2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #32398

Women in Science and Engineering: A Tale of Two Countries

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Abstract: Despite poor retention and advancement prospects, as well as female-unfriendly workplaces and corporate policies, women continue to flock to and excel in STEM (science, technology, engineering, mathematics) fields. In this paper, using data and narratives from the United States and Iran as examples, I identify roadblocks to the engagement of women in STEM careers. Using the two countries with which I am most familiar as examples is instructive, because this side-by-side comparison shows that undesirable outcomes in the domain of women in STEM fields can and do occur for vastly different reasons, which I discuss.

Keywords: education; equal opportunity; gender equity; labor laws; misogyny; sexism; women's rights; workforce diversity

1. Introduction

It is generally recognized that the economic benefits of scientific and technological advancement cannot be achieved unless the available workforce is efficiently and fully utilized [1], [2]. So, far from being an issue that concerns only women, gender equality in scientific and technological domains is a national and global concern. Known collectively as "STEM" (science, technology, engineering, mathematics), these fields have traditionally lacked significant opportunities for and participation by women (and other under-represented groups).

We in the US were making progress in improving women's participation, both at educational institutions and in the job market. The said progress seems to have stalled or, in some cases, reversed. For example, US Department of Education data shows a 50% drop over the three decades 1985-2015 (37% to 18%) in women's share of bachelor's degrees in computer science (look ahead to Figure 5). In this paper, I draw from a large number of sources to see what happened, using US data and information about somewhat similar outcomes in Iran.

In order to understand the present situation, awareness of the historical trends in women's participation in science and technology is necessary. Nobel science prizes (chemistry, physics, physiology/medicine) aren't quite representative of the entire STEM domain, but the dearth of women winners (20 in all; see Table 1) is indicative of under-representation [3]. Of the 20 Prizes, 2 went to Marie Curie, the first woman winner and the only one to win more than once, in 1903 and 1911.

Temporal distribution of Nobel Prizes appears in Table 2. Overall, 52 Nobel Prizes have been awarded women [4], so the 20 listed above represent around 38% of all awards to women, indicating a possible bias against women in the "hard" scientific disciplines. Because Nobel Prizes represent the peak of scientific achievement and recognition, the dearth of women honorees confirms the pyramidal distribution of women in STEM disciplines, with the percentage dwindling as we climb higher.

Table 1. Nobel Prize winners, 1901-2018, by area. The "Share" figures are rounded to the nearest percent [4].

Areas	Men honored		Women honored	
	Number	Share	Number	Share
Chemistry	176	97%	5	3%
Physics	207	99%	3	1%
Physiology/Med	204	94%	12	6%
Literature	100	88%	14	12%
Peace	89	84%	17	16%
Economics	80	99%	1	1%
All areas	856	94%	52	6%

Table 2. Nobel Prize winners, 1901-2018, by decades [3].

Decades	Men honored		Women honored	
	All	Science	All	Science
1901-1920	94	57	4	2
1921-1940	98	68	5	1
1941-1960	114	87	3	1
1961-1980	170	122	11	4
1981-2000	187	121	7	3
2001-2018	186	128	22	9
Total	856	587	52	20

Ten representative women scientists in modern times are shown in Figure 1 [5]. Similarly, Figure 2 depicts 10 prominent women in computer science & technology [6]. STEM disciplines not represented by Nobel Prizes are mathematics, computer science, and engineering. The most prestigious prize in mathematics is the Fields Medal [7], awarded only once, out of the total of 60, to a woman (the late Maryam Mirzakhani, 2014). The highest honor in computer science is the A. M. Turing Award [8], for which 3 of 70 recipients since 1966 are women: namely, Frances Allen, 2007; Barbara Liskov, 2008; Shafi Goldwasser, 2012. In engineering, election to the National Academy of Engineering is considered the pinnacle of success. Of the 2297 NAE members, 205 are women, 33 of whom were elected in 2019 and 19 in 2018 [9].

Figure 1. Ten notable women scientists (left to right): *Top*: Marie Curie, Jane Goodall, Maria Mayer, Rachel Carson, Rosalind Franklin. *Bottom*: Barbara McClintock, Rita Levi-Montalcini, Gertrude Elion, Elizabeth Blackwell, Christiane Nusslein-Vorhard [5].

Figure 2. Ten notable women in computer science and technology (left to right):
Top: Susan Kare, Hedy Lamarr, Grace Hopper, Ada Lovelace, Mary Lou Jepsen,
Bottom: Roberta Williams, Radia Perlman, Erna Hoover, Marissa Mayer, Barbara Liskov [6].

Recent books [10], [11] reveal that some contributions of women to science and technology were concealed, either deliberately (e.g., because they involved classified work) or unconsciously due to bias. Additionally, men tend to take or be given credit for a good chunk of women's contributions [12].

2. The higher-education scene in the US

In the US, the number of women students in STEM fields has been fluctuating around 20-25%. According to American Society for Engineering Education [13], women accounted for ~20% of all engineering graduates, 25% of master's degrees, and 23% of doctoral degrees in 2015. The fraction of female assistant/associate professors at engineering institutions is consistent with this 1/5-1/4 share, but the fraction drops sharply, to half of this level, in the case of full professors. The picture painted in Table 3 [14], [15] is somewhat more encouraging.

Many innovative programs to attract and retain women in STEM fields have been devised. For example, Stanford University runs the VMware Women's Leadership Innovation Lab (Figure 3) "to advance women's leadership by providing students with a foundation of frameworks, knowledge, and skills so they will be prepared when they encounter gender dynamics in STEM" [16].

Table 3. US Women in STEM fields, by degree level: numbers rounded to the nearest percent [14].

Field	BS	MS	PhD
Biology & Biomedicine	60	57	53
Math & Stat	43	42	29
Physical sciences	39	38	32
Engineering & Tech	20	25	24
Computer & info science	19	31	20
All STEM	36	33	34

I cite just two other examples of programs to improve gender diversity in US institutions of higher learning. Carnegie Mellon University has taken aggressive steps to improve its female/male admission ratio from about 1/3 in 2010 to near-parity in 2018, as shown in Figure 4 [17]. Harvard University also has had some success with its WiSTEM mentorship program [18]. Of course, admitting more women is a necessary step, but it isn't sufficient. Providing an inclusive learning environment that leads to a high rate of graduation is even more important.

Figure 3. A group of participants at Stanford VMware Women's Leadership Innovation Lab. [16].

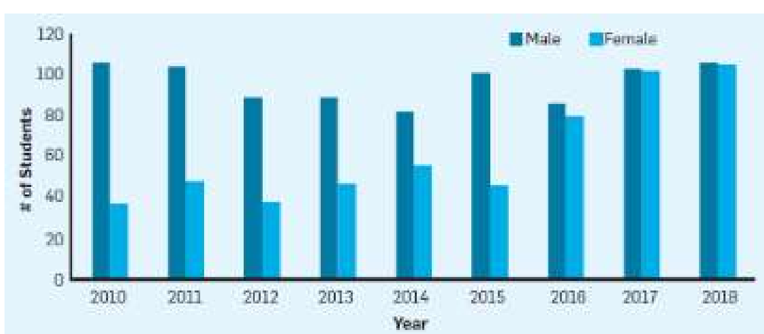

Figure 4. Male and female first-year students in computer science at Carnegie Mellon University, 2010-2018.

Professional societies too are active in educating and mentoring of women in STEM fields. Institute of Electrical and Electronics Engineers (IEEE) works through its Women in Engineering group to promote women engineers and scientists and inspire girls to follow their educational and career interests in engineering and science [19]. Similarly, Association for Computing Machinery (ACM) runs ACM-W [20], to support, celebrate, and advocate for the engagement of women in all aspects of computing.

Only in computer & info science is the fraction of advanced degrees earned by women higher than BS degrees. Biology and biomedicine are the only fields where women students are in the majority, even at MS and PhD levels. Engineering/tech is particularly male-dominated, followed closely by computer & info science, and these fields account for higher-paying STEM jobs.

Even though the focus in this section is on the US higher-education scene, it might help to cite data from other advanced countries for comparison. Canadian figures are similar (~34% of STEM degrees go to women), while the 53% figure for the European Union is much better, although even for EU the percentage drops to ~19% in higher-paying categories. UK is among the countries that have recognized the importance of facilitating the entry of women to various fields of engineering, particularly computing. Publications of the UK-based British Computer Society (BCS) and Institute of Engineering and Technology (IET) often carry articles about such efforts and their outcomes.

We in the US must resume our efforts in this regard, which were quite successful in the 1980s, with the fraction of women computing majors rising to 37%, before taking a nosedive and settling at half that level in recent years (Figure 5). Medical schools have been most successful in this regard, with the fraction of female students now hovering at just over 50%.

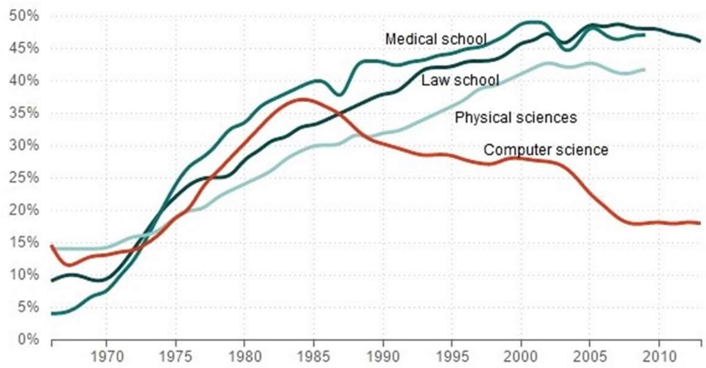

Figure 5. Percent of women majors, by field. [Credit: Quoctrung Bui, NPR, using data from National Science Foundation, American Bar Association, and American Association of Medical Colleges]

Compiling data on how well colleges do in recruiting and graduating women in STEM majors can raise awareness and help spread best practices. For CS&E, *Chronicle of Higher Education* has used US Department of Education data to produce such a ranking [21], which places Salisbury University, with 36% women, at the top of the list of public institutions, followed closely by University of Washington (35%) and five others at 30% or higher. For private co-educational institutions, New School achieves an impressive 75%, with two other institutions scoring above one-half. Because women tend to consider factors such as safety in choosing the institution they attend, correlating such rankings with data on campus safety forms a fruitful area for further studies.

3. The job market in the US

In the US, blind spots continue to hold back women in the corporate world, beginning at the first promotion [22]. Women fare a tad better than men of color, who in turn have 2-4 times more opportunities than women of color to reach top management levels. Job-level designations 1-6 in Figure 6 correspond to entry-level, manager, senior-manager/director, VP, senior-VP, and C-suite (CEO, COO, CFO, CIO), respectively. Dearth of women at the higher job levels is evident from Figure 6.

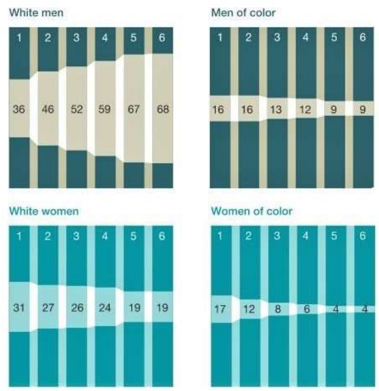

Figure 6. Women and minorities in US corporate ranks.

A new study shows that women hold 1/5 of top STEM jobs worldwide [23]. With regard to positions for women in academia, the same study has uncovered the alarming 50%-40%-30%-20% progression of students, assistant professors, associate professors, and full professors in STEM disciplines. In a survey of 4500 female IEEE members [24], women technologists said they had faced demeaning comments, inappropriate job-interview questions, and exclusion from networking events. Nearly half experienced sexist behavior at off-site meetings or conferences.

In the domain of computer science and engineering, with which I am most familiar, a disturbing roller-coaster-like pattern has developed. In the early days of digital computing, around the mid-20th century, women were very much involved in technological innovation [25], and their ranks gradually grew, both in military and civilian sectors. Legend had it that the women shown in front of early computers were models, but they were not; they were real programmers. Somehow, members of the next generation of women were delegated to simple data-entry and other routine tasks. A somewhat successful push to increase women's participation in late 20th century fizzled, when job opportunities and female-friendly work environments and corporate policies failed to materialize.

Despite the overall strength of the tech job market, positions available to and desired by women STEM specialists is small and, unfortunately, has been somewhat shrinking in recent years. The hi-tech job market in the US is also unfriendly to women scientists and engineers, but opportunities for employment and advancement do exist. The law, though sometimes ignored, prohibits employers from discriminating against women and other under-represented groups, and some employers are even proactive in recruiting women. Given the facts just cited, the reverse relationship between the talent pool and available opportunities is quite puzzling.

Significant effort is devoted to studying the roots of the problem, and proposing remedies, through meetings held at professional conferences and social events, particularly on International Women's Day (Figure 7). In short, the will to solve the problems is there, but the social inertia, resulting from deep-rooted patriarchal tendencies has proven quite difficult to overcome. Awareness of inequalities is rising, so much so that self-organizing groups of individuals are being formed to raise awareness of the problem and to help advance the cause of gender equity on university campuses and elsewhere (see, e.g., [26]).

Figure 7. International Women's Day 2019 discussion on women in STEM, held at US Embassy in London.

I cite just a few studies and diagnostic efforts. Sexism in the tech industry in general [27], and in Silicon Valley in particular [28], is well documented. A survey called "The Elephant in the Valley" [29] found that nearly all of the 200+ responding tech senior women had experienced sexist interactions. Some 84% had been told they were too aggressive; 60% reported unwanted sexual advances, of which 2/3 went unreported for fear of retaliation.

Studies on gender issues in tech jobs [30], [31], [32] indicate that it's not just a matter of fairness to women, compassion, or humanity. Silicon Valley loses $16 billion annually as a result of discrimination and the attendant turnover of women and minorities [33]. And the $16 billion excludes losses from discrimination lawsuits and the hidden costs of not bringing in talent. So, just as using green energy is good for the bottom line, hiring and advancing women more than pays off in the long run.

Efforts have been undertaken to explain puzzling gender differences in research careers and academia. A recent study reached the conclusion that men's and women's contributions are similar in terms of amount and impact, so the gender gap is due to woman having shorter careers and higher drop-out rates [34], [35]. A stealth contributor to the perceived gender gap is what has been referred to as the "invisibility" of women's contributions due to gaps in data collection, which produces serious bias in many data bases used in data-driven decision processes [36].

4. The higher-education scene in Iran

Iranian universities teem with girls in science and engineering disciplines (Figure 8), despite the fact that upon graduation, their prospects for getting jobs commensurate with their qualifications are slim. Some 70% of STEM graduates at Iranian universities are women [37], [38]; at 60%+, Saudi Arabia and United Arab Emirates aren't far behind.

Figure 8. Women tech students taking a selfie in front of Tehran University's College of Engineering (photo credit: Blog of Soodabeh Milanlouei).

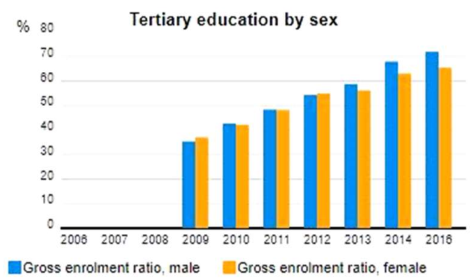

Figure 9. Enrolment ratio of Iranian men and women in post-secondary education [39].

Zahidi [40] estimates women as constituting 1/3 or more of STEM-trained talent across the Muslim world. The latter number is bound to grow, given the current university enrollment trends. Across the same landscape, public-sector jobs for women are scarce, which limits their job prospects to private firms and start-ups. More on this topic in Section 5.

According to UNESCO's 2012 data, women constituted more than half of post-secondary students in Iran, marking the fifth largest female enrollment after China, India, US, and Brazil. In engineering, Iranian female enrollment ranked first in the world and second in science fields, after the US [39]. It seems, however, that 2012 was a peak and female post-secondary enrollment ratio has dropped a bit since then, when compared with the corresponding figure for men (Figure 9). Gross enrollment ratio for tertiary education is the ratio of those enrolled relative to the population in the 5-year age group after the official secondary-school graduation age (so, the ratio can exceed 100% if there are many older/younger students).

As for what caused the downward trend of women's post-secondary enrollment ratio after 2012, I have been unable to find any published analysis. One can argue, however, that changes in the country's economic and political climates might have played a role. President Mahmoud Ahmadinejad, whose key supporters were fundamentalist clerics and politicians, held office from August 2005 to August 2013. Towards the end of Ahmadinejad's term, Iran's economy took a nosedive, which, combined with scarce opportunities for women during his administration, might have turned off women from pursuing STEM majors and careers.

Iranian universities are co-educational, although, as in the US, a number of all-women colleges also exist. From time to time, however, conservative Islamic clerics take issue with women and men mixing in classrooms, going as far as proposing a curtain or partition separating men and women, the way it is done in religious wedding ceremonies. Also objectionable to such clerics is women professors lecturing to men.

It is worth noting that primary and secondary schools in Iran are single-sex. While misguided proposals for separating university-level instruction for men and women have little chance of being implemented, there is pressure on women students (and faculty) to "behave," because they are watched by religious extremists among the students and by campus security personnel. Laughing aloud, studying with men, or wearing "inappropriate" clothing (including not following the rules on covering their body features and hair) can get women in trouble. This added pressure on women, combined with rampant sexism (which, however, usually does not go as far as sexual assault) is not conducive to learning. A side effect of such shortsighted regulations and attitudes is that women tend to hang out and study with other women.

5. The job market in Iran

Discrimination in university admission policies based on sex aside, there is overt bias in employment laws. The country's legal code (particularly sections on marriage, divorce, and women's autonomy) also indirectly affects women's job prospects. As a result, women's unemployment rate has hovered around 20%, to men's 10% [41]. I suspect that the stats are even worse for STEM specialties, but have been unable to find discipline-specific data.

Sociopolitical challenges facing Iranian women are brought to fore in a recent report [42]. The government passes overtly discriminatory employment and other civil laws and when women organize to oppose the unjust laws, they are arrested and imprisoned. There aren't even adequate legal protections against domestic violence.

Government jobs are not readily available to women, as priority is given to married men and then to single men, over married/single women. So, despite the prevalence of non-sanctioned civil unions ("white marriages"), which free women from the control of their husbands in working outside the home, employment obstacles are still in place. Private companies and tech start-ups (Figure 10) absorb a small minority of STEM women, pushing a vast majority into low-skill jobs or careers that are outside their areas of expertise.

Some highly qualified Iranian women in STEM and other fields leave their homeland to seek employment in the West and elsewhere. Not everyone has the opportunity or the financial means to study at elite universities abroad, even on full scholarship, but those who manage to do it invariably achieve impressive levels of success, going for post-doc positions or immediately entering the job market thereafter. As a case in point, Iranian women were vastly over-represented at Rising Stars

Academic Careers Workshop for Women in EECS [43], held at University of Illinois in October 2019 (Figure 11).

As in the US, many STEM graduates in Iran end up working at jobs for which they are highly over-qualified, which leads to lack of professional fulfilment. When women do manage to get a foot in the door, they tend to stay at lower technical and managerial positions, and this is particularly the case in the public sector, where many men consider it below their dignity to be managed or supervised by a woman.

Sexual harassment and other abuses of power are also prevalent in workplaces, to the extent that women try to avoid assuming supervisorial positions, on the rare occasions when opportunities present themselves. Compulsory veil (and dress code, more generally), touched upon in Section 4, is equally problematic in the workplace. Even in the mildest form of a headscarf and manteaux, the "approved" clothing restricts freedom of movement and is very uncomfortable in hot summer months. Iranian women view compulsory veils not as mere inconveniences, but as the most-visible symbols of women's oppression. So, women, and their male allies for gender equality, are fighting it vigorously [44], [45].

Figure 10. Tech start-ups provide the bulk of opportunities for Iranian women graduating in STEM fields, but their capacity is rather limited. The photo shows women participants at a start-up weekend event in Tehran.

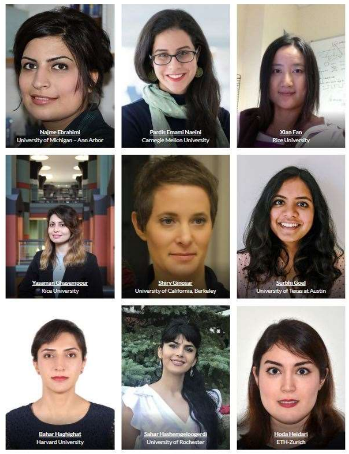

Figure 11. Young women from Iran were over-represented among the participants at a recent Rising Stars Academic Careers Workshop for Women in EECS [43] at University of Illinois.

6. Similarities and differences

The undesirable outcome of women being marginalized in STEM fields is common between Iran and the US, but the underlying reasons are different. Iranian women are under duress to prove themselves. Men who are less qualified, both academically and technically, are hired, while some intelligent and well-prepared women go unemployed or are forced to work outside their fields of expertise. High academic achievement is viewed by Iranian women as a kind of insurance policy to make discrimination less likely, or at least more difficult. However, not all discrimination against women is intentional, as aptly noted by Perez [36], who extensively catalogues the ways in which women are missing from data sets used for planning and decision-making.

Defying family and societal norms, which deem women less capable than men, is another motivating factor for Iranian women. Discriminatory employment laws add to women's challenges, but even without such laws, the cultural view of women as "the weaker sex" would be hard to overcome while old, patriarchal men are still running the country. Ironically, at school, Iranian women are viewed as peers and even looked up to by male students, whereas, in the US, women report that they are harassed during both high-school and college studies.

In a forum [46] about why Iranian women overachieve in STEM fields (the question was actually posed in reverse-sexist terms, “Why are Iranian women much smarter than Iranian men with regard to the STEM fields … ?”) a wide variety of answers are provided, ranging from a desire to achieve independence to gaining an edge in their fight against inequality.

The difficulties enumerated in Section 5 apply to women with a more or less traditional gender role and belonging to the dominant Shi’i religion. Any deviation from these norms heightens the problems. Members of religious minorities, even Sunni Muslims, have to overcome additional, often insurmountable, obstacles in both employment and university admissions. For example, Baha’is are routinely denied college admission or are expelled upon discovery of their faith. When Baha’is organized to teach their youth through what later became known as an “underground university” [47], the institution was banned for promoting an “extremist cult.” For these reasons, emigration is even more common for religious and ethnic minorities or those with nontraditional gender identities [48]. Combined with educated men also leaving the country in record numbers, the resulting brain drain is debilitating [49].

The United States does not have discriminatory laws that systematically preclude women from certain university majors or job categories. Another difference is that US women have quite a few career options available to them outside STEM fields, and some of these options are often viewed as “easier” paths to lucrative jobs. Such options make the difficulties of breaking into STEM fields much less critical, law and healthcare being two examples. Iranian women cannot become judges or assume other prominent positions in the judicial domain. High-level, and thus higher-paying, healthcare jobs are also closed to them.

Another difference between the two countries is the result of an interesting general phenomenon. It has been suggested that societies with greater gender equality tend to have fewer women in STEM [50]. As stated earlier, one reason may be the availability of other options for lucrative careers to women who enjoy greater equality. This is not unrelated to men, too, not pursuing STEM fields when they can become successful through careers in business, law, and the like, or even foregoing higher education and its steep costs (requiring the accrual of significant debt) altogether.

Here is yet another difference. In the US, half of the women who land tech jobs eventually leave the field, compared with less than a quarter for men. Women make up 25% of tech workers but only 11% of the executives [27]. Iranian women have offered significant contributions to tech start-ups within Iran. In diaspora, both Iranian and Arab women have been successful in tech start-ups [51]. This success is quite significant and surprising, given the mismatch of the high-pressure start-up culture to the needs and preferences of women.

7. Conclusion

For at least two decades now, I have been an advocate of women's rights and gender equality. Given this societal interest, it was natural for me to combine it with my teaching and research expertise in computer science and engineering and try to contribute in some way to the discussion of why there is still a dearth of women in CSE educational programs and professions, despite the fact that in the early days of digital computing, women played a prominent role in establishing and advancing the field. Later, I expanded my focus from CSE to science and engineering in general.

Clearly, oppression of women and lack of opportunities for them figure prominently in every field where they are under-represented. In fact, even women's over-representation in certain fields can be attributed to bias and social injustice. But I was curious whether something about the field of computing, and areas of science and technology more generally, contributes to the gender gap. I quickly came to the conclusion that there is absolutely nothing in the nature or contents of STEM fields that can be viewed as a barrier to women's entry and success.

Among social factors that discourage women from pursuing STEM degrees and careers, workplace culture is perhaps the most prominent. I have already alluded to studies that show how culture of tech workplaces in general, and Silicon Valley in particular, is hostile to women [10], [27], [28]. Some companies are trying to remedy the problems, but the efforts are at best ad hoc and unsustainable. Rigid social beliefs, particularly in religious contexts, can serve as inhibiting factors. In the case of Iran, this is somewhat paradoxical, given the high educational attainment of Iranian women in the face of a backward, patriarchal power structure and rampant oppression justified by religious dogma [52].

In the end, the best strategy is to pay attention to the entire pipeline, from high school to graduate school and beyond [53], instead of one-of-a-kind efforts often taking the form of one company stealing female talent from another to improve its diversity stats. Particular attention should be paid to the impact of gender stereotyping on career aspirations of secondary-school students [54]. An important Microsoft study [55] has found that girls across 12 European countries tend to lose interest in STEM fields around the age 15, when their confidence in being able to successfully pursue a career in STEM drops markedly. A similarly comprehensive study of when/why girls lose interest in STEM fields is lacking in the case of the US.

Unfortunately, full gender equality in STEM remains elusive. I have already cited several sources that attribute the gap, at least within the contexts of high-tech and Silicon Valley, to gender discrimination [10], [27], [28]. Alternative views have also been expressed. For example, it has been argued that of the three possible explanations for the current gender gap, that is, (a) differences in mathematical and spatial ability, (b) sex discrimination, and (c) gender differences in interests, preferences, and lifestyle choices, the third one, particularly as it relates to “fertility choices,” is dominant [56]. There is much room for research to reconcile the differing views. An up-to-date assessment of persistent gender gaps in a number of STEM subareas, referred to as PECS (physics, engineering, and computer science), has been offered by Cimpian, Kim, & McDermott [57].

To recap key aspects of the discussions and opinions appearing in the preceding pages, I offer Table 4, in which I have listed my subjective rankings of various factors that help women’s participation and achievement in STEM fields, based on my personal observations and experiences in the US and Iran over a 48-year academic career. I could have listed inhibiting factors, but perhaps accentuating the positive is preferable as well as more intuitive (higher scores reflect greater desirability). The total score should be taken with a grain of salt, as not all factor have the same importance.

Table 4. A comparative summary of factors helping women’s participation/achievement in STEM educational programs and careers (on the subjective scale of 0-10).

Facilitating factor	US	Iran
High school STEM preparation	2	8
Access to higher education	5	9
Motivation and family support	4	7
Cultural/Religious inducement	6	3
Gender-equitable family laws	9	2
Gender-neutral labor laws	9	3
Women-friendly workplaces	3	5
Social/Workplace safety	5	4
Overall facilitation score (out of 80)	43	41

References

[1] H. M. Maceira, "Economic benefits of gender equality in the EU," *Intereconomics*, Vol. 52, pp. 178-183, 2017.

[2] N. D. Pham and A. J. Triantis, A. J., "Reaching the full potential of STEM for women and the US economy," US Chamber of Commerce Foundation, Center for Women in Business, 2015.

[3] Nobel Prize Organization, "Nobel Prizes awarded women," 2018. https://www.nobelprize.org/prizes/lists/nobel-prize-awarded-women

[4] Areppim, "Nobel Prize awards by gender in each category," 2018. Online document. https://stats.areppim.com/stats/stats_nobel_sexxcat.htm

[5] C. Fogolin, "Ten famous women scientists in history," 2019. https://www.pinterest.com/pin/231513855618157866/

[6] R. Ribeiro, "Mothers of technology: 10 women who invented and innovated in tech," BizTech Magazine on-line, 2012. https://biztechmagazine.com/article/2012/05/mothers-technology-10-women-who-invented-and-innovated-tech

[7] International Mathematical Union, "Fields Medal," 2019. https://www.mathunion.org/imu-awards/fields-medal

[8] Association for Computing Machinery, "A. M. Turing Award," 2019. https://amturing.acm.org/

[9] National Academy of Engineering, "List of members," 2019. https://www.nae.edu/19581/MembersSection

[10] L. Mundy, "Why is Silicon Valley so awful to women?" *The Atlantic*, April 2017.

[11] M. L. Shetterly, *Hidden Figures: The American Dream and the Untold Story of the Black Women Mathematicians Who Helped Win the Space Race*, William Morrow, 2016.

[12] H. Lykins, "Men are taking credit for women's work, and now we know why," *TheMQ*, May 2019. https://themq.org/2019/05/articles/news/men-are-taking-credit-for-womens-work-and-now-we-know-why/

[13] B. L. Yoder, "Engineering by the numbers," American Society for Engineering Education report, 2015. https://www.asee.org/papers-and-publications/publications/college-profiles/15EngineeringbytheNumbersPart1.pdf

[14] Catalyst, "Quick take: Women in science, technology, engineering, and mathematics (STEM)," June 2019. https://www.catalyst.org/research/women-in-science-technology-engineering-and-mathematics-stem/

[15] IES National Center for Education Statistics, "Table 318.30: Bachelor's, master's, and doctor's degrees conferred by postsecondary institutions, by sex and discipline, 2014-15," 2015. https://nces.ed.gov/programs/digest/d16/tables/dt16_318.30.asp

[16] Stanford VMware Women's Leadership Innovation Lab, 2019. https://womensleadership.stanford.edu/seedsofchange

[17] C. Frieze and J. L. Quesenberry, "Broadening participation: How computer science at CMU is attracting and retaining women," *Communications of the ACM*, Vol. 62, pp. 23-26, 2019.

[18] S. Zhang, "Fostering a community of women in STEM," November 2018. https://www.seas.harvard.edu/news/2018/11/fostering-community-women-stem

[19] IEEE Women in Engineering (Professional group), 2019. https://wie.ieee.org/

[20] Association for Computing Machinery, Women in Computing (ACM-W), 2019. https://women.acm.org/

[21] Chronicle of Higher Education, "Which colleges are best and worst at enrolling and graduating women in computer science and engineering," February 2019. https://www.chronicle.com/article/Which-Colleges-Are-Best-and/245758

[22] A. Krivkovich, M.-C. Nadeau, K. Robinson, N. Robinson, I. Starikova, and L. Yee, "Women in the workplace," McKinsey & Company report, 2017. https://www.mckinsey.com/featured-insights/gender-equality/women-in-the-workplace-2018

[23] G. Evans, and K. Ryan, "Women hold one in five top science and tech jobs," Thomson-Reuters Foundation report, 2019. https://www.reuters.com/article/us-global-women-science/women-hold-one-in-five-top-science-and-tech-jobs-idUSKCN1VQ2RQ

[24] K. Pretz, "IEEE survey finds that female technologists face unequal treatment and sexist workplaces," *IEEE, The Institute*, May 2019. https://spectrum.ieee.org/the-institute/ieee-news/ieee-survey-finds-that-female-technologists-face-unequal-treatment-and-sexist-workplaces

[25] B. Little, "The first 1940s coders were women—so how did tech bros take over?" August 2018. https://www.history.com/news/coding-used-to-be-a-womans-job-so-it-was-paid-less-and-undervalued

[26] B. Parhami, "Men Advocating for Gender Equity," a group of self-selected UCSB staff and faculty members. https://web.ece.ucsb.edu/~parhami/men_adv_equ.htm

[27] S. Kolhatkar, "The tech industry's gender discrimination problem," *The New Yorker*, November 13, 2017.

[28] Z. Corbyn, "Why sexism is rife in Silicon Valley," *The Guardian*, March 17, 2018.

[29] L. Mundy, *Code Girls: The Untold Story of the American Women Code Breakers of World War II*, Hachette, 2017.

[30] J. Graham and S. Smith, "Gender differences in employment and earnings in science and engineering in the US," *Economics of Education Review*, Vol. 24, pp. 341-354, 2005.

[31] IT Professionals Australia, "Tech's women problem: More than just a pipeline issue," 2019. http://www.professionalsaustralia.org.au/professional-women/wp-content/uploads/sites/48/2019/02/Techs-woman-problem-more-than-just-a-supply-issue.pdf

[32] US National Science Board, "Science and engineering indicators: Chapter 3: Science and engineering labor force," 2018. https://www.nsf.gov/statistics/2018/nsb20181/assets/901/science-and-engineering-labor-force.pdf

[33] A. Hickey, "Systematic gender discrimination costing tech billions," CIO Dive, December 7, 2017.

[34] C. Flaherty, "Gender inequality in science careers and publishing," *Inside Higher Ed*, 2020. https://www.insidehighered.com/quicktakes/2020/02/19/gender-inequality-science-careers-and-publishing

[35] J. Huang, A. J. Gates, R. Sinatra, and A.-L. Barbasi, "Historical comparison of gender inequality in scientific careers across countries and disciplines," *PNAS*, 1914221117, 2020. https://www.pnas.org/content/117/9/4609

[36] C. C. Perez, *Invisible Women: Data Bias in a World Designed for Men*, Harry N. Abrams, 2019.

[37] Financial Tribune, "Iranian women in science & tech," January 24, 2016. https://financialtribune.com/articles/people/34895/iranian-women-in-science-tech

[38] A. Guttman, "Set to take over tech: 70% of Iran's science and engineering students are women," *Forbes*, December 9, 2015. https://www.forbes.com/sites/amyguttman/2015/12/09/set-to-take-over-tech-70-of-irans-science-and-engineering-students-are-women/#5df5f5cc44de

[39] UNESCO, "Sustainable development goals: Iran (Islamic Republic of)," Report, 2019. http://uis.unesco.org/en/country/ir

[40] S. Zahidi, *Fifty Million Rising: The New Generation of Working Women Transforming the Muslim World*, Bold Type Books, 2019.

[41] Human Rights Watch, "It's a men's club: Discrimination against women in Iran's job market," May 25, 2017. https://www.hrw.org/report/2017/05/25/its-mens-club/discrimination-against-women-irans-job-market

[42] Minority Rights Group International and Ceasefire Center for Civilian Rights, "Beyond the veil: Discrimination against women in Iran," September 2019. https://minorityrights.org/wp-content/uploads/2019/09/MRG_CFR_Iran_EN_Sept191.pdf

[43] Rising Stars, "Academic Careers Workshop for Women in EECS," 2019. https://publish.illinois.edu/rising-stars/participants/

[44] S. Ebadi, *Until We Are Free: My Fight for Human Rights in Iran*, Random House, 2016.

[45] K. Laub and M. Nasiri, "Iran women protest mandatory hijabs by going without," *Christian Science Monitor*, July 15, 2019. https://www.csmonitor.com/World/Middle-East/2019/0715/Iran-women-protest-mandatory-hijabs-by-going-without

[46] Quora, "Forum about why Iranian women overachieve in STEM fields," 2018. https://www.quora.com/Why-are-Iranian-women-much-smarter-than-Iranian-men-with-regard-to-the-STEM-fields-in-Iran-70-of-university-graduates-in-science-technology-engineering-and-mathematics-STEM-are-women

[47] A. Shahm, "Iran's secret university for Baha'i: Global and underground," 2017. https://psmag.com/education/irans-secret-university-for-bahai-global-and-underground-43600

[48] Home Office, United Kingdom, "Country policy and information note—Iran: Sexual orientation and gender identity or expression," Version 3, June 2019. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810845/CPIN_-_Iran_-_SOGI_-_v3.0__June_2019__EXT.PDF

[49] Wikipedia, "Human capital flight from Iran," 2019. https://en.wikipedia.org/wiki/Human_capital_flight_from_Iran

[50] O. Khazan, "The more gender equality, the fewer women in STEM," *The Atlantic*. February 18, 2018.

[51] A. H. Koblitz, "Life in the fast lane: Arab women in science and technology," *Bull. Science, Technology, & Society*, Vol. 36, pp. 107-117, 2016.

[52] N. Tohidi, N. (2016). "Women's rights and feminist movements in Iran," *Int'l J. Human Rights*, Vol. 24, pp. 75-90, 2016.

[53] J. Welsh, "These are 7 things keeping women out of science careers," *Business Insider*, October 16, 2013.

[54] E. Makarova, B. Aeschlimann, and W. Herzog, "The gender gap in STEM fields: The impact of the gender stereotype of math and science on secondary students' career aspirations," *Frontiers in Education*, Vol. 4, 10.3389, July 2019. https://www.frontiersin.org/article/10.3389/feduc.2019.00060

[55] S. Choney, "Why do girls lose interest in STEM? New research has some answers—and what we can do about it," Microsoft Features, March 13, 2018. https://news.microsoft.com/features/why-do-girls-lose-interest-in-stem-new-research-has-some-answers-and-what-we-can-do-about-it/

[56] S. J. Ceci and W. M. Williams, "Sex differences in math-intensive fields," *Current Directions in Psychological Science*, Vol. 19, pp. 275-279, 2010.

[57] J. R. Cimpian, T. H. Kim, and Z. T. McDermott, "Understanding persistent gender gaps in STEM," *Science* (Policy Forum), Vol. 368, pp. 1317-1319, June 2020.