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# Challenges and Opportunities: Asian Women in Science, Technology, Engineering, and Mathematics

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**Abstract**

This special issue brings selected papers from an international conference which brought a group of approximately 30 Science Technology and Society and Popularization of Science experts from nine South Asian and Southeast Asian countries (Bangladesh, India, Indonesia, Malaysia, Nepal, Pakistan, Singapore, Sri Lanka, and Thailand), plus the United States. They discussed how best to enhance public awareness about the role of women in Science, Technology, Engineering, and Mathematics (STEM). These papers show how to develop strategies for increasing the participation of women in STEM, both as STEM professionals and as informed and engaged, lifelong participants in a STEM-rich world.

**Keywords**

Asian women, gender, science popularization, STEM education

Traditionally, women have been underrepresented in Science, Technology, Engineering, and Mathematics (STEM) education and thus in the STEM workforce (Landivar, 2013). According to a recent report by the United Nations Educational, Scientific, and Cultural Organization (UNESCO, 2017), only 30% of STEM students in

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higher education globally are women. Catalyst (2020), a global nonprofit organization, reported that in 2016, women accounted for less than a third (29.3%) of those employed in scientific research and development across the world. Despite improvements at the senior leadership position, globally women accounted for only 3% of chief executive officers (CEOs) and 20% of chief financial officers (CFOs) in technology industries.

The equal representation of women, therefore, emerges as a significant issue, within the STEM education arena (Scantlebury, 2014), the STEM workforce (Metcalf, 2010; Cannady et al., 2014), and in civic STEM literacy (Boumlick et al., 2016). For one thing, we are in the midst of a technology revolution which is transforming societies and dramatically changing the way people live and work (Forrester, 1987). Scientific and technical inventions are being converted into innovations which are spreading into most aspects of contemporary societies (Miller, 2011). Without women, STEM organizations are likely to miss out on new innovative ideas. Organizations with homogeneous workforces are unlikely to operate effectively in an environment that is constantly changing and diverse. As a result, the extension of educational and career opportunities to women has been framed as a means of making better use of the *entire* pool of potential STEM innovators (Pearson et al., 2015). Wajcman (2004) has argued that women ought to become designers and producers of scientific and technical inventions. Most importantly though, it is an issue of fairness and justice. Democracy demands that women be included in all facets of STEM education, civic engagement, and the workforce. In several countries, various attempts are being made to increase the participation of women in STEM education, civic engagement, and in the STEM workforce.

Recently, some notable exceptions have emerged within some Asian countries, where women have been significantly increasing their representation in selected STEM fields, namely, computer science and computer engineering (Fan & Li, 2004; Lagesen, 2008; Varma, 2015). For instance, women in India earned over half of undergraduate degrees in both information technology and computer science (50.7%) and natural science (54.1%) fields (Catalyst, 2020). This is interesting on both economic and social grounds. Western countries such as the United States, Canada, Australia, and those in European Union are considered developed. These countries have a mature industrial sector, strong domestic markets, advanced technological infrastructures, high investment in foreign countries, high gross domestic products, and high per capita incomes. Most Asian countries are considered developing countries, some growing faster than others. Typically, they have different production functions in the advanced and traditional sectors of the economy, a relatively small middle class, low wages, and pervasive poverty. Socially, women have had fewer rights and opportunities in most countries. Educational opportunities, particularly within STEM, have long emphasized males over females. Whereas the Western countries have moved toward an egalitarian form of social organization, Asian countries' social value systems remain largely patriarchal (Mukhopadhyay & Seymour, 1994; Varma, 2009). Despite economic and social advantages in the Western countries, Asian countries exhibit different perspectives on advancing women in STEM learning and workforce.

Gendered social relations prevalent in different Asian countries, impact the education and career prospects of women in STEM. Studies show that the gender gap in STEM is mostly due to gender stereotypes and what is considered women's role and work in Asian countries (UNESCO, 2017). Despite the challenges created by this gendered outlook, many Asian women do pursue careers in STEM and daily need to navigate a male-dominated work environment. Even though women in some Asian countries have increased their representation in selected STEM fields, for the most part, they do not enjoy leadership positions in these fields (Campion & Shrum, 2004). Asian women face gender bias, which overshadows their capability, experience, and skill. Scholars have drawn attention to the need for STEM *gender-consciousness* in both school and out-of-school settings. Within the education realm, the construct of science capital has been used to highlight the challenges girls face relative to boys in becoming active participants in a STEM future, either as professionals or lifelong informed citizens and informal STEM leaders (McCreedy & Dierking, 2013; Dawson, 2014; Archer, et al., 2015). It should be noted that gender is, but one societal division women face; issues such as social and economic class, ethnicity, language, and religion also shape women's overlapping identities and experiences as they face bias in STEM.

We are living in the era of globalization—a worldwide phenomenon of technological, economic, political, and cultural exchanges in the last 50 years resulting from modern communication, transportation and legal infrastructures, as well as the political choice to consciously open cross-border links in international trade and finance (Guttal, 2007). Asian countries operate in a global environment, often deriving their identity and legitimacy from such participation. By in large, these Asian countries draw on modern/Western science and scientific methods, which are considered universal. The STEM educational infrastructure needs to be able to support both mechanisms for individuals to acquire the necessary modern STEM knowledge and skills required of STEM professionals, as well as supporting individuals who possess lifelong interest in, and informed engagement with STEM. Although modern science is considered universal, a range of economic and social considerations impact Asian countries' ability to produce STEM professionals and informed citizens, which has implications for women's participation in STEM.

These developing Asian countries represent some of the most vibrant emerging economies in the world, and the Western countries can learn much from better understanding the opportunities and challenges these countries face in promoting STEM to women. It is important to learn what are the challenges and opportunities related to equity for women in STEM participation, employment, and leadership (AASSA, 2015). The increasing representation of women in some STEM and popularization of science fields in Asian societies in the last decade has opened "new horizons" by widening the empirical base for a comparative understanding. Examining similarities and differences among women in both the STEM professions and in STEM popularization efforts in different national settings makes it possible to identify several commonly shared attributes as well as differences which can shed new light on the old question: What can be done to make STEM careers and lifelong participation in STEM

more gender inclusive? Work in this area is significant and timely considering that technology is rapidly changing these countries.

Research and practice paradigms in science and technology studies and STEM (formal and informal) education in Western countries have been dominated by assumptions about beliefs and behaviors that are limited to Western realities; often male and majority-population-skewed realities. International work often yields surprises that have the power to shake assumptions about what is apparently well established or seen as normal when a single culture is the context. For example, although the U.S. believes it is on the cutting edge of equity issues, female representation in some STEM fields in both the U.S. and other Western countries is declining, while increasing in some Asian countries. International work can be a powerful new tool for revealing new insights, even within such an "old" question as female representation and participation in STEM.

In September 2019, with the support from the U.S. National Science Foundation (NSF)[1], the authors of this article sought to organize an international conference with a group of approximately 30 scholars from nine Asian countries (Bangladesh, India, Indonesia, Malaysia, Nepal, Pakistan, Singapore, Sri Lanka, and Thailand) and the United States to discuss how best to advance the participation of Asian Women in STEM. Dr Fahmida Chowdhury, Program Director in the Office of International Science and Engineering (OISE), was instrumental to start this project. She was joined by Dr Jessie Dearo, Program Director for ADVANCE: Organizational Change for Gender Equity in STEM Academic Professions (ADVANCE), and Dr Frederick Kronz, Program Director for Science and Technology Studies (STS). The goal of the international conference was to address collective national and international strategies for promoting public awareness and appreciation of STEM as important factors in economic development and societal well-being, with a particular focus on gender equity and inclusion (NAS, 2011; West, 2011; Nazneen & Mahmud, 2012; Holman et al., 2018). The conference sought to present cross-national perspectives on women in the STEM workforce and within STEM popularization efforts, exploring frameworks of the globalization of science and gendered social relations in STEM. The conference was to take place in Bangkok, Thailand in the spring of 2020.

At the time of conference organization, we did not anticipate a global pandemic—a global disease outbreak that undermined many of the processes the proposers envisioned. In late December 2019, several cases of pneumonia of unknown cause began to rise. On March 11, 2020, the World Health Organization (WHO) declared coronavirus disease (COVID-19) a global pandemic caused by the SARS-CoV-2 virus. Plans, therefore, were adjusted, and a series of both small- and large-group virtual meetings were organized. The papers presented in this volume represent just one of the "products" of this project. Additional products focus on policy issues as well as suggestions for ways to improve representation of women and girls in STEM through better educational practices. To address the scope of the conference, below is a brief overview of papers which were presented in the conference but are not included in this volume.

Afia Rosdiana from Taman Pintar Science Center in Yogyakarta discussed the urgency of increasing the number of women in STEM in Indonesia. Women make-up approximately 12% of STEM graduates in Indonesia, which is comparatively lower than other Southeast Asian countries such as Malaysia (26%), the Philippines (18%), Thailand (15%), and Vietnam (15%) (Marshan & Nikijuluw, 2020). Up until high school, both male and female students show equal interest in taking mathematics and science as their focus of study. In fact, female students tend to score slightly higher than male students in standardized tests such as Trends in International Mathematics and Science Study or TIMSS. Indonesia offers the opportunity for women to go to pursue higher education and major in STEM. However, the traditional concept that STEM-related careers are more suited for men than women discourages women. This suggests that Indonesian government needs to figure out how to combat deep-rooted traditional values which prevent women's participation in STEM.

Samarendra Kumar from National Council of Science Museums presented the All India Survey on Higher Education data, which showed that women constitute nearly 43% of the total STEM enrollments at the undergraduate level in the country; however, the disparity becomes starker with subsequent higher level. Only 3% of women enroll in PhD in science and 6% opt for a PhD in Engineering and Technology. Further, they account for only 14% of the total scientists, engineers, and technologists in research development institutions as compared to 28% globally. This "leaky pipeline" in STEM fields leads to fewer women reaching higher levels as professional engineers or scientists specially in leadership roles. Women who are employed in STEM face "dual role" syndrome, wherein professional decisions are largely affected by their domestic responsibilities. Kumar also discussed recent reforms in the National Education Policy 2020 to modify curriculum to address biases and stereotypes including those related to gender.

Tengku Nasariah, formerly CEO of the Petrosains Science Center, and Noraini Idris from National STEM Movement discussed the feminization of certain STEM fields in Malaysia and the barriers to advancement for women in STEM careers. At the undergraduate level, women outnumber men in the natural sciences, medicine, computer science, and mathematics; however, men outnumber women in construction engineering and manufacturing. Still women make-up approximately 37% of students enrolled in construction, engineering, and manufacturing. However, women are underrepresented among professional engineers with practicing certificates (7%) (Society for Women Engineer, 2021). It seems work in construction, engineering, and manufacturing in Malaysia is not seen as women friendly, mostly due to the outdoor nature of the fields.

Anjana Singh from Tribhuvan University, Swati Thapa from Pratiman-Neema Memorial Foundation, and Vijaya KC from Pratiman-Neema Memorial Foundation led the discussion on Nepal. They pointed out that despite the fact that the number of women graduating in STEM fields has been growing, they remain outnumbered by men. Most young girls show interest in science and mathematics subjects during their primary and secondary schools. However, this interest significantly declines when they

reach high school. According to a Nepal Telecommunication Authority survey, only 12% of girls/women are represented with e-skills in STEM fields in Nepal. These low percentages correspond with Nepal's patriarchal societal values, which portrays that "technology is not for women."

Pervez Hoodbhoy, a prominent nuclear physicist and author of *Islam and Science: Religious Orthodoxy and the Battle for Rationality*, presented his overall disappointment with the education system in Pakistan. At the quantitative level, Pakistan appears to be making a progress. As of 2019, there were 195 officially registered universities in Pakistan with about 45,000 teachers and 1.6 million students, almost 40% of which are females. In addition, there are 1675 degree-granting colleges with 0.5 million students studying for bachelor-level degrees. The government spends 2.1–2.4% of its national GNP on education as a whole with higher education getting about 15% of this amount. Hoodbhoy, however, questioned the quality of education. He raised the fundamental question: what is the value-added when a student goes through the Pakistani university system? According to him, STEM in Pakistan is going nowhere. Year after year, the system has been degraded—ethically, morally, and professionally—to the point that there are only tiny pockets left where anyone knows anything about their field. In this situation, it is not what women have or have not done that matters.

Whereas multiple papers discussed under-representation of women in STEM education and possible causes for such state of affairs, the opposite was the case in Singapore. Speaking about the Singapore condition, Monamie Bhadra from Nanyang Technological University, Anne Dhanarai of Science Center of Singapore, and Germaine Shalia of the Agency of Science, Technology, and Research pointed out multiple public and private initiatives undertaken in their country to increase the presence of women. Most of these initiatives include enhancing professional networking, hosting scientific seminars and summits, sharing inspirational talks by successful female researchers, facilitating personal support networks, providing mentorship, facilitating self-reflection, and building leadership qualities. In Singapore, women are seen as untapped economic actors to fulfill the objectives of Singapore's "Smart Nation" goal. The Singapore government has been advocating a core principle of meritocracy which means equal opportunities are available to both men and women. However, women still face the double bind challenges of patriarchal construction of leadership as masculine and the need to perform within the dictates of Asian femininity (Dutta, 2018). Also, most of initiatives to include and support women in STEM do not target minority women such as Malay.

Thilinakumari Kandanamulla of the National Science Foundation, Sri Lanka, provided data on the status of STEM education in the country and presence of women in it. At the university level, women outnumber men in science and biosystem streams; however, in engineering stream, men outnumber women. In 2018, except for medical and health sciences (55.91% females and 44.08% males), participation of females as researchers/scientists was less than males in other STEM fields; for example, engineering and technology (31.88% females, 68.12% males), agricultural sciences (41.97% females, 58.03% males), natural sciences (45.64% females, 54.36% males),

and social sciences and humanities (48.49% females, 51.51% males). This suggests there is a need to bridge the gap by involving female students in engineering subjects. Cultural norms such as females as primarily caregivers remain prevalent, and a lack of proper understanding about future career pathways also act as a barrier for female students in selecting the STEM subjects.

Like Singapore, Thailand participants—Ganigar Chen from the National Science Museum, Arom Mucharin from Natural History Museum, and Sasitorn Srisawadi from National Metal and Materials Technology Center—pointed out the equal educational opportunities available to both men and women to enroll in any STEM subject in Thailand. In higher education, Thai women make up 53% of students in the sciences, though they are only 24% of students in engineering, manufacturing, and construction studies. Women make up more than half of researchers (53%) working in Thai science, technology, and innovation (Royal Thai Embassy, 2017). Despite such representation, women consistently face "glass ceiling" issues as there are fewer women at the top levels in Thai STEM projects and organizations. The participants attributed this to more of a cultural than structural problem. In Thai culture, women are humbler and less risk taking than men (qualities needed for leadership role).

Finally, Karen Peterson of National Girls Collaborative and Paige Miller from University of Wisconsin-River Falls presented the status of women in STEM in the U.S. Peterson presented recent data which demonstrates that women constitute 56% of total undergraduate enrollment, yet women remain underrepresented in STEM fields at all levels of education and occupations. This disparity in representation is even greater for women of color. In 2015 while African Americans made up about 11% of the total US labor force, they only held 4.8% of all science and engineering (S&E) jobs; further, African American women only held 1.6% of those jobs. Similarly, Hispanic people made up 16% of the US labor force and held 6% of S&E jobs, but Hispanic women only held 1.8% of S&E occupations. Peterson noted that there are multiple programs in the U.S. to engage girls in STEM, including girls from communities historically underrepresented in STEM. Yet, she sees most of such programs tending to appeal to girls who already are interested in STEM or computing; and thus, failing to reach girls who either do not identify with STEM or are resistant to cultural stereotypes about who does or does not succeed at STEM, or who lack the family resources (time and networks) to find and enroll them in specialized girls science programs. Miller identified a number of challenges which women face, namely, prevalent cultural assumptions regarding gender and STEM, token status and the lack of female mentors/role models, and unequal distribution of material resources along gender lines.

This special issue brings half-dozen in-depth treatments of women in Asia as well as Asian women in the United States. Chowdhury discusses several cases the importance of role models in inspiring and influencing the career path of young people, particularly women and girls. Her paper includes case studies of several Asian women as a way of illustrating this point. Gupta's paper focuses on the challenges faced by Indian women in STEM, using the perspective of social construction as an analytical lens. This perspective helps to focus on the specific socio-cultural issues that act as both barriers to

career advancement as well as suggesting possible solutions. Ahmed, Chowdhury, Urmi, and Jamal explore the current state of female student enrollment in tertiary education in Bangladesh, followed by the challenges female graduates of tertiary education face in the technical workplace. The paper seeks to provide guidelines for policies to ensure a more inclusive future for women in STEM. Ling discusses how the role of women in STEM can be enhanced through the vehicle of "fan-fiction." She discusses how this novel approach can be deployed to mainstream the incorporation of indigenous and cultural ways of knowing within Malaysia into the rubrics of institutionalized STEM education, with particular benefits for girls and women. Finally, Varma provides an overview of the status and reality of Asian women in STEM in the U.S. Although there are many Asian women participating in both higher education and careers in the U.S., most encounter the "double bind" of both ethnicity and gender bias resulting in significant barriers to work satisfaction and professional advancement.

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## Note

1. NSF has many programs relating to broadening participation in the STEM disciplines. It has a mandate to do so through the Science and Technology Equal Opportunity Act. As a result of this Act, the NSF has created diversity programs spanning all of its directorates. Each of the science directorates has programs focused on broadening participation in its own scientific or engineering discipline—sometimes these are focused on research, but more commonly they are focused on intervention (Aspray, 2016).

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