic development largely predict women's participation in health and IT majors. It is interesting to note that there is a negative correlation in these industries between gender equality traits and women's representation (Perez-Felkner et al., 2020).

Female students' enrollment in science classes fell precipitously from 97% to 42% in Cambodian upper secondary schools between 2014 and 2019, whereas their enrollment in social science programs rose from 4% to 58%. The easiness of national exams, high passing rates, pursuing grades, attitudes toward science, and the cost of private tuition were all significant influencing variables. Female students stated they had no intention of pursuing STEM degrees, frequently due to family disapproval of science-related fields. (Pov, 2023). Social Cognition Career Theory (SCCT), which was developed from Albert Bandura's social cognitive theory, was deemed the most relevant framework for analyzing the situation of women in STEM in Cambodia. It looks at how societal influences, gender, cultural norms, genetic characteristics,

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and unforeseen life events can affect one's career choice. It also highlights how an individual's job decisions are shaped by the interaction of their self-efficacy, outcome expectations, and personal aspirations. (Monyrath Sar, 2021).

Deeply rooted social conventions, religion, and culture all play a part in Myanmar's widespread inequality. The heritage of patriarchy and authoritarianism sustains the acceptance of women as a secondary gender. Women's equality is limited in this country due to the macho state and male-dominated institutions; national participation in upper and lower houses is less than 14% (Khin Khin Mr, 2021). In Myanmar, women's and girls' job advancement is impeded by institutional restrictions. Elevated academic barriers, especially in fields like engineering and medicine, disproportionately benefit men, restricting girls' educational opportunities and violating their human rights. This framework prevents women from achieving leadership positions, perpetuating gender inequality (Ei Yin Yin Phyu, 2023).

While there was initial progress, Myanmar's existing political and socio-economic challenges demand extra research and dedicated efforts to promote quality education and establish gender justice. The term "culture" in Indonesia has to consider the complexity brought about by several religions, especially Islam, which is the predominant religion and cannot be limited to the varied local ethnic groups. In this environment, the concept of "local culture" becomes complex. In Indonesia, women who want to go to college must negotiate several public spaces in addition to intricate cultural and religious norms. It might be not easy to juggle responsibilities as workers, instructors, spouses, mothers, and students. These women must manage a complex network of social, cultural, and familial roles, reflected in their juggling these varied responsibilities. (Priyatna, 2013) . Even though gender equality is becoming more widely acknowledged in Indonesia, women in postsecondary education face obstacles in pursuing senior leadership roles. The leading causes of obstacles are not institutional barriers but family obligations, patriarchal cultural norms, and inadequate assistance (Dini Cahyati et al., 2021).

Female scientists from Western Europe and North America said Singapore had a less family-friendly work environment in qualitative research with STEM professionals. On the other hand, Asian participants mentioned that they could focus more effectively on their scientific careers if they had domestic servants. Male secondary students in Singapore showed a predisposition for engineering and mathematics programs, while female students tended to gravitate toward the arts, social sciences, and medicine. Students who identified as female were more inclined to think that their skills were necessary. Males preferred engineering in junior college, while females selected the arts and social sciences. The latter group's choice was influenced by professional goals and parental guidance (Teo & Yeo, 2017).

According to a case study on women's careers in agricultural science in the Philippines, women who have two jobs have more significant difficulties than males. Delays in training, moves brought about by husbands' jobs, and restricted mobility are some of the restrictions. Gender roles continue to be

stereotyped in culture, which affects interactions at work and prevents women from rising to top positions. Cultural obstacles remain the principal obstacle preventing women from advancing in their careers, even in emerging countries where the number of women working in research institutions is rising (Brush et al., 1995) . According to a study conducted on 4967 junior high school students in Vietnam, gender has no bearing on academic success in STEM fields. Still, female kids did better when their parents worked in non-manual jobs than male students. Improved study scores were connected with non-manual jobs, higher parental education, and better economic standing. On the other hand, poorer academic achievement was linked to having 0 or more siblings. These results highlight the significance of preserving family size and giving women access to education to guarantee fair resource allocation for children (Ho et al., 2020). In a qualitative study that included 21 participants in a Vietnamese university, the women leaders were inspired to progress in their careers by ongoing support from family and mentors, shifting employer perceptions, and their proven leadership abilities. (Maheshwari & Nayak, 2022).

In the Lao PDR, economic priorities and educational goals sometimes collide, especially in underprivileged areas where kids must help support the family. Primary education quality, the competency of teachers and principals, the absence of learning resources, multi-grade teaching, and a poor pedagogical support system are among the issues that need to be addressed. These limitations greatly influence how girls and women will participate in STEM education in the future, both in their career trajectories and at higher levels (Niane Sivongxay et al., n.d.) Improving the quality of life for women in Timor-Leste requires meeting their fundamental requirements, which include access to primary education, health care, food, clothes, and shelter. These needs are frequently the focus of traditional aid. To overcome women's adverse conditions relative to males, it is equally vital to fulfill their strategic demands. These strategic needs include political voice, education, freedom from violence, access to personal income and a means of subsistence, and support for early childhood care. Women now confront several obstacles, such as pervasive poverty, a high rate of spousal abuse, and a lack of recognition for their contributions to the political, economic, and social spheres (H Hill, 2012).

3. Efforts made to support Women's Participation in STEM institutions in Southeast Asia

Table 3: Programmes to Improve the participation of Women in STEM in Southeast Asia

Country	Programme	Description
Indonesia	SheHacks	Indosat Ooredoo Hutchison's SheHacks program in Indonesia aims to empower

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		women and girls in technology. Since its 2020 launch, the program has empowered over 1,500 women and expanded in 2022 to include mentoring, incubators, and boot camps.
Myanmar	Geek Girls Myanmar	The organization empowers women in the ICT industry, enhancing their tech access and narrowing the gender digital gap. It offers tea talks, roundtables, webinars, and workshops covering leadership, female entrepreneurship, cyberbullying, digital literacy, and more. Additionally, it fosters an online community for women and girls to share tech knowledge.
Thailand	STEM Training Program	In 2019, the Ministry of Labor, ILO, and UNESCO collaborated to develop a STEM training program for entry-level women workers in the electronics sector. This enhanced data collection, analysis, and presentation skills for informed decision-making. It served as a pilot for a UNESCO global STEM policy toolkit aimed at addressing gender disparities and improving evidence-based policy in STEM.
Brunei Darussalam	Women in Science Competition	Seria Energy Lab's competition, launched in 2019, crowns a young woman (age 13–17) in science. It aims to empower Brunei Darussalam's young women to tackle global challenges and improve their leadership, project management, and innovation skills.
Vietnam	SHINE:	12-week incubation program for early-stage

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		startup women founders by Ascend Vietnam Ventures.
Lao PDR	ADB's SSHEP II Project	It was enhancing higher education and vocational training for job-ready skills. Through grants and loans, it boosted women's leadership, educator expertise, and STEM enrollment.
Malaysia	IEM's Women Engineers Section	Uniting women in engineering across Malaysia with six chapters.
Philippines	Women: Innovating Social Enterprises (WHWise) Program	Philippine Council for Industry, Energy, and Emerging Technology Research and Development's (PCIEERD) WHWise Program supports women-owned social enterprises with technology access, funding up to Php 5 million, incubation, mentoring, and research assistance.

3. Intervention by the United Nations for the promotion of women in STEM fields

The United Nations is a central hub for dialogue and cooperation, facilitating collective solutions. Strong member state support provides a clear roadmap towards a shared goal addressing global challenges and caring for our typical global home.

On September 25, 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development, succeeding the Millennium Development Goals (MDGs) as the global framework for international development. The Sustainable Development Goals to increase the participation of women in STEM are Goal 5, i.e., Achieve Gender equality and empower all women and girls, and Goal 10, i.e., Reduce inequality within and among countries. Goal 5 talks about the significant legal and legislative reforms essential to safeguard women's rights worldwide. Despite some progress, there remains a global gender wage gap, with women earning, on average, 24% less than men in the labor market. UN Women supports women in obtaining quality employment, acquiring assets, and exerting influence on institutions and public policies. It emphasizes the importance of acknowledging, reducing, and redistributing the

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burden of unpaid care. Goal 10 talks about how the wage gap varies between countries, with women earning 24% less than men. Additionally, they are also more prone to vulnerable employment, with up to 75% of women's jobs being informal or lacking protection in developing countries (United Nations, n.d.) Globally, 83% of domestic workers are women, and the majority lack legal entitlement to a minimum wage. Gender discrimination can intersect with other forms of discrimination, including age, disability, ethnicity, and economic status, compounding the burden of inequalities. UN Women actively addresses inequality within and among countries by advocating for decent work, social protection, and gender-sensitive economic policies globally. This includes eliminating discriminatory laws and practices and promoting appropriate legislation, policies, and actions. It advocates for employment policies that enhance labor market conditions and promote decent work for women, along with ensuring the safe migration and social protection of domestic workers (UN Women, 2013)

The aims and role of UNESCO for the promotion of women in STEM include enhancing the participation, achievement, and continuity of girls and women in STEM education and careers to narrow the gender gap in STEM professions, building the capacity of countries to provide gender-responsive STEM education, focusing on teacher training, educational content, and pedagogy, raising awareness about the significance of STEM education for girls and women (*International Day of Women and Girls in Science*, 2018). The UNESCO Engineering Initiative (UEI) focuses on increasing enrolment in engineering programs at the tertiary level to sustain and enhance socio-economic development, thereby encouraging and inspiring the youth to address contemporary challenges and ensure an adequate supply of engineers for future sustainable development. UEI provides a platform for youth to express their views on current engineering and development issues through events like the UNESCO Youth Forum and World Science Day 2013. Some more initiatives include the 8th UNESCO Youth Forum, World Science Day 2013, World Teachers' Day 2013, Engineering Outreach Event in Nigeria, and Airbus: Fly Your Ideas(United Nations, 2021).

STEM and Gender Advancement (SAGA) is a Global UNESCO project supported by Sida to reduce the gender gap in STEM across education and research levels. It identifies and addresses gaps in policy related to gender in science, technology, and innovation (STI) based on evidence, enhances capacity for data collection on gender in STEM fields, increases visibility, participation, and respect for women in STEM, improves tools for measuring the status of women and girls in science (UNESCO, 2015).

Women in Science Report (UIS) data reveals that women comprise less than 30% of the world's researchers. The data also provides insights into the distribution of these women across public, private, and academic sectors, as well as their respective fields of research (UNESCO Institute for Statistics, 2019)

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Under L'Oréal-UNESCO For Women in Science, UNESCO and the L'Oréal Corporate Foundation aim to honor women researchers who have significantly contributed to addressing global challenges. By recognizing their work in areas such as new technologies, aging populations, and biodiversity threats, UNESCO and L'Oréal aim to acknowledge and support these women researchers, enabling them to continue their impactful contributions to science (UNESCO, n.d.-a)

The World Federation of Engineering Organizations (WFEO), established in 1968 under UNESCO, unites national engineering institutions from around 100 nations, representing over 30 million engineers. Its mission is to enhance engineering practice and advance the UN Sustainable Development Goals. The Paris Declaration (March 2018) reaffirms engineers' commitment to sustainable development, fostering socio-economic security, sustainable development, and global poverty alleviation through the proper application of technology. (UNESCO, 1968). The WEF Future of Jobs Report aims to analyze and offer detailed insights into the extent of emerging trends by industry and geography. It focuses on the expected timeframe for these trends to impact job functions, employment levels, and required skills (World Economic Forum, 2023).

The Organization for Women in Science for the Developing World is an international organization (program unit of UNESCO) offering research training, career development, and networking opportunities for women scientists in the developing world at various career stages (UNESCO, n.d.-b)

4. Recommendations

Legislation plays a crucial role in establishing an equitable and equal workplace. Government policies effectively address the representation and rights of disadvantaged groups, fostering a fair and inclusive work environment. Schemes and measures should aim to mitigate disruptions and support the continuity of careers. Sensitization efforts should prioritize facilitating the return of women to the field of science after career breaks. There is a need to change the mindset of administrators and colleagues. Child-care gaps reflect a systemic bias against women's employment globally, and efforts need to be made to provide for child care at the workplace. This issue persists mainly in Western countries, hindering women's career paths as women in institutes face challenges balancing work and childcare due to the lack of support. Re-entering the profession is also hindered by age-based restrictions. The goal is to create workplaces that eliminate the need for career breaks. Institutions should actively recognize and reward excellence women demonstrate as more women will be encouraged to pursue STEM careers. Women may endure unacceptable behavior due to fear of potential repercussions. The most extreme form of social exclusion is sexual harassment. There is a need to underscore the importance of addressing such concerns promptly and thoughtfully. Sexual harassment encompasses instances where male scientists seek sexual favors from

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their juniors, along with various forms of verbal and other abusive behavior. Implementing effective measures for addressing and preventing harassment issues is the need of the hour. In this regard, gender sensitization programs for male and female scientists in major R&D institutes are facilitated by organizations such as UGC, CSIR, IAIR, ICMR, etc. Another concern is lack of proper transportation and safety, leading to lower stay-backs for work and informal interactions necessary for collaborations. Women are eight times more likely to reach leadership or supervisory positions if the organizational form of networking exists as opposed to hierarchy or bureaucracy in other disciplines. (Smith-Doerr, 2004) . Informal interactions between male and female researchers are crucial for dismantling organizational hierarchies and fostering a socio-cultural environment conducive to fruitful research. Inspiration from seeing other women at the top in science fields inspires the ones in the lower positions too to achieve success. (Blaszczak et al., 2022) . Because of the trickle-down effect of few role models for women engineering students, there is a dearth of academic women engineers in visible leadership positions responsible for the under-representation of women engineers in academia, industry and government. Encouraging women faculty to consider formal leadership positions and providing structured opportunities to explore those options will likely result in faculty members participating as academic leaders. (O'Bannon et al., 2010). Family, gender ideology, and HR organizational practices determine the employment relationship and can help women in S&T to grow in their careers. (Valk et al., 2014). Apart from the support from spouses and encouragement from peers, the workplace environment has to be more supportive of the needs of women, fewer differences remaining in interpersonal communication, and the adoption of specific strategies by women to work effectively in male-dominated organizations would be helpful (Boiarsky et al., 1995). Family-friendly policies and organizational norms help women progress in their careers, whereas toxic work environments and societal issues inhibit the growth of women in the business sector. (Nabila Khurshid1, 2022) . Female scientist's productivity is not only positively influenced by intrinsic factors like self-motivation and confidence, but extrinsic institutional factors such as flexible working hours, woman-oriented management policies, fair appraisal, and mentorship also play an essential role (Fathima et al., 2020). Patriarchal norms restricting women's mobility hinder their effectiveness in career-related tasks and advocacy for career advancements. These barriers limit women's engagement in the public arena, impacting their roles as scientists. To avoid discrimination in grant funding because of certain stereotypes of women being incapable of doing science, grants should be awarded based solely on the merit of proposals.

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5. Conclusion

Llimited research exists on barriers women face in STEM leadership roles, especially in Southeast Asian nations, despite extensive studies on women in leadership and STEM separately. The disparity in understanding the unique challenges women face in STEM leadership in these nations presents a significant barrier to advancing female participation and progression in STEM fields. It is imperative to explore these obstacles comprehensively, considering their potential impact on gender equity. Persistent barriers such as work-life balance struggles, gender bias, and microaggressions underscore the necessity for targeted research in this area. Support from individuals championing gender equality is crucial in enabling women to persist and advance in STEM leadership roles. Achieving gender equity requires a cultural transformation within STEM and leadership domains, fostering environments where women's achievements are valued and their authority is respected. There is a dire need to improve the chilly climate for women in STEM. This means revising institutional cultures to be more inclusive, creating educational environments that support and validate women's contributions, and implementing policies that promote equal treatment and support for women scientists, particularly from disadvantaged backgrounds. Addressing inequality in STEM participation necessitates educational and awareness programs, scholarship incentives, and flexible career policies to support women's advancement. Ensuring R&D institutes provide essential facilities for women scientists, including appropriate toilets and transportation during odd hours, similar to provisions in call centers. They are encouraging professionals to realize their full potential, guiding them to available support, and promoting a professional approach to careers. Raising awareness about societal and institutional structures that facilitate successful navigation of family and career dynamics and promoting awareness and sensitivity across society and institutions regarding the challenges women face in successful participation in science.

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Published by Global Confluence Review
www.globalconfluencereview.in
editorglobalconfluencereview@gmail.com
A Publication of Bliss Global, Delhi

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