**Qeios**

Review Article

# Where Are the Female Role Models in Science?

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This paper provides an answer to the question of where our women role models in STEM are. It is clear that having role models in particular fields provides an impetus and confidence to challenge social norms that may provide normative limitations on a given social group's academic aspirations. The underrepresentation of women in STEM is a widespread, global issue. These dynamics are clear and current in the open discourse in the Global North (GN). However, as with many post-colonial dynamics, these systemic limitations are even more pronounced in the Global South (GS), and there is little acknowledgement of the issue. Gender bias is a foundational feature of women's invisibility in STEM fields and a primary area of normative obstruction of women's progress. Role models can be found anywhere but female role models, especially those from GS countries, are primarily found in countries in the GN. In some countries, the percentage of female immigration has dramatically increased in the last decade. According to the Organization for Economic Cooperation and Development (OECD), the US, Australia, Canada, Italy, Spain, Germany, France, and Portugal are among the leading destinations for female immigrants from the GS. Women teachers, who have dedicated their effort to lifting others into the understanding and practice of STEM from primary school, through secondary school, and into all levels of higher education are the frontline of STEM hegemony cycle-breakers. Women scientists who have shattered glass ceilings, survived glass cliffs, and made significant contributions on various levels serve as beacons of hope and aspiration for future generations of scientists particularly for girls and women. The state of the world requires the full use of our social capital with global warming and all that comes with diminishing resources and the need for rapid, adaptive methods and policies for a sustainable future. The presence of female role models plays a crucial role in this journey, inspiring future generations of scientists and changing limiting paradigms. While progress has been made, we must remain vigilant in addressing ongoing challenges

and striving for a future where science truly reflects the diversity of the world it seeks to understand and improve. Our stories need to be told, and heard.

## Introduction

A role model can be broadly defined as someone who is a "successful exemplar and can impact a person's motivation, achievement, and sense of belonging"[1]. Role models are a motivational element in society and can range in impact and social exposure (i.e. from primary school teachers to famous people to aspire to). The importance of role models is well studied[1][2]. According to Gladstone and Cipian[1], it is also clear that having role models in particular fields provides an impetus and confidence to challenge social norms that may provide normative limitations on a given social group's academic aspirations. Being that education is the cornerstone for STEM careers, the presence of role models is subsequently beneficial in promoting diversity, equity, and inclusion in the foundation of STEM development: the classroom. Research shows that when role models are effectively implemented in STEM classrooms there is a greater potential for successful, long-term outcomes in several areas: increased motivation[3][4][5], achievement[6] (Marx & Roman, 2002), STEM identity[4][7], feelings of belonging[3] (Johnson et al., 2019), and self efficacy[8]. This is especially true when the role model and student share similar social identities that are generally viewed as underrepresented in STEM fields[5] (Johnson et al., 2017). It is important to note that Schunk and DiBenedetto[9] found that role models that had commonality with students, having either a similar experience, background, personality, or values, are more likely to be influenced by a role model. To the contrary, if students perceive the role model's success as unattainable, then the opposite can be true of the role model's effect. It is therefore pertinent to look at role models' path to success in terms of "controllable factors" such as effort, rather than innate talent or luck[5], as this is one of various strategies that promote a "growth" mindset (Dweck & Master, 2006) versus a sense of fate or individual destiny. Gladstone and Cipian[1] echoed these findings in a meta-review of 55 studies on the subject.

Along this vein, Bandura's work over several decades (1977-2021) shows that students come to value competence and develop self-efficacy through the observation of encouraging role models[10]. Clearly, connection serves a number of areas around career success in all groups. However, a university study by Dasgupta and Asgari[11] showed that not only does specific exposure to women role models in their field

of study influence female students' counter-stereotype beliefs about women in leadership positions, but it also substantially lowered implicit gender biases within a year or two of that exposure[12]. Gonzalez-Perez et al.[8] found that providing some focus on female role models for girls in primary and secondary education additionally increased the students' enjoyment of STEM materials. This study also echoed the substantial influence on eliminating implicit gender bias around women in STEM and leadership. The global data also shows that girls have at minimum a comparable aptitude for STEM as boys, and in many cases score higher in STEM subjects[13]. Sadly, however, the leaky pipeline for women starts very early, particularly in the periphery areas of the Global South (GS), where females in general have a much lower percentage of participation in STEM disciplines.

The underrepresentation of women in STEM is a widespread, global issue[14]. Gender biases, shaped by cultural stereotypes, influence how we evaluate and treat one another. While explicit gender bias is declining, implicit or unconscious gender bias remains widespread[15]. Research highlights the impact of stereotypes and gender bias on women in engineering and computing, indicating the need for effective mentoring[16] (Astegiano et al., 2019). These dynamics are clear and current in the open discourse in the Global North (GN). However, as with many post-colonial dynamics, these systemic limitations are even more pronounced in the Global South (GS), evidenced on the one hand by low participation and on the other by brain drain which will be discussed later in the chapter. This is due to the prevalence of stereotypes steeped in implicit bias, and discriminatory social norms that result in hostile environments for girls and women. Because of these, girls move away from STEM areas as early as their primary and secondary school experience, if they are afforded one[13]. Women and girls internalize these damaging stereotypes as they move through the social institutions, ultimately avoiding STEM trajectories and choosing more accessible careers in order to avoid toxic work environments, stereotype threat, and glass ceilings[16]. For those who do pursue STEM education and careers, the competition is fierce and imbalanced[13]. Women have to invest much greater energy and resource expenditures in their professional work to justify their inclusion while fighting imposter syndrome[17]. So, for those women in STEM who break all of these barriers to achieve success, why aren't they more visible to the girls and women who seek STEM trajectories?

# High achieving women are there...So, what limits women from acting as role models?

Overall, women graduate at a rate of only 30% in post-secondary STEM academic programs[18]. According to the 2023 Global Gender Gap Report, women made up 29.2% of the STEM workforce in 146 countries, which is significantly lower than the 49.3% of non-STEM occupations[19]. This represents a 1.58% increase from 2015, a low increase by any standards. This begs the question of why women, having dispelled the myth that STEM ability is gender-specific[20][21], are unavailable to other women or abandoning STEM fields? The general answer is the hostile environment created by implicit bias and hegemonic gender stereotypes that girls and women are barraged with as early as primary school. The research also highlights the subsequent lack of women role models as a factor in success[18][8][16]. This is, of course, a vicious cycle. The same pressures that limit women's success create barriers to mentoring and being role models for other capable women.

## Role model gatekeeping

Gender bias is a foundational feature of women's invisibility in STEM fields[22][16]. A primary area of normative obstruction of women's progress centers around the demands on our time[23]. Obligate domestic responsibilities continue to weigh inordinately on girls and women, globally, with a greater intensity in the GS[24]. These obligate demands require flexibility in women's schedules to accommodate these demands, resulting in "flexibility stigma," which further undermines women's advancement[25]. This self-perpetuating feedback loop results in the exclusion of many women from even participating in career-growth opportunities. Women additionally have limited access to necessary academic and career resources in STEM[26][27]. This inequitable withholding of resources exacerbates the difficulties faced by women in academic STEM fields to such a degree that there has consistently been a significant curtailment in their professional potential and contributions[28]. Consequently, workplace support declines, their performance evaluations suffer, and are weaponized as a generalization of women's potential, thus supporting gender stereotypes. To complicate matters, women's achievements are perceived as a factor of influences from luck to manipulation rather than competence[29], which is intensified in the GS. This dynamic is an additional factor in the elusiveness of role model status. Women still earn less than their male counterparts, as well[30].

Prescriptive gender limitations result in a suppression of creativity and authenticity due to "stereotype threat"-- the fear of confirming negative stereotypes about a prescribed group. Consequently, women often avoid fields where we are perceived as inherently less capable than men, like mathematics and science, thereby reinforcing the stereotype of female incompetence and inherent lack of interest in these areas[31]. Moreover, due to the hostile environment, women leave STEM fields for occupations that are less normatively repressive because of the impossible hurdles women are subjected to and the stress associated with them[32]. This avoidance behavior is partially attributed to 'social identity threat,' which van Veelen et al.[31] define as the experience of feeling devalued or stigmatized at work based on gender identity, similar to stereotype threat. The women who do arrive at success are considered either unusual or "tokens" of diversity in the GN and overlooked as role models[12]. These dynamics, too, are considerably magnified in the GS.

Gender bias, rather than capacity or interest, is further evidenced by the lack of women leadership across all sectors[13]. If women cannot break the glass ceiling, then who determines the discourse? Women's stories are not told, having a significant impact on the exposure of successful women to those who are in a STEM trajectory[33]. Women are rarely showcased for their accomplishments or their trajectory as part of the hegemonic narrative. This is evidenced in how women are perceived as less competent than men, based solely on gender rather than performative substance. A study by McNell et al.,[34] showed in a double-blind study that students rated instructors lower if they were perceived as female, even if the male instructor was presented as female in remote courses. Kolev et al.,[35] found that women were significantly less likely to get published and receive credit for work than their male colleagues. This also extended to receiving grants and other funding, being passed over for male colleagues[36]. Furthermore, studies show that manuscripts in which women are listed as first or last authors are cited less frequently[6].

Consistent with this, the global pattern shows a negative correlation between the rank and the number of women represented, with few reaching senior and leadership roles all[37]. According to Lorens et al.,[38], this trend persists despite an awareness of gender inequity. Women, particularly those in early stages of their careers, are frequently expected to provide skilled labor for lower compensation. This scenario effectively entraps them in a cycle of low-paid work, undertaken in the hope of securing a competitive advantage that never really comes for most due to the exclusion and dismissive attitudes toward women's achievements. It is a scenario that represents and perpetuates gender imbalances and is a factor that

results in women leaving STEM trajectories. If there are few women who can push through the barriers, there are few or none who have the recognition or resources to act as role models.

Hegemonic masculinity and Femininity are underpinnings of these biases and normative impositions. Hegemonic masculinity and femininity are the dominant, ruling stereotypes of gender norms and expectations. These dominant norms and ideologies relegate women to a lower rung on the social ladder[39]. For a plethora of reasons, this creates a very unstable substrate for role models to emerge– if a woman adheres to the hegemonic feminine, she is considered lacking sufficient leadership qualities. Consequently, women who strive for higher status use prescriptive gender stereotypes to their benefit[40]. However, at a certain point, professional expectations are tied to a specific concept of disciplined, hegemonic femininity. This puts women between a rock and a hard place as we face backlash from crossing hegemonic gender expectations, or align with the "hegemonic femininity incentive"[40]. This is the relative advantage of demonstrating traditional feminine behaviors. This is particularly true in environments where women are not rewarded for having hegemonic masculine traits. Hamilton et al., [40] assert that by upholding these societal norms, women perpetuate inequality by accepting a lower status within the professional hierarchy and/or by holding other women to those restrictive standards because of the same. Ironically, this can also undermine women's ambitions, limiting their professional growth because of a perceived lack of "leadership skills" attributed to male traits. To gain respect, power, and privilege, women often have to demonstrate an ability to navigate the sexist dynamics of their organizational environment around these gender expectations[40]. This can also relegate women to a strategic position rather than one of genuine connection and leadership.

So pervasive and persistent is the tendency to overlook women that there is an actual term for it: "The Matilda Effect," which embodies the tendency to overlook or downplay the contributions of women in science[41][42] (Rossiter, 1983). While we often hear about exceptional cases of women breaking through the "glass ceiling" in STEM and paving the way for others, these women are sometimes portrayed as outliers. However, when we examine the definition and evidence of the Matilda Effect, it is clear that the perception that exceptional women are anomalies is fallacious. Starting in academia[43] and bleeding into professional sectors[44], we see that there is clear evidence that women are not only overlooked but fall prey to plagiarism, appropriated work, and erasure[45]. Additionally, the higher the position a woman holds, the more likely it is that the penalties for violating these stereotypes will be harsher and more pronounced (Ceci et al., 2011). Beyond navigating impossible workplace politics, women are often required to exceed the baseline performance standards deemed sufficient for their male colleagues'

advancement. Research indicates that women are held to stricter performance criteria, necessitating that we work harder to achieve similar recognition[46] (Hengel, 2017). Consequently, women are less likely to ascend to high-status, high-paying positions, such as those at the management level. Arbitrary (versus merit-based) performance benchmarks are set for women. This results in increasingly unattainable limitations and serves as a normalized barrier to their professional advancement and certainly to recognition. This trend results in women occupying lower socio-economic levels than their male counterparts at all career stages[15]. This is known as the glass ceiling[47] and has been observed in all employment sectors[6]. Women of color feel a magnified effect of this[48]. Women in the GS, even more so.

The oppressive truth of the glass ceiling and stolen or overlooked work as a feature of implicit bias is a pervasive narrative for women across the globe. The "glass cliff", coined by Ryan and Haslam[49], is an even more precarious role, where women are put into leadership positions as a sort of professional scapegoat to make unpopular changes or as a canary in the mine to determine whether a particular policy will be beneficial and successful...or not. This means that a woman's tenure in such a position will be limited and failures weaponized as evidence of gender-based biases. If a woman is successful, this success will be attributed to the man that follows her, once she has been removed from the position[50]. There is evidence that women are judged more harshly, penalized more harshly, and demoted more frequently. Additionally, the success of women can be weaponized[51]. This gatekeeping provides a control for how far and how long a woman can attain leadership, where women are 'outsiders' in a system that predominantly accommodates men[52]. Given this persistent exclusion, it stands to reason that the criteria for 'role model' would stay unmet by women in STEM, in spite of the Herculean efforts we must make to arrive at any level of professional achievement. This dynamic is in itself a direct limitation to women as role models, since they cannot freely rise in status, nor share an organic story of personal achievement. And, consistently, this dynamic is intensified in the GS.

The practice of dismissing and pilfering women's accomplishments is fundamental in the professional repression of women even while in the GN women appear to have more open access. In the GS this dynamic is much more intense starting with limited access (6et al., 2024), snuffing out girls' chances before having a role model can even be contemplated, much less being one. It is important to acknowledge that, given the evidence we do have, there are likely numerous women whose achievements have been overshadowed or buried by their male counterparts currently and historically[44][53] (Ross et al., 2022; Lerner, 1975). Because of the omission of such women, it is difficult to know how many discoveries should be attributed to women, nor how many have been lost as a result of gender

dismissiveness[53]. The GN is retroactively allowing the stories of unsung and overlooked women in STEM to be told but frequently much after the fact and in a way that perpetuated the idea that these women were anomalies.

# Where are the women role models in the Global South?

## *Push-pull factors*

Push–pull factors in migration are well-established dynamics that influence where there is movement across the globe. Push factors are reasons why people might leave a region, while pull factors are reasons why people might move into a region. Migration often happens due to a combination of both push and pull factors. For women in STEM, access to education, compensation for skilled labor, and access to higher-level employment are push/pull factors that influence professional decisions along their STEM trajectory– and these decisions take access into account. Periphery areas are often known for a greater number of push factors because we are limited in access to the dominant core areas, where access to resources (like quality education and employment) is determined by socio-political power dynamics established in post-colonial global politics[54]. In contrast, core areas are generally attributed with pull factors because of that same dynamic, and are focused in the GN. Women who pursue secondary and post-secondary degrees in the GS start with greater systemic limitations that push them from their native homelands and pull them towards core areas where they can access employment that provides better compensation than the restrictions in their own place of origin[55]. Certainly, the movement towards cities in the GS is well documented. Women face difficulties inherent in their movement, consistent with general safety issues and gender biases in education and employment access. Anastasiadou et al.[56] found that there are a number of complications for women migrants versus men, even down the networks we rely on for migration, particularly that women rely on family networks vs. acquaintances. Women have to consider safety issues not pertinent to men, and many women students who study abroad, stay there[57]. Dumont et al.[58] make the point that where women and men are represented equally in highly skilled migration, it is important to recognize the significance of this statistic for women in skilled labor since the limitations for their success are so numerous. Anastasiadou et al.[56] echo this but highlight the issues with assessing gendered nuances because of limitations in data availability around gendered dynamics. Fundamentally, what is apparent is that the women who achieve advancement in STEM fields are essentially pushed out of periphery areas and pulled towards the core
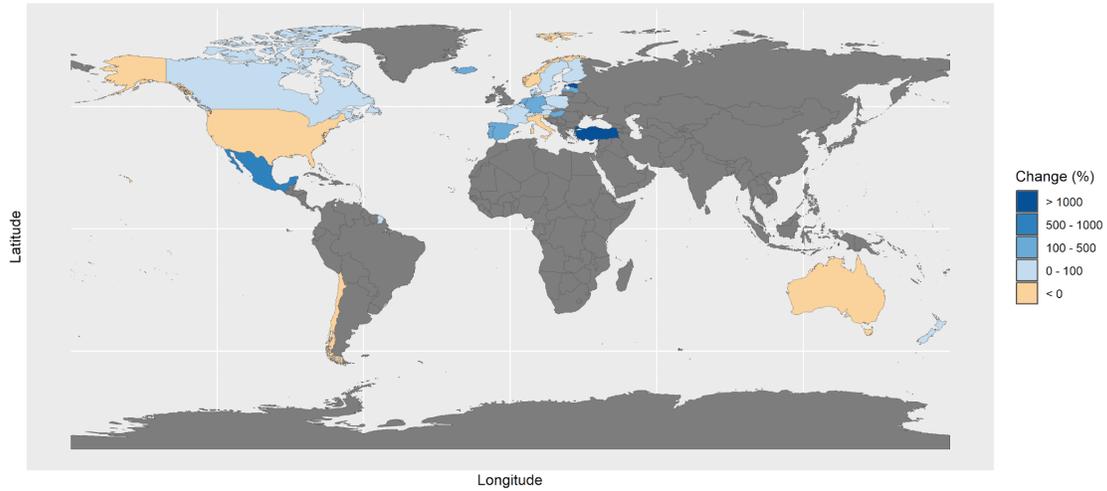
areas because of better opportunities in spite of gender biases and gender norms that limit their total success. One could argue that the still disparate compensation, recognition, and access to STEM jobs to men is still a more acceptable compensation for the intensive investment of a STEM education in core areas because of the greater disparity apparent in those in the periphery. Even when women achieve STEM positions, there is income iniquity that grows as women rise in status[59]. This remains a global problem.

Push/pull factors also apply to advancement in a given career in terms of the decision to advance in leadership or whether that is even possible. This has been evidenced in the decision to leave STEM areas by women, particularly in various levels of academia, because of these stressful, systemic limitations based on gender norms and bias[8]. These layered push/pull factors and their impacts on decisions by women in STEM are multifaceted and have real societal impacts.

*Role models and fem brain-drain*

Role models can be found anywhere but female role models, especially those from GS countries, are primarily found in countries in the GN (Figure 1). According to the Organization for Economic Cooperation and Development (OECD), the US, Australia, Canada, Italy, Spain, Germany, France, and Portugal are among the leading destinations for female immigrants from the GS (Figure 2). In some countries, the percentage of female immigration has dramatically increased in the last decade, and even in countries where the proportion of female immigrants has slightly shrunk, like the US, Australia, and Italy, the numbers of female migrants from the GS remain steadily high. Interestingly, countries from the GS, such as Chile, Mexico, and Türkiye, are also popular destinations for female migration, a result of the socioeconomic and sociopolitical push/pull factors[56].

**Figure 1.** Countries of destination of female migration from Global South countries from 2009 to 2019 according to OECD 2024 data.
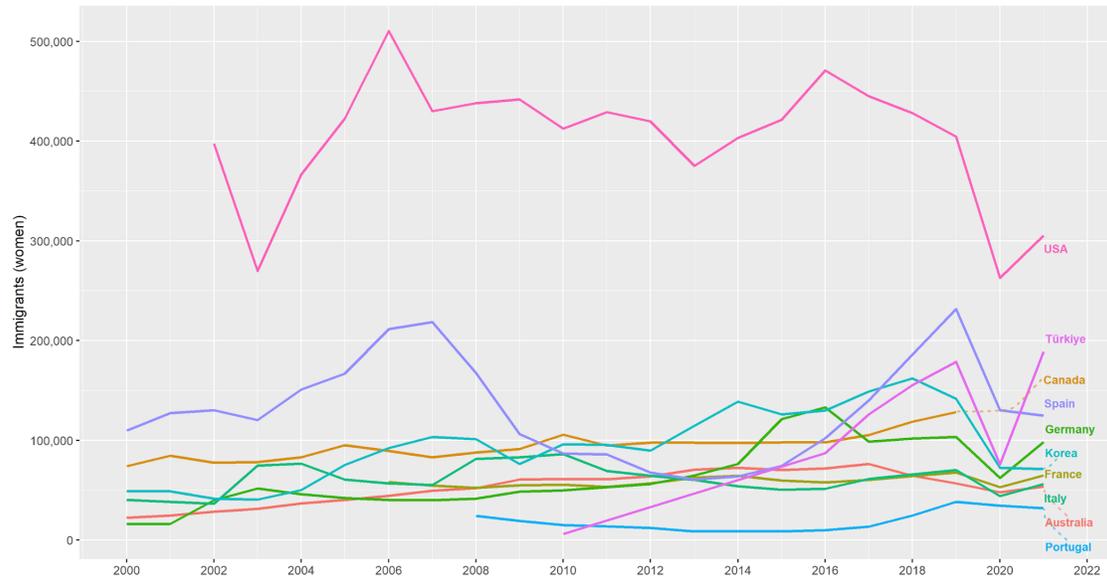


**Figure 2.** Main countries of destination for female migration from Global South countries from 2000 to 2022 according to OECD 2024 data.

Female migration is part of a well-known phenomenon called "brain drain", in which highly skilled working professionals are forced to leave their countries, seeking better job opportunities and quality of

life[60][61]. The brain drain phenomenon thus represents a severe and permanent loss of human capital for countries in the GS, as people who leave usually do not return[61][62]. The brain drain phenomenon was, until very recently, treated as a non-gender-specific problem. However, according to Dumont et al. [58] and Anastasiadou et al.[56], there is an increasing migration pattern of women that started in the eighties and has increased in the last decades (Figure 3). According to the most recent data from the OECD, there was a drastic increase in female migration from 2000 to 2019, with notable examples like Bhutan and Yemen, whose number of female migrants increased by more than 10000%. Elveren and Toksöz[63] revealed that gender inequalities in access to education and the job market are critical factors motivating female migration, promoting a sort of fem-drain scenario in the last two decades. Thus, our female role models are leaving our countries in the GS if we can to pursue opportunities that would be closed to us in our home countries, as a result of gender bias.
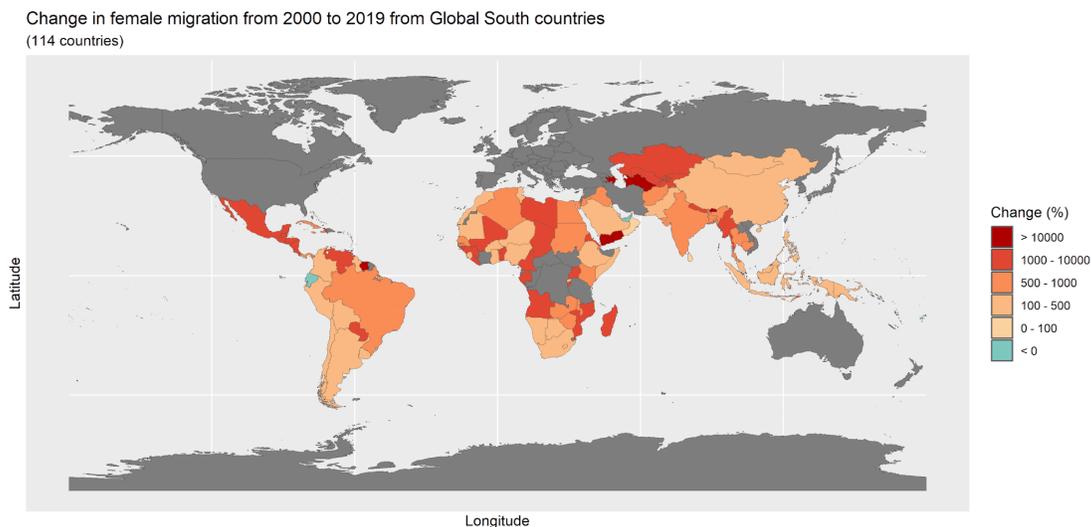


**Figure 3.** Change in female migration from 2000 to 2019 from Global South countries according to OECD 2024 data.

These factors impair our global access to available social capital and future social capital. With the wicked problems we are facing as a species resulting from anthropogenic climate change and other significant management failures, there is an urgent need for an "all hands on deck" scenario where our best minds are seeking mitigation, reversals, and long-term solutions. Gender bias, particularly in STEM, limits

everyone. At the end of the day, it is about recognizing the women who are and have been successful so that they can be motivational and instructional for others.

# Who are the role models we have?

So, who are the women breaking the glass ceilings and surviving the glass cliffs whose stories could be motivational to the next generation of women in STEM? We are now more aware that women in STEM have been responsible for many of the important technologies and techniques we rely on today, although most often (and certainly historically) these women's names are not immediately associated with the achievements (*e.g.* Hedy Lamar and internet, Gladys West and GIS, Nettie Stevens and sex chromosomes, Chien-Shiung Wu and particle physics, etc.). The dynamics discussed thus far in the chapter make finding information on women in STEM complicated, even today. Thankfully, especially with digital media, access to information for those with accessible internet makes it much easier than it has been historically to seek out information on women who have succeeded at various levels. However, even a key-word guided search on "award willing women in STEM" includes men and yields content that consists mostly of women from the GN in the results. Thankfully, the United Nations has a dedicated area on the web specifically to highlight women around the world. After a somewhat more protracted search, here are just a handful of women who are current role models for other women in STEM from the GS:

## 1. *Africa*

**Juliana Rotich** is a Kenyan IT entrepreneur and co-founder of *Ushahidi Inc*. This non-profit tech company develops open-source software and crowdsourcing tools to visualize information and allow public participation in decision-making and crisis response[64]. Ushahidi was fundamental during the resulting violence after the election in Kenya in 2008 and the Haiti earthquake[65]. Growing up in Kenya, Juliana had to overcome social conventions that did not support women's achievements. However, inspired by the American astronaut Mae Jemison, she chaired her school computer club, and after school, she studied computer science at the University of Missouri in the US[65]. In a male-dominated field, Juliana keeps inspiring and creating a platform for other women worldwide to follow, giving society a voice to promote change in their communities[64].

**Lydie Hakizimana** is a Rwandan entrepreneur and ex-CEO of the African Institute of Mathematical Sciences (AIMS)[66]. Her goal is to provide children with access to education and give them inspiration and hope through literature[64]. In 2015, she founded "Happy Hearths" in Rwanda, a chain of schools that

provides early childhood education[64]. She also founded *Drakkar Ltd.* Through *Drakkar Ltd.*, Lydie distributed more than one million textbooks in primary and secondary schools in Rwanda[66].

**Dr. Nana Ama Browne Klutse** is a senior lecturer in the Department of Physics at the University of Ghana. Her research in climate sciences focuses mainly on the African Monsoon because of their importance as indicators of climate dynamics and the impact on Africa[67]. Besides being an accomplished scientist, Dr. Nana engages in service and outreach, mentoring students, especially young girls, to pursue a career in STEM[68].

**Dr. Sherien Elagroudy** is an associate professor of environmental engineering at the Ain Shams University in Egypt, where she co-founded the first Solid Waste Management Center of Excellence[69]. Dr. Elagroudy has designed novel bioreactor landfills to avoid greenhouse gas emissions to the atmosphere and the leaching of wastewater byproducts into drinking water supplies[70]. Dr. Elagroudy works in academia and as a consultant in waste management and wastewater treatment projects locally and internationally[70]. In 2016, she was awarded the Next Einstein Forum Fellow[70]; prior to that, she was L'Oreal UNESCO Arab Fellow in 2013[69].

**Professor Francisca Nneka Okeke** is a Physics professor at the University of Nigeria, Nsukka (UNN). Prof. Okeke broke many records as she was the first head of the Department of Physics and Astronomy between 2003 and 2006, the first female dean of the faculty between 2008 and 2010, and the first Indigenous woman to become a faculty of Science at UNN[71]. Her work has enhanced the teaching and learning of physics at secondary and tertiary levels in Nigeria[71], and she supervised many students throughout her career[72]. She was awarded the L'Oreal–UNESCO 2013 Award for Women in Science for Physical Sciences[71], and on a daily bases, she demonstrates that Physics is not and should not only be a male domain[72].

## 2. *Asia*

**Dr. Hayat Sindi** is a South Arabian biotechnologist and medical scientist seeking affordable health care for poor communities worldwide. Growing up in South Arabia, where educational barriers for women are substantial, she convinced her family to support her higher education abroad. She got a degree in pharmacology from the King´s College of London and a PhD in Biotechnology from Cambridge[73]. Combining her background in medicine and technology, she co-founded "Diagnostics for All", a non-profit organization that develops low-tech devices to detect diseases by analyzing saliva, urine, or blood.

Dr. Sindi also founded the Institute for Imagination Ingenuity to promote education in STEM for future generations. She became the first Saudi female UNESCO Goodwill Ambassador in 2013 for her achievements. Her engagement and commitment continue inspiring women worldwide to pursue STEM careers.

**Tu Youyou** is a Chinese Nobel Laureate in medicine for their work on an innovative therapy against malaria[74], combining modern and traditional Chinese medicine[75]. The recognition of her findings was prevented under Mao Zedong's regime, and her first international paper was published without her name in the Lancet in 1982[75]. Only 25 years later, two scientists from the National Institute of Allergy and Infectious Diseases in Rockville, Maryland, encountered Tu Youyou's work, an event that gave her the deserved recognition[75]. Tu Youyou, despite not having post-graduate studies and international research experience[75], discovered artemisinin, the most effective drug against malaria that has saved tons of lives worldwide[74].

**Dr. Suchana Apple Chavanich** is an associate professor at the Department of Marine Science, Faculty of Science, Chulalongkorn University in Thailand[76]. Her research on nearshore species like coral reefs has inspired Thai youth to value their marine ecosystems[76]. Dr. Suchana is currently the Coral Reef conservation project leader in the Western Pacific and a Thailand Reef Check coordinator[77]. In these positions, she promotes community engagement in protecting coral reef health using sustainable solutions[77].

**Dr. Champika Ellawa Kankanamge** is an engineer from Sri Lanka. Her studies mainly focus on conserving aquatic ecosystems from heavy metal pollution[78] and ecological restoration using native plants and animals, preventing the adverse effects of invasive aquatic species[79]. In 2020, Dr. Champika was awarded the OWSD—Elsevier Foundation Award for early-career women scientists in the Developing world[79]. As a university professor at the University of Ruhuna[78], Dr. Champika continues advocating for conservation projects of natural species in Sri Lanka.

**Dr. Samia Subrina** is a Professor at the Department of Electrical and Electronic Engineering at the Bangladesh University of Engineering and Technology[79]. She specializes in nanoscale materials, including studies on nanomaterials for thermal and electrical transport in renewable energy[80]. She has published her work in top journals, including Nature[80], and was awarded the OWSD—Elsevier Foundation Award for early career in 2020[79]. Dr. Subrina is one of Bangladesh's leading experts in nanotechnology, a still unexplored field in the predominantly male-dominated country[79].

## 3. *Latin America*

**Dr. Dení Ramírez Macías** is a Mexican marine biologist and marine life conservationist[81]. She has co-founded Whale Shark Mexico, where she works as a director and studies the migration patterns of whale sharks across the Pacific coastline[82]. Her work on migratory whale sharks has led to the creation of three protected areas in Mexico[82]. Her innovative research in marine wildlife includes, among others, ultrasound of pregnant whale sharks and manta rays. She was entered into the Hall of Fame for Women Divers in 2021. Her work has been showcased in many international films and documentaries on Discovery Channel and National Geographic and continues to inspire the new generation of marine conservationists. She has been recognized as the mother of marine conservation in the Caribbean[83].

**Valentina Muñoz Rabanal** is a feminist youth activist, and a recent high school graduate. She has been a programmer since she was 12 years old; and three-time regional champion, national and world champion, of the First LEGO League international robotics competition. Ashoka elected her as one of the 7 most influential young people in Chile in 2020. She is also the founder of the Secretariat for Gender Diversity and Sexuality of the Carmela Carvajal High School (Sedigesex), and continues as president of the Association of Young Women for Ideas (AMUJI Chile). She is currently pursuing her STEM goals and acts as a social media influencer. She is currently the Embajadora de la Política de Igualdad de Género en Ciencia y Tecnología (Ambassador for political gender equality in science and technology) for the Ministerio de Ciencia Tecnología Conocimiento e Innovación of Chile. She has acted as an official Sustainable Development Goal Advocate for the UN since 2021.

Guatemalan scientist **África Flores** works with GIS systems to monitor the health of global ecosystems through a network of NASA satellites. She won the *Geospatial Women Champion of the Year* award in 2020, as regional coordinator of the National Aeronautics and Space Administration's SERVIR program. This program exists to detect critical information on food security, water resources, land use, natural disasters and climate change. She focuses on her home country, Guatemala, and on countries the Amazon spans. She was featured in the UN Women in Science in 2021. She is quoted as saying, "Don't give up. I would not be where I am today if I had succumbed to the many obstacles I faced due to my position, in terms of my gender and economic situation." This quote is taken from the Applied Sciences Program–NASA[84].

Animal Husbandry Engineer **Lilia Janine Chauca Francia**[85] studied animal husbandry at the Universidad Nacional Agraria la Molina in Lima and is currently the coordinator of the Guinea Pig program at the Instituto de Innovación Agraria INIA. As a child, she was very passionate about

mathematics and was encouraged by her school teachers to become one of the few women in her group to pursue a career in STEM. Her work in Guinea Pig breeding profoundly impacts the well-being of many Peruvian families in the Andes and highlights the role of women in guinea pig management and breeding. Her work has empowered many Andean women to grow their own businesses breeding guinea pigs, creating better opportunities and independence for them and their families.

**Ana Inés Zambrano** is a Uruguayan biochemist from the Universidad de la Republica who has worked in genetically modified organisms and diabetes[86]. She advocates for increasing science diversity and improving the gap between men and women in STEM-related fields. As a member of the ASBMB Science Communication and Outreach Committee and the collective Bardo Científico, Ana Inés organizes activities to promote science and education with a gendered perspective in Uruguay[87].

**Carolina Susana Vera** is an Argentine meteorologist, full professor at the University of Buenos Aires School of Science, and principal researcher of the National Council of Sciences. As vice chair of the IPCC's Physical Science Working Group, Carolina is a voice for underrepresented groups, a leader in climate science, specifically understanding and predicting climate variability and change in South America[88], and a female role model for future climate scientists[89].

## 4. *Caribbean*

**Professor Idelisa Bonnelly de Calventi** was a Dominican marine biologist and founder of the Dominican Foundation for Marine Research. Her research on humpback whales helped create the first protective zone for marine life in the Dominican Republic in 1986[83]. Her determination to improve the education system and bring the marine biology field to her country led her to create the CIBIMA Institute for Marine Biology, dedicated to creating healthy fishery areas, protective areas for marine life, and the humpback sanctuary[83]. She also founded the National Academy of Sciences and the School of Biology at the Autonomous University of Santo Domingo. She was awarded the Marie Curie Medal in 2009 for her achievements. Her work set the path for new young female marine biologists, and her legacy will continue to motivate future scientists in STEM.

**Dr. Sandra López Verges** is a Panamanian microbiologist and biochemist from the Université Paris 7 Denis Diderot in France and a trained immunologist at the University of California, San Francisco[90][91]. Dr. López Verges is currently a Health researcher at the Gorgas Memorial Institute of Health Studies (ICGES)[90], where she studies innate immunity to arboviral diseases and mentors students at all

levels[91]. Dr. López Verges was awarded the UNESCO-L'OREAL International Fellowship for Young Women in Science in 2014 and has been a Global Young Academy (GYA) member since 2018[90]. As a scientist based in Panama, Dr. López Verges encourages young women to pursue careers in STEM-related fields to achieve gender equity in science[91].

**Kristal Ambrose** is an environmental scientist from the Bahamas who is deeply committed to reducing plastic pollution in marine ecosystems[92][93]. In 2013, she founded the Bahamas Plastic Movement to reduce plastic pollution by developing technologies and education[92][93]. Kristel was awarded the Environmental Youth Leader in the Bahamas for her work in 2014 and won the Goldman Prize for grassroots environmentalists in 2020[92][93].

**Ayanna T. Samuels** is a Jamaican aerospace engineer who graduated from MIT and has been the only black woman in this field since 1972[94]. She also has a master's degree in MIT Technology Policy[94]. She combines her science and policy backgrounds to promote gender equality in STEM and empower emergent economies to eradicate poverty[95].

## 5. *Indigenous women*

There is still a clear discrepancy between a racial and ethnic composition of an area and the racial and ethnic composition of the corresponding STEM workforce[96]. The most underrepresented group (among women and in general) are Indigenous women[97]. This is sadly true across the globe. All of the aforementioned limitations make any success for this marginalized group of women particularly laudable, and most are in the GN for a plethora of reasons, not the least of which are those covered in this chapter and book. Here are just a few examples of successful Indigenous women in STEM:

**Nicole Aunapu Mann** is a mechanical engineer from Stanford University[98] who made history as the first Indigenous woman from NASA to be in Space as a commander of NASA´s Space X Crew-5 mission. Nicole is a member of the Wailacki of the Round Valley Indian Tribes in California[98]. Nicole takes with her into the cosmos the hopes and dreams of many native Americans who are still enduring oppression and discrimination and inspires native American children to break the barriers society still imposes[99].

**Mariah Gladstone** is a Blackfeet, Cherokee environmental engineer from Columbia University who founded Indigikitchen[99]. Mariah promotes traditional Indigenous food as a means of Native American resistance to colonialism and encourages healthy lifestyles and ecosystems[100]. She was also awarded a

"Culture of Health Leader" through the Robert Wood Johnson Foundation and a "Luce Indigenous Knowledge Fellow" through the First Nations Development Institute[100].

**Dr. PennElys Droz**, an Anishinaabe and Wyandot descendant, is an environmental engineer with a Ph.D. in Biocultural Engineering Design American Indian Studies from the University of Arizona[101]. Dr. PennElys worked for over 20 years toward building ecologically, culturally, and economically sustainable Native Nations[99]. For this purpose, Dr. PennElys founded Sustainable Nations, a native-led organization that supports tribes, cities, and businesses on renewable energy projects, traditional buildings, and ecological wastewater treatment[99][101].

**Elaina Saltclah** is a third-year Navajo physics student in the graduate physics partnership program between Los Alamos National Laboratory and Fort Lewis College[102]. This program aims to engage Native American women in Physics, a field that is mainly male-dominated[103]. As a child, and despite being in love with the world of physics, Elaina did not think that a career in Physics could be an option for her[102]. Now, Elaina will soon become a prominent physicist who will inspire more young native American Women to pursue a career in STEM.

There are many, many accomplished women role models in STEM and we encourage the readers to dig deeper to see the pivotal role women have and continue to play in innovation and sustainability in all areas of STEM. Seeing that there is more information access and thus more spaces for women's successes to be visible, the age of information brings greater potential to break the barrier of invisibility. We can be hopeful that the recognition of inherent bias and gender discrimination will open doors to allow merit-based advancement around the world. In order to do so, we must ensure our stories are shared and heard.

## The future of science requires a diverse voice: Enabling women to become future role models

The presence of female role models is essential to inspire future generations of scientists and challenge limiting stereotypes[8]. Some studies show that same-gender role models appear to be more effective in attracting young women into STEM fields[104]. Exposure in preteen age to female role models showed increased academic interest and motivation. This is particularly important when taking into account that this is the age when their self-perception of competence and self-confidence becomes susceptible to implicit bias[105]. However, due to the low participation rates of women in these fields, especially in

engineering and physical sciences, finding a sufficient number of professional women in STEM in the GS is challenging. Additionally, sharing stories of women in STEM positively affects not only STEM but also non-STEM students' interest in STEM[4][106].

Changing the image of STEM talent is an imperative as we move deeper into the 21st century. Given that the image of STEM is still male[107], increasing women's representation at all academic levels needs something other than institutional inclusion policies. To encourage women to pursue careers in science, we must provide them with role models to aspire to. It is essential to demonstrate that being a woman and a successful scientist are not mutually exclusive. This is especially important in more traditional countries in the GS, with more defined gender roles and less support for female education in general[13]. In this context, role models and mentors[108], even as early as elementary school[109], become fundamental to starting associations of women with traditionally male-dominated careers. Eliminating the obstacles that hinder women from entering the fields of STEM will be crucial in reshaping the current academic landscape, which is vital for addressing emerging forms of gender inequality[8]. There are numerous ways to change the hegemonic gender biases and we will discuss just a few of those highlighted in the literature.

The main solution is to highlight women in STEM and their stories. An important initiative towards this is the celebration of the International Day of Women and Girls in Science (February 11th). This day aims to promote gender equality in STEM fields by recognizing the significant contributions of female scientists and encouraging young girls to pursue scientific careers in GS. By fostering inclusivity and diversity, the day enhances creativity, innovation, and problem-solving across the scientific landscape. Celebrating this day also helps break down barriers and address gender disparities, inspiring future generations to see themselves as part of the scientific community (United Nations, 2024). Working on Sustainable Development Goal 5 (SDG 5), which aims to achieve gender equality and empower all women and girls, is particularly impactful in the Global South. Efforts to implement SDG 5 in these areas are critical for addressing systemic inequalities and promoting sustainable development. By advancing gender equality, the Global South can make significant strides toward achieving other Sustainable Development Goals, ultimately leading to a more just and prosperous world.

Mentoring, both formal and informal, provides crucial support for women in STEM. Formal mentoring programs typically involve structured training and discussions, while informal mentoring relies on personal experiences and perceptions. Understanding the key issues for peer mentors and the strategies they recommend can offer valuable insights into the challenges women face in STEM and how to

improve their support systems[110]. This aligns with previous research on the key attributes of effective STEM mentoring[111][112]. The unique role of research mentors in developing students' research skills and self-efficacy is remarkable[112][3][113]. Ensuring that women have spaces to mentor is imperative to this goal, which requires a change in the imbalanced demands and expectations on professional women's (and female students') time and productivity. Mentorship cannot reasonably be additional. Peer mentoring plays a crucial role in providing the necessary advice and support to help women navigate these difficulties and persist in their STEM majors[110]. In the GS, where cultural and educational contexts may differ significantly, peer mentoring can be particularly impactful. Informal mentoring relationships can help women in these regions overcome unique barriers. By sharing the experiences and advice of women who have successfully navigated these challenges, institutions can create environments that foster STEM participation and persistence among women[16]. This approach is vital for attracting and retaining women in STEM fields and ensuring their success globally.

Another aspect to consider is changing the gender stereotypes associated with STEM. For example, there is an irrational, deep-rooted cultural association between masculinity and objectivity[114]. Furthermore, nonscientists are less likely to identify a woman as a scientist if she has a feminine appearance[115][24]. Another challenge is that researchers in the GN are often seen as experts with a great reputation, while those in the GS are perceived as regionally confined and dependent on knowledge from the GN. These beliefs are augmented for STEM women in the GS. This perception perpetuates the post-colonial power structure, where expertise flows from the GN to the GS[116].

While the gender feature of inequality affects ~51% of the globe, issues focused on equity should not be treated in isolation. They require deeper analyses related to age, education, culture, socioeconomic status, ethnicity, and geographic location, among other factors. Creating spaces to discuss these issues, activating measures, and working together to achieve equity in science and technology is a feasible goal for academia and society as a whole. Having open and equal access to all STEM inclined social capital is imperative as we face wicked problems and a rapidly evolving world. Ensuring that women's voices, stories and wisdom are heard is a key step towards equity and balance in our access to indispensable social capital[117].

# Conclusion

Imagine a future where laboratories, classrooms, awards, publications, and scientific conferences are truly representative of the population[118]. Imagine a world where gender and discrimination no longer dictate who gets recognition and role model status. One of the cornerstones of achieving timely scientific advancements and equal gender representation in science is the presence of female role models[119]. These women are many, as every one of us has faced these and other Herculean hurdles. Women teachers, who have dedicated their effort to lifting others into the understanding and practice of STEM from primary school, through secondary school, and into all levels of higher education, are the frontline of STEM hegemony cycle breakers. Women scientists who have shattered glass ceilings, survived glass cliffs, and made significant contributions on various levels need to serve as beacons of hope and aspiration for future generations of scientists– particularly for girls and women. This is even more agathokakological for women in the GS and women of color everywhere[120] (Chemers et al., 2011). These women's stories merit open acknowledgement and inclusion so that they can serve as reinforcing and motivational examples for other women with an inclination towards STEM. Women role models demonstrate that gender is not a barrier to success in science and provide a source of encouragement for girls and women considering careers in STEM. Female role models challenge stereotypes and biases that persist in STEM. Our presence and persistence are evidence that intelligence, creativity, and scientific excellence know no gender boundaries. Gender parity in science is not just a goal but an attainable reality that can be achieved applying scientific principles and dispassionate logic to sharing the evidence and stories of women in STEM. This vision is not merely an ideal; it is a necessity for the advancement of science and society as a whole (Holmaat & Hamborg, 2023). We have a global imperative to perpetuate a STEM culture where scientists work side by side, contributing their unique perspectives and insights to unravel the mysteries of the universe... and in solving wicked immediate problems like global disparity and climate change.

The future of science is bright, and it hinges on the realization of a diverse and inclusive scientific community. We have numerous ways forward[121]. Achieving equitable gender representation is vital to unlocking the full potential of human ingenuity and creativity. The state of the world requires the full use of our social capital with global warming and all that comes with diminishing resources and the need for rapid, adaptive methods and policies moving into the future. The presence of female role models plays a crucial role in this journey[13][122], inspiring future generations of scientists and changing limiting

paradigms. While progress has been made, we must remain vigilant in addressing ongoing challenges and striving for a future where science truly reflects the diversity of the world it seeks to understand and improve. Only then can we harness the collective power of all voices, regardless of gender, and usher in an era of scientific excellence and innovation that knows no bounds. By virtue of the adversity women in STEM endure, every woman involved in STEM are role models– and our stories need to be told, shared, and honored.

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## Declarations