Women in Science: Surpassing Subtle and Overt Biases through Intervention Programs

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2 ABSTRACT

3 This study discusses factors that keep women from entering science and technology, which
4 include social stereotypes that they struggle against, lack of maternity leave and other basic
5 human rights, and the climate that makes them leave research positions for administrative ones.
6 We then describe intervention processes that have been successful in bringing the ratio of women
7 close to parity, compare different minorities in the US, and also consider data from India, Western
8 and Eastern Europe. We find that programs that connect the different levels of education are
9 needed in addition to hiring more women, providing them with basic human rights from when they
10 begin their PhD onwards and promoting support networks for existing employees. The authors of
11 this paper hail from Sri Lanka, Romania, India, and the United States. We hold undergraduate
12 and graduate degrees in physics or chemistry from the United States, India and Switzerland.
13 Our conclusions are based on data that is publicly available, on data we have gathered, and on
14 anecdotal evidence from our own experience.

15 **Keywords:** women in science and technology, STEM gender gap, gender parity in STEM, intervention programs promoting science
16 and engineering, stereotypes about scientists, keeping women in science, superdiversity

1 INTRODUCTION

17 Studies show that a child's early interests are not gender specific with females benefiting more from a
18 gender neutral upbringing (Raag, 1999; Shutts et al., 2017). The gender gap in Science, Technology,
19 Engineering and Mathematics (STEM) with a significant male to female ratio is then attributable to societal
20 cues as to what constitutes being male and what constitutes being female. Early on these cues are provided
21 in families by the gender specific roles of the parents, and by the toys and activities boys and girls are
22 encouraged towards. The shaming of girls when they act like "boys", media depiction of males and females,
23 indulgence of boys when they are exploratory and even break things, while letting girls know that such
24 behavior is unacceptable for them leads to building societies where STEM exploration and creativity are
25 considered the man's purview. Any challenge to the status quo results in a reaction that is detrimental to
26 women. Studies find that by the age of 6 girls dissociate their gender from cleverness (Bian et al., 2017,

2018). By the age of 10-11, STEM loses the interest of girls who already believe that a science career is not for them (Archer et al., 2012). By highschool there is a significant gender gap. While girls outnumber boys when it comes to taking Advanced Placement (AP) tests, they are underrepresented in advanced placement in STEM fields other than biology and environmental science. Boys outnumbered girls by more than 4:1 among AP tests in computer science, and by more than 2.5:1 in physics AP and 1.5:1 in calculus (Ericson, 2013).

The gender gap widens in college and graduate school when it becomes common for the women who succeed to stay in science to end up the only ones in their class or research group. The overall fraction of women with STEM degrees flattens at around 35%. The gender ratio varies between the subfields with physics, computer science, and engineering retaining a substantially lower number of women than other fields. The percentage of women who obtain bachelor degrees in physics hovers around 20% since 2005 (American Physical Society, 2015).

A problem that manifests world-wide is that women drop out of science and engineering mid-career. Out of 41% women scientists, engineers and technologists on the lower rungs of the corporate world, 52% of them drop out to switch to less technical fields in their mid to late thirties (Hewlett et al., 2008). In the US in 2017, women held only 24% of STEM jobs even though there were paid 35% more than women in non-STEM jobs and had a smaller gender wage gap than in non-STEM jobs (United States Economics & Statistics Administration, 2017). This leaky pipeline manifests in scientific research: when one averages over 137 countries, the number of women researchers is only 28% (Huyer, 2015). Gender parity occurs at masters and bachelor level, but the pipeline start to turn leaky at the PhD level. The current environment weeds out talented individuals of both genders, who leave their fields wondering what they could have accomplished had the environment been supportive.

Stoet and Geary (2018) find that countries with greater gender equality have fewer women by percentage in STEM than many countries with higher gender inequality. We present some statistics here and later in the paper explore the subtle biases that cause this discrepancy. It is clear that apparent gender equality in every day life does not mean a gender equal STEM culture. Biases add up resulting in lower creativity and productivity of women in STEM fields compared to men and in more women than men leaving their field of expertise (Johnson et al., 2018). Finland has reached gender parity in natural sciences, mathematics and statistics degrees, while retaining a low number of women in Information and Technology (IT) and engineering (Statistics Finland, 2018). Women hold only 16.3% of engineering degrees, and 20% of information and communication technology degrees. The number of women professors in Finland is 24% across all disciplines even though for the last 30 years, 50% to 60% of university graduates have been women. The numbers also vary across disciplines with women in physics comprising 25% of graduates and only 7% of professors (Banzuzi, 2013). In contrast, women in developing countries are better represented. In the 2016-2017 academic year in India, women obtained around 47.6% of science degrees, 42.4% of IT and computer degrees, and 28.4% of engineering and technology degrees (All India Survey on Higher Education, 2017). Of the tenure-track faculty in physics 20% are women, and out of these only 12 women are Fellows of the Indian Academy of Sciences, while there are 197 men (Wired, 2018). In the European Union, women comprise 17 % of the information, communication and technology (ICT) students. Among the member states, Eastern Europe has the highest number of women studying ICT with the highest number of women being in Bulgaria (34.4%) and Romania (29%) that is comparable to India's percentage (EuroStat, 2017). In natural sciences and engineering, the representation of women in India was 11% among full professors (European Platform of Women Scientists, 2015). Thus even in countries with a high number of science graduates, most do not achieve leadership in their fields of expertise.

Intervention programs that focus on attracting talented highschool students to STEM programs in college coupled with a modernization of the course-work were shown to lead to gender parity at college level. The Massachusetts Institute of Technology has successfully brought women's enrollment in its mechanical engineering program to 49.5% (Massachusetts Institute of Technology, 2017). They find that existent women faculty and students attract more women students. It is reasonable to conjecture that with appropriate intervention programs, the hiring of more women can lead to a snow-ball effect, and that allowing for basic human rights like maternity leave is a necessary part of the process. Programs that connect the different levels of education could perhaps, in time, replace standardized tests. These tests are tools introduced since 1940s that were shown to typically fail at predicting success, while keeping women and minorities out of the best schools (Ripin, 1996; Miller and Stassun, 2014).

Scientists who do succeed in obtaining STEM bachelor degrees and choose to stay in science often work in an array of countries. In the training period that can last 15 years or more their rights are restricted by their immigration status. Obtaining a doctorate degree can take five years or more, and the postdoctoral period extends to the mid (and sometimes the late) thirties. Doctoral students and postdoctoral scholars are temporary employees with very limited rights. Scientists who are immigrants have a restricted visa status and do not have the same rights as regular staff during maternity/paternity leave or illnesses. More generous rights to maternity leave and childcare are awarded to women who have tenure-track or permanent positions, but such positions are often reached past the child-bearing years. Since the support net is not there when it is needed, most talent is lost at the end of the PhD or after the first postdoctoral position (Huyer, 2015). Some women transition to administrative positions inside the academia, and many quit while believing they were not good enough to succeed, which is an attitude that is not conducive to maximize success elsewhere.

Unfortunately, the low numbers of women in STEM in the western world are still used as an argument against allocating funds to provide daycare on campus, maternity leave, sick leave and other basic human rights for PhD students and researchers. Since most women leave their field of expertise in their mid and late thirties, it is likely that the lack of basic human rights does play a role along with the toxic attitude that is naturally exhibited towards minorities. While women and minorities in the western world choose to stay out of STEM fields whenever they are able to do so because of toxic environment, the inclusion of women should never be presented as a choice between diversity and greatness. It has been shown that collaborations are fully empowered only when there is enough diversity to prevent grouping based on prejudices (Page, 2007), which abuse minorities. This ensures social coherence.

To avoid losing our best and most talented individuals mid-career, employers have to encourage a healthy balance between work and family life where paid maternity/paternity leave, egg freezing, sick leave, child and elderly-care are available for all employees independent of nationality, visa status or gender. Today, instead of ensuring all employees have basic human rights, the blame is shifted from the inadequate policies that can and should be changed to the employees, who are accused of not being assertive enough or even worse of daring to "want it all". This culture of blame has devastating consequences for women and minorities, and particularly young mothers who are more vulnerable to depression and self-blame. Instead of finding more reasons for blaming them, we ought to focus on changing rules to help them stay in their field of expertise.

The final goal of society should be to have as many people as possible choosing what they would like to pursue and to be productive and innovative in their chosen fields. No one should be stymied in their endeavors because they have to cater to ordained repressive societal norms. A change in attitudes will only come when a sizeable number of women make the leap. This requires an understanding of the current conditions and support of innovative intervention strategies.

Unlike modeling, sport and acting, science is still presented in abstract, uninteresting ways that have not changed for centuries. Traditionally, scientists are portrayed as crazy, dysfunctional men who manage to make use of random numbers, strange objects and outdated materials, while the life of actors and models is seen as glamorous and desirable; yet it has its own problems and stories of abuse. This portrayal together with other choices made for children starting in early childhood discourages girls and most minorities from all countries and cultures from understanding science and engineering. We advocate gender neutral toys, and the exposure of all children to science from the very beginning. Science can be part of bed-time stories, and part of the curriculum starting in kindergarten and pre-school. Girls and boys should be taught to use their natural curiosity and some of the knowledge accumulated from other people to understand how the world works. It was shown that through intervention programs parity can be achieved even at schools that are highly technical like the Massachusetts Institute of Technology. Furthermore, the degree obtained, whether it is a BA/BS, MA/MS or PhD, should not be seen as an end at which point all interest in the student is lost, but as a new beginning where investment is made towards a smooth transition to the next level.

The authors of this paper hail from Sri Lanka, Romania, India, and the United States with formative education in these countries. All have undergraduate and graduate degrees in physics or chemistry from the United States, Switzerland, and India. This paper discusses gender balance in STEM fields across cultures. The authors studied, taught and performed research at Cornell University, Massachusetts Institute of Technology, Washington University in St Louis, Harris-Stowe State University, Mount Holyoke College, the University of Illinois at Urbana-Champaign, Pennsylvania State University, the University of Zürich, Caltech, the Jet Propulsion Laboratory, the South Pole Telescope, IBM and SpaceX. The conclusions of this manuscript are based on personal experiences, and on data gathered by us/for us and cited references.

2 A FIRST PROBLEM: THE ATTITUDE TOWARDS GIRLS AND WOMEN

In most cultures, a woman gets positive reinforcement from an early age only when being passive and nurturing. Her curiosity, analytic mind and ability to take things apart and put them back together are not rewarded the same way. If one goes to a toys store, there are clear indicators that certain toys are for boys, and certain other articles are for girls. From labels to colors one is informed what is for boys and what is for girls. Construction and mechano-spatial toys, trucks, cars all scream “boy”. T-shirts that encourage leadership roles are generally in the boys sector. Only boys can aspire to be batman, superman or spiderman. Girls are mostly expected to dress in frilly and revealing clothes and aspire to be saved by, or if they are extremely lucky, marry the superheroes (Graff et al., 2012). This stereotyping is encouraged by movies (Bleakley et al., 2012), and books (Hamilton et al., 2006), and by the larger society as well. It makes children feel unfit if they are attracted to articles from another category. Ideally, toys should be without a gender assigned to them so that parents can let children decide where their interests lie. The stereotyping goes beyond toys. Boys often deconstruct gadgets, reconstruct them, sometimes incorrectly and even break them. This behavior actually helps them learn and explore and is vital to the growth of STEM skills. Such behavior by a girl will often be discouraged. She will be admonished and will learn to stop these explorations as inappropriate. This continues in school, college and beyond.

The conjecture that attitude and not aptitude is causing the gender gap has been validated by various studies (Penner, 2015; Leslie et al., 2015), but no steps have been taken to change the attitude. From clothes to toys, science and leadership are still sold as a boy-man-interest. Some gender specific books have appeared that recount the adventures and successes of women, but they are by far not enough to change such fundamental stereotypes.

157 Instead of continuing to promote a culture of blame that tells women of all ages that they have not
158 succeed because they are lacking, they are not brave enough and not strong enough, we could make
159 changes. Stores could label most products without assuming a gender. Children products could come
160 with recommendations based on age, size and interests exhibited by the child to allow them to pick in an
161 unbiased manner. Similarly, starting in pre-school all children could be exposed to a variety of science
162 books and experiments, while allowing them to lead towards more depth through asking questions.

163 More intervention programs that link schools and graduate schools are needed. Such programs could
164 encourage graduate students in universities around the world to go beyond being research tools, and spend
165 some time explaining science to the next generations. This is currently done in one-day workshops that
166 include Expanding Your Horizons Program at Cornell University (2018), and Astrofest at Pennsylvania
167 State University (2018). These workshops have proven to be extremely successful, and could be expanded
168 to semester long programs that expose children to science.

169 In addition, women must be made aware that the lack of female role models in STEM and other fields is
170 not because of incompetence but because of a restrictive history. Men have had a much longer history of
171 exploring their passions and interests, of being able to have a say in how life has to be lived, how science
172 is presented, and in being able to vote than women. There was a time when, in the US, women were
173 barred from certain work post marriage (Rindfuss et al., 1996). Women's suffrage happened as late as 1920.
174 Women authors had to write under male names (e.g., George Eliot) because women were not allowed to
175 publish. Such restrictions made it hard for women who were competent to grow and reach their potential.
176 In general it is not just men who prevent women from succeeding. Women who maintain the status quo are
177 lauded by society and also restrict women who think differently.

178 During wars, injured men needed care and many women were conscripted into nursing. This history
179 has led the way to women being better represented in biology and health care fields than in other STEM
180 areas. Women must be made aware of their own role in encouraging the success of other women, not
181 underestimating women, and in exploring different ways to promote knowledge for different learning styles.
182 Additionally men must be made aware of the advantages of history that have contributed to their success so
183 that they also become enablers of success independent of sex, color or nationality.

184 Figure 1a) shows the distribution of the US population of ages 18-64 in terms of race and gender, while
185 Figure 1b) shows the distribution within science and engineering. The data is taken from Guterl (2014). In
186 this segment of the US population, white males are 32% of the population, while making up 51% of the
187 STEM workforce. Black females are 6.5% of the population and only 2% of the STEM workforce. White
188 females are 32% of population, and also under-represented at 18% of the STEM workforce. The same
189 trend is observed for Hispanic women. On the other hand, Asian females comprise 2.7% of the working
190 population and 5% of the STEM workforce, and Asian males are 2.4% of the population, which is a similar
191 fraction of the population as Asian females. They, however, make up 13% of the STEM workforce (Guterl,
192 2014). So, while in the US people of Asian origin are overall more likely to enter the STEM workforce
193 than white people, the push towards STEM is more effective in the male population than in the female
194 population. This data shows that Asian men are almost three times more likely than Asian women to join
195 the STEM workforce. However, the push towards STEM irrespective of the toxicity of the environment,
196 while raising the average STEM competence, suppresses higher end creativity and innovation (Nager et al.,
197 2016).

198 In developing countries, STEM education is seen as a sure path to a reasonable income. Families then
199 pressure both men and women to succeed in these fields irrespective of other environmental factors. Under

Figure 1. a) US population in 18-64 age group and b) STEM population in the same age group. It can be seen that the percentage of women is always comparable to that of men in the general population, but the STEM population is overwhelmingly male even for Asian minorities where both gender are pressured towards science and engineering. The data is from Guterl, F, 2014.

pressure, those factors can become something one has to deal with. The primary and secondary education is focused to this end. This idea is reinforced through school uniforms and standard classroom curricula. Although the society still has a clear bias that favors men, more women make it into STEM fields. A recent study (Escueta et al., 2013) found that while women in India experience no bias in school, they experience bias in the larger society. They also hypothesize that there may be biases that are ignored by women, but that this is unlikely. The lack of overt biases may reflect a change in attitude from when one of the authors (J.B.) attended school in India when engineering and technology were considered to be 'smart fields' with boys being suited for these fields. These attitudes are highlighted in the section where the authors discuss their personal experiences later in the paper. Nevertheless, the pressure on boys to learn lucrative skills like computer science and engineering independent of their inclination is higher than on women because they are seen as the supporters of the family. They react to this pressure through increased competitiveness and attempts to eliminate any competition, which makes it more difficult for girls and other minorities to fit in. The pressure to conform to femininity standards and be perceived as non-aggressive shapes women's behavior and makes them leave STEM positions and avoid leadership roles.

For every 200 students getting degrees in India and the US, 52 Indians and 26 US residents obtain STEM degrees. Of these students, in India, 32 will be male and about 18 female (male:female ratio of 2:1), while in the US, 21 will be male and 5 female (4:1 ratio) (Katsomitros, 2013). We conjecture that the pressure to

217 be in STEM in developing countries is from families understanding the job market and having a major role
218 in their children's decisions and is not correlated to how comfortable women feel in the field. In the U.S.
219 the career decision comes from individuals who seek out their comfort zones based on the cues they get
220 and from how their aspirations project on the social environment around them. In attitude studies women
221 in both countries women expressed lower confidence, less assertiveness, and the unlikelihood of expressing
222 an answer for fear of being wrong (Yardi et al., 2017).

223 A lot of learning happens through making mistakes and then reworking through and correcting them.
224 People and societies have been more indulgent to males being exploratory and breaking objects before
225 fixing them. Women are thus more diffident in exploring because they feel they will be chastised if they
226 do not obtain the right answer on the first try. This attitude results in a significant gap in confidence
227 between women and men. If women are rejected by an employer, they are 1.5 times less likely than men
228 to apply to another job opening by the same employer (Brands and Fernandez-Mateo, 2017). Women are
229 generally better at group work because of their attitudes of consideration (Yardi et al., 2017). However, if
230 the group dynamic is such that the women and men take only the men in the group seriously, it has serious
231 consequences for the creative expressions of women.

232 The expectation that men do more valuable work than women, and hence are more valuable for the society
233 is far-reaching and goes beyond STEM statistics. In India and China, the sex ratio is skewed towards men,
234 and is still increasing (Central Statistics Office, Government of India, 2017; Hesketh et al., 2011). Parents
235 want fewer children while ensuring there is a son.

236 In Eastern Europe, the ratio of males to females is closer to parity in STEM fields. The Information and
237 Technology workforce is about 27% female in Bulgaria and Romania (Commission, 2017). However, the
238 attitude that women should place men first and be able to do all the house-work still prevails. Females are
239 often expected to be emphatic at work while listening to jokes about beautiful secretaries, shop for office
240 supplies, clean and make coffee at the office, and be the party that buys the necessary things at home from
241 their income alone, while the man of the house enjoys his at a bar. Yet the subtle message that women
242 and minorities are not suited for STEM appears to be more effective in cultures where women are free to
243 choose a non-toxic career in which the employees can be comfortable.

244 Cultures with group dynamics react differently to the same pressures than cultures which are more
245 individualistic. In the former, the family pressures to succeed in these fields irrespective of other
246 environmental factors makes those factors something to deal with. However, the existence of such factors
247 in the first place, creates an intimidating atmosphere that can kill creativity and innovation. In 2017 90.8%
248 of U.S. patents were granted to men versus 9.2% to women. The numbers of patents granted to women is
249 still very low even though a positive grow trend of about 18% is reported: the percentage went up from
250 7.8% to 9.2% in the past 10 years (Stembridge, 2018).

3 INCREASING PERFORMANCE AND DECREASING ABUSE THROUGH SUPERDIVERSITY

251 Minorities stand out, which makes them more prone to abuse by colleagues and/or supervisors. Since they
252 are different, their interests and abilities, and even the way they dress and the way they behave will be
253 noticed and judged. This scrutiny adds additional pressure to fields where very few succeed and pushes out
254 the few who almost make it to the very top of their professions. Any potential abuse is further facilitated
255 by immigration status and by the very limited set of rights provided by universities for their temporary
256 employees, i.e., their graduate students and postdoctoral scholars.

257 A gender equal society encourages innovation. French (11.7%) and Russian (15.7%) female inventors are
258 a long way ahead of Japanese (3.7%), Korean (4.4%) and German (5.5%) female inventors. British (7.3%)
259 and American (8.7%) female inventors are relatively close to the worldwide average of 7.2% (Nager et al.,
260 2016).

261 Immigrants comprise a large and vital component of U.S. innovation: 35.5% of U.S. innovators were
262 born outside the United States. Another 10% of innovators have at least one parent born abroad. Over
263 17% of innovators are not U.S. citizens, and are nonetheless making invaluable contributions to U.S.
264 innovation (Nager et al., 2016). Immigrants born in Europe or Asia are over five times more likely to have
265 created an innovation in America than the average native-born U.S. citizen. Immigrant innovators are also
266 better educated on average than native-born innovators, with over two-thirds holding doctorates in STEM
267 subjects (Nager et al., 2016). In part, this may be because there is often a selection process for foreign-born
268 innovators where the ones with the most talent (and perhaps most motivation) choose to come to America
269 because of the significant opportunities this country promises for innovators.

270 Women represent only 12% of U.S. innovators. This constitutes a smaller percentage than the female
271 share of undergraduate degree recipients in STEM fields, STEM Ph.D. students, and working scientists
272 and engineers. The average male born in the United States is nine times more likely to contribute to
273 an innovation than the average female. The United States is therefore missing an enormous potential
274 source of innovation by not creating a gender equal society. Even at this low level, however, the United
275 States outperforms Europe. U.S.-born minorities (including Asians, African Americans, Hispanics, Native
276 Americans, and other ethnicities) make up just 8% of U.S.-born innovators. However, these groups total
277 32% of the total U.S.-born population. Despite comprising 13 % of the native-born population of the United
278 States, African Americans comprise just half a percent of U.S.-born innovators (Nager et al., 2016). Here,
279 too, is an untapped resource of great promise.

280 Since many women in science are immigrants with limited visa statuses and human rights, they can more
281 easily become trapped in abusive relationships with their co-workers and academic advisors (or principal
282 investigators). Most subfields have small communities where it can be very difficult to impossible to escape
283 abusers without quitting the field. If they cannot graduate and find a job, which is already challenging with
284 the full support of one's supervisor, an immigrant has to leave the country in shame. This adds pressure
285 and discourages students from seeking help. When they do seek help, they find that complaints (e.g., Title
286 IX) are worded in ways that ensure anonymity for the institution and the abuser while providing little help
287 or protection for the persons being abused.

288 Studies find progress is optimal when a super-diversity is maintained, where the teams are not dominated
289 by a single gender or by one or two national identities (Page, 2007). They suggest we limit our achievements
290 by limiting diversity. Europe has a strong culture of promoting its own nationals that is partly justified
291 through language barriers. On the other hand, the US, as a new country, included people with a wide range
292 of national identities and upbringings. Until recently, its openness attracted a diverse scientific community.
293 As a consequence, it still holds the most productive scientific community that exists today. However, the
294 low number of women and minorities, emphasize that the community is not as diverse as it could be,
295 and thus does not maximize creativity. The need for superdiversity has yet to be embraced by scientific
296 communities across the world.

297 In order to build a gender equal society that taps into the potential offered not just by white men, but
298 also by women, people of color, and other minorities, people should be celebrated and appreciated for
299 their difference in thinking. Typical traits that are today recognized as being feminine such as empathy and

300 compassion need to be recognized as core values in the corporate culture, and not presented as weaknesses.
301 The ability to nurture a culture of compassion, connect on a personal level and coach people needs to be
302 rewarded to enable and retain not only women, but the best and most talented professionals. Work-place
303 approaches that have proved effective in reducing gender bias include (1) gender bias training for all
304 employees, (2) regular round tables with senior women engineers who provide role models for younger
305 women, and (3) special assignments where women can continue to learn new skills while working with
306 mentors outside of their sub-group.

4 ADMISSION AND RETENTION IN GRADUATE SCHOOL

307 Admissions rely on standardized tests to select their students and top universities boast very high scores.
308 Studies have shown that performance in graduate school is correlated with GPA and with the ability to
309 communicate and interact. The standardized tests, introduced since the 1940s as admission requirements,
310 were found to be better predictors of gender and color than professional success (Ripin, 1996; Miller
311 and Stassun, 2014). These tests play a major role in increasing the gender gap by keeping women and
312 minorities out of top schools. Some graduate schools do not require standardized tests, but recommend
313 them. However, test scores are still the primary basis for evaluating students who are chosen for college and
314 graduate school because they allow for fast comparisons of students of different backgrounds. Programs
315 such as the Fisk-Vanderbilt (Miller and Stassun, 2014), which offer a master that acts as a bridge to the
316 PhD, employ a 30-minute interview instead of a Graduate Record Examinations (GRE) cut-off. It proved
317 to be very successful with a high retention rate of women and minorities of over 80% towards the PhD.

318 Since the late 1990s, Cornell University has opted against applying a GRE cut-off when selecting graduate
319 students in physics and astronomy. If the student has outstanding GPA and research credentials, low test
320 scores are ignored. Cornell even accepts some men and women with GRE subject test percentiles under
321 50%. In the past, these students did well in their coursework, passed qualifying exams, and graduated
322 without problems. However, most Cornellians have high GRE scores. For their incoming class of 2018
323 in physics, the average percentile for the Physics GRE Subject Test as reported by students to the school
324 is 78% for the 5 women who matriculated, and 82% for the 24 men. The students who reported their
325 nationality were either White/Caucasian or Asian American. The number of students who matriculated
326 with GRE subject test scores under 65% is 4 or about 14% of the incoming class. The lowest Physics GRE
327 Subject Test score reported by a student was 42%, and is held by a young men who comes from an ivy
328 league school and has had a GPA of 3.92. The incoming class has average GRE General Test percentile of
329 90% and 83% for the quantitative and analytic section, respectively. Our brief analysis shows that while
330 one can get away with low GRE scores if they have other outstanding credentials, this is not the norm at
331 Cornell, and that the GREs are still an important part of the selection process.

332 In terms of gender ratio, out of the students offered admissions in 2018 in physics 23% were women.
333 Fewer women accepted than men, and so the incoming class of 2018 in the physics department is 17%
334 women (data provided by the Cornell Physics Department). This is comparable to the average number of
335 women obtaining PhDs in physics in the US, which is around 20% (American Physical Society, 2015).
336 While these numbers are still low, Cornell has a high retention rate relative to other universities. We looked
337 at data starting 1993, and found that between 1993 and 2011, the Cornell physics program graduated 54
338 women PhDs out of 74. This means that 73% of women graduated with a PhD from this ivy league school,
339 when the average graduation rate for graduate students was reported by the National Science Foundation
340 (NSF) to be 59% in 2008. The high attrition rate is due to the supportive environment. Roles models
341 also play a role. The physics department has 8 women faculty (amounting to 15% of the faculty body).

In 2010, only about 15% of PhD physics departments had 5 or more women faculty members, 47% of bachelor's-granting departments and 8% of PhD physics departments had no women at all (Ivie et al., 2013). In addition, Cornell hosts about 4-5 women speakers per semester in their physics colloquium. They also encourage women graduate students in proposing and inviting women speakers of their choice, and in meeting with the speaker for informal conversations over lunch and/or dinner.

In the past decade, the physics department at Cornell admitted an average of 4.7 women/year, and in the decade before that 4.8 women/year. Thus, Cornell data is consistent with the global trend for the advancement of women in science in that physics will not reach parity or increase the number of minority students unless admissions procedures are changed dramatically. In the US, the number of women obtaining bachelor degrees in physics hovers around 20% since 2005. While retaining as many women from this pool as possible is important, it is not sufficient. An option to increase the number of women enrolled, would be to advertise graduate programs and increase the applicant pool from countries where more women obtain STEM degrees, which include Eastern Europe and Asia. In the long term, attracting more children to science is needed. Graduate students love science and could be the best resource for teaching it to the next generation. If each graduate school had a requirement that its graduate students work with school teachers and teach for a semester at a school in the area, more children would be exposed to science and perhaps be molded into future PhDs. Invariably, teaching in schools would be promoted as a viable career choice, and not be looked down upon as some kind of work that only those who fail to become university professors do. In addition, more universities could have programs where talented highschool students take classes and are part of laboratories for a semester or a summer. Participation in such programs could be offered for free to talented women and minorities. Such a program was proven to work by MIT's Mechanical Engineering Department.

The number of women in tenured professor positions is still very low with some departments having a single woman faculty member and some having no women at all. In industry, the percentage of women-headed ventures flattened at 17% in 2012 (Teare, 2017), and has seen no growth since. These low numbers emphasize the need to (1) invest in intervention programs that work (2) hire more women to increase the number of women mentors and potentially induce a snow ball effect that attracts more women, and (3) to build support networks that connect existing students and faculty (a) among themselves and (b) to the next generations. Universities could work closely with schools to expose more students to STEM and with companies to make a smoother transition for their graduates, while providing support and basic human rights to ensure more women become leaders, mentors and faculty and increasing the number of women faculty and permanent staff. Since only a few percent of PhD holders become professors or permanent staff (Larson et al., 2014), it is important to stop seeing the degree as the ultimate goal that in itself insures success and invest more in connecting STEM graduates with potential employers via workshops on campus and through summer and semester-long programs. This is currently done only in certain experimental fields where the expertise obtained in graduate school is directly relevant for acquiring patents while theorists and other experimentalists fend for themselves.

5 INTERVENTION PROGRAMS AND SINGLE SEX EDUCATION: PART OF THE SOLUTION

It is clear that intervention programs that address the gender gap do work. In the US in the 1990s boys outnumbered girls in science and math classes in high school, but the numbers have evened out and in some cases girls outnumber the boys (Jones, 2017). According to this study intervention programs like A AUW, the Girl Scouts, Girls Inc., Tech Bridge and Girls Who Code, that offered after school STEM

383 programs and scholarships for girls were a big part of why this change occurred. This clearly shows that
384 the gender gap is not due to innate abilities of men versus women in these fields.

385 The pathway to interest in any field is often through activities one grows up doing. A study of video
386 games mentions that despite an increase in female characters, games still depict them often in secondary
387 roles and sexualized them much more than their male counterparts (Lynch et al., 2016). Stereotyping
388 of roles starts with children's toys with clearly defined gender roles inherent in them. These have to be
389 removed to allow children to choose the roles they play. Shops, games and shows have to portray women
390 and girls as valuable assets of the society, and not as sexual objects. Furthermore, the role of the media,
391 which is led by educated individuals, should not contribute to the objectification of women and should not
392 pressure women to conform to some fake ideals.

393 While early learning of girls has to be more supportive to toughen them up to stand up to the rigors of
394 male dominated fields, there is a need to remove at least some of the toxicity of the STEM environment.
395 Women and minority students should be and can be taught to take risks, make mistakes and be bold similar
396 to how boys are typically encouraged. For this, mentoring has to happen from kindergarten age onwards
397 and continue to evolve with age. The love of learning and the growing of skills needs to be a continuous
398 focus especially post-graduate school. Though attaining the PhD may seem as the end goal, it is just the
399 beginning of a professional STEM career.

400 The percentage of women in physics, engineering and computer science in many universities is still of
401 the order 20% or under. This means the women attempting to make it will likely be the only female in their
402 research group, and sometimes the only woman in the class, which increases their vulnerability to abuse.
403 Women in science are more likely to be in medicine and biology rather than physics and engineering fields.
404 Male students are more likely than female students to take engineering (3% versus 1%) and computer
405 science courses (7% versus 4%) and are enrolled in AP computer science at much higher rates (81% males;
406 19% females) (National Girls Collaborative Project, 2016).

407 The larger number of girls in science and math classes has so far failed to lead to an increased female
408 STEM enrollment in college. This emphasizes the need for intervention programs that connect highschool
409 students to colleges, and of more women faculty, graduate and undergraduate students to whom highschool
410 and college students can relate, see them as proof of success and as role models. Such programs were
411 proven to work.

412 In a climate where women receive 19.5% of bachelor degrees in engineering and only 7.9% of mechanical
413 engineers are women, the Massachusetts Institute of Technology (MIT) succeeded to attract 49.5% women
414 in 2017 to its mechanical engineering program. Fig. 2 shows the percentage of women in a sample of 12
415 physics courses and 9 mechanical engineering courses from MIT. The data is taken from the interactive map
416 available online Huang et al. (2017). From the figure, it can be seen that mechanical engineering department
417 went from under 30% women in 1996 to almost-gender balanced classes. In physics, in the sample of
418 courses we considered, gender parity is only reached in the first two introductory courses. The rest of the
419 courses held a mean of 20% women in 1996 and 22% women in 2016. In mechanical engineering, in 1996,
420 the mean over the courses considered, was 26% women. The situation has improved dramatically by 2016.
421 After successful intervention programs that increased the number of women admitted and modernization
422 of the curriculum, the same courses have a mean of 43% women. It is notable that the number of male
423 students that enroll in the courses has increased as well.

424 Gender parity was achieved through deliberate structural changes of the department that included (1)
425 stimulating talented women to apply to MIT through on-campus visits and intervention programs like the

426 Women's Technology Program (WTP), where talented highschool students live on campus and participate
427 in classes and laboratories for an entire summer, (2) increasing diversity through the hiring of more women
428 faculty, and (3) modernizing the curriculum in both content and pedagogy (Huang et al., 2017; Xu et al.,
429 2017). The latter part should not be overlooked. Courses can no longer push students to simply acquire
430 information that can already be found on the Internet. They need to instead focus on teaching students to
431 understand and use available data and tools. The presence of women faculty was shown to play a crucial
432 role in attracting other young women to the department who saw them not just as role models, but as a
433 proof that success and a stable job can be attained in the field as a woman (Xu et al., 2017).

434 Another tool are student blogs that show that the campus is no longer predominantly male and that
435 women can thrive at MIT (Xu et al., 2017). They promote their experience through social media, which
436 attracts more students from the next generations. Students participating in laboratories and classes on
437 campus took the social media by storm when they shared selfies of the experience that lead to the hash tag
438 #ILookLikeAnEngineer. They even proposed a reality in which women scientists are revered as much as
439 actors and athletes (Huang et al., 2017).

440 Another resource are single sex high schools or women's colleges for undergraduate studies. They can
441 substantially help women pursue and command STEM fields. In the absence of boys/men, the focus is
442 purely on women's capabilities and not contrasted against the opposite sex. Especially in cultures where
443 boys are regarded as more valuable from a young age, having single sex schools can help to mitigate that
444 effect in women's daily lives. Though girls grow up with the added burden of having to be more pleasing in
445 terms of physical beauty and subservient in attitude, they learn to be certain of their aptitude in academics
446 due to single sex education. It also provides an environment for girls to be mentored and recognized in the
447 absence of boys which can have a lasting effect as they grow into young women.

448 Mount Holyoke is the first of the seven sister colleges to be established in 1837 when Ivy league colleges
449 were male only and still continues its mission for leading the way for women in STEM. From 1966 to 2004,
450 according to the NSF's Survey of Earned Doctorates, Mount Holyoke graduated more women than any
451 other liberal arts college who went on to get U.S. doctorates in the physical and life sciences (356 and 109,
452 respectively). This puts Mount Holyoke in the top 2 percent of all colleges and universities—even major
453 research universities with at least double the enrollment and faculty. Among all colleges and universities,
454 Mount Holyoke ranks eighth (tied with Stanford and Wellesley) in the number of graduates who earned U.S.
455 doctorates in physics from 1966 to 2004; ninth in chemistry; and sixteenth in biology. Mount Holyoke also
456 leads with its commitment to minorities. From 2000 to 2004, Mount Holyoke produced more international
457 (non-U.S. citizen) female graduates who went on to receive U.S. doctorates in the physical and life sciences
458 than any other college or university. Twenty-three MHC alumnae received U.S. doctorates in life or physical
459 sciences, compared with 21 women from the University of California-Berkeley, 19 from Harvard, and 17
460 from the Massachusetts Institute of Technology. Among those 23 Mount Holyoke alumnae who went on to
461 receive U.S. doctorates in life and physical sciences from 2000 to 2004, 22 of them are minority women,
462 the highest number along tier 1 liberal arts colleges in the United States (Mount Holyoke College Data,
463 2018).

464 Similar to women's only colleges, the role of Historically Black Colleges (HBCUs) is to reduce the
465 isolation of minorities in Predominantly White Institutions (PWIs) (Reid, 2012). In polls on HBCUs versus
466 PWIs, it is clear that black students on an average felt better supported in HBCUs than in PWIs. Seymour
467 and Ray (2015) reports that 29 % of black graduates who did not attend an HBCU said they were "thriving
468 in financial well-being," and 51 % of black HBCU graduates reported doing so. Most HBCUs reach gender
469 parity in STEM courses and in some female enrollment exceeds male enrollment (Simms, 2014). The lack

Figure 2. The percentage of women at MIT in a sample of a) Physics b) Mechanical Engineering courses. In physics, parity is only reached in the first two introductory courses, while the rest of the courses held a mean of 20% women in 1996 and 22% women in 2016. In mechanical engineering, in 1996 the mean was 26% women, but in 2016, after a successful intervention program and after a modernization of the curriculum, the same courses have a mean of 43% women.

of male students is connected with the hardships they endure while living in underserved communities (Cuyjet, 1997; White and Cones III, 2013). Black people of both genders have a longer history of exclusion than white women (Hine, 1997).

Unfortunately, even within women-only colleges and HBCUs fields that are associated with being “smart” have less representation than fields associated with “perseverance”. In Mount Holyoke College, the Physics department (5 faculty in physics, and 2 in astronomy) is clearly smaller than biology (13 full time faculty and 2 visiting lecturers). Wellesley also has far more students in biological sciences than in physics (Wellesley College Fact Book, 2017). Some HBCUs have comparable biology and physics departments, but most do not, e.g., Morehouse College is a male liberal arts college with 12 biology faculty and 10 physics and engineering faculty, while Xavier University has 12 biology faculty and 5 physics full time faculty. Another issue is that, in many colleges, a significant fraction of the teaching is done by adjunct professors who are underpaid and have fewer rights than full professors.

482 Studies say girls disassociate their gender from smartness from a very early age (Bian et al., 2018).
483 Minority students who are also targeted by negative stereotypes do the same. This is disturbing on multiple
484 scales since not only does it keep talent from certain fields, it also makes people not trust themselves and
485 stops them from reaching their potential. They end up not believing in their own strength and creativity,
486 which leads to less innovation and a lack of belief in the smartness of other women/minorities.

6 MOTHERS IN SCIENCE CHALLENGE THE MATERNAL WALL

487 The subtle pressure in STEM is to dedicate one's life to work, and to feel guilty when taking time away
488 from what's considered to be one's life-long passion. This leads to postponing having a family sometimes
489 indefinitely. When such pressures are defied, it can be assumed that the person will quit the field sooner
490 or later unless they are already established and that they cease to be a worth-while time investment. The
491 same can happen when an illness appears. So, if the decision to have a child is made, the tendency is to
492 hide the pregnancy for as long as possible, and to avoid mentioning it until after a job offer is made when
493 applying for jobs. The child will then be planned between jobs or assignments if at all possible so that the
494 pregnancy does not show on one's CV. Beyond this, the prevalent attitude is that funding maternity leave
495 and providing adequate day-care will not increase the number of women in the STEM workforce. It is
496 accepted that maternity leave and day-care on campus should, in theory, exist and be available, but also
497 that there is no need to hurry and make any changes when such services are not available because changes
498 that lead to providing mothers in academia or industry with adequate support will not matter. This attitude,
499 while far too common, it is, of course, faulty and endangers lives.

500 While exchanging work duties with colleagues and planning children in vacations may be possible, it
501 should not be the norm. Studies find paid maternity leave is not a luxury. It is a basic human right that can
502 be life saving for both mother and child. The lack of antenatal leave has been associated with a three-fold
503 increase in the risk of pre-term delivery and has been observed to have similar effects on the birth-weight
504 as smoking during pregnancy (Cerón-Mireles et al., 1996; Del Bono et al., 2012). Mothers who take
505 short leaves are up to four times less likely to initiate breastfeeding when compared to those who do not
506 work (Huang and Yang, 2015; Baker and Milligan, 2008). Paid leave for mothers is linked to increased
507 breast-feeding rate and returning to work is cited as the top reason for breast-feeding cessation (Schwartz
508 et al., 2002). The American Academy of Pediatrics says infants not breastfed face more than 3.5 times the
509 odds of Sudden Infant Death Syndrome (SIDS) mortality when compared to exclusively breastfed babies
510 (Eidelman, 2012). Furthermore, paid leave has long-term benefits that go beyond survival of the child, and
511 benefit the child's long-term development and leads to higher achievements (Berger et al., 2005; Carneiro
512 et al., 2015). It is noteworthy that paternity leave is linked to an array of long-term benefits as well (Huerta
513 et al., 2013).

514 Many scientists are immigrants for at least some part of their career and thus not eligible for standard
515 maternity leave and child-care support offered to citizens, which puts them in a particularly vulnerable
516 situation even in countries where such leaves are the norm. They have to rely then on company/university-
517 specific policies that also provide full support only for permanent employees. Graduate students and
518 postdoctoral scholars are temporary employees with limited rights that end with their contracts. Yet
519 graduate school lasts an average six years in the US and four years in Europe. The postdoctoral period
520 can still last ten years. This system leaves men and women in their twenties and thirties unprotected for
521 maternity, paternity or illness. In companies, when policies for paternity and maternity leave exist, their
522 applicability depends on the project the person works on with successful employees that are difficult or
523 impossible to replace being constraint to have less time off.

524 In the academia, most universities offer no adequate support system for mothers to be until they become
525 professors, which often happens in their forties. At that time it can be too late to start a family. Even for
526 permanent staff, maternity leave can be complicated to attain e.g., at Penn State University maternity leave
527 is comprised of gathering sick day leaves. Furthermore, waiting to provide support until the position is
528 tenured or tenure-track gives the message that one has to postpone having a family, and often choose
529 between attempting to have a career that is likely to not work out and having a family, which adds to
530 the toxicity of the environment. For students and postdoctoral scholars, the work schedule is flexible and
531 an understanding advisor will try to navigate the system to help their postdoctoral scholars and graduate
532 students take advantage of various workarounds. Unfortunately, the attitude towards maternity coupled
533 to the lack of supportive services for child rearing, forces women to either postpone childbearing until
534 their career stabilizes, which could be never, or jeopardize their career by hitting the maternal wall. Since
535 many scientists tend to be immigrants, they will not have the right to maternity leave or sick leave even in
536 countries where such leaves are the norm.

537 The few specific programs that encourage women to return to work are done in a proforma way. For
538 example, the Horizon 2020 program of the European Union included the Marie Curie Career Restart (CAR)
539 Program to decrease the gender gap and help scientists who were out of the field come back to work.
540 In physics, it had a lower success rate than the regular program; so experienced staff advised applicants
541 against checking the CAR box when they qualified. Scientists were told this was because all the money
542 came from the same pocket since the CAR program had no additional funds. Switzerland funds programs
543 that aim to fix the leaking pipeline to encourage the hiring of more women faculty. However, departments
544 and advisors neither have the requirement nor are encouraged to report pregnancies to human resources or
545 provide maternity leave beyond the end of the contract. When asked Human Resources argue that they
546 try to provide a case-by-case workaround when the pregnancy is reported early enough to their office.
547 Advisors are generally supportive. This means they tacitly accept a lesser presence in the office during
548 the contract while pregnant, fewer research results, and perhaps a longer time to graduate. Still, at the
549 end of the contract, women scientists can end up in their home country unemployed, heavily pregnant or
550 with a young child, and without the right to paid leave or even health insurance. Unfortunately, in these
551 circumstances, the chances of staying in science are minimal. The women who are under-contract and
552 have children, have to plan and get on the waiting list for the often extremely small day care on campus
553 sometimes before their pregnancy even begins. The insufficient child-care facilities are a problem that is
554 common to university campuses across the world.

555 Many women who have shaped our world have had and raised children. Marie Curie raised two daughters
556 – her eldest won the Nobel Prize; the other was a bestseller author and journalist with a leading role in
557 UNICEF. Marie Curie, her daughters, and sister were leaders in a male-dominated society and excelled.
558 They succeeded in spite of the society they lived in. Marie chose to not only work hard, but to share her
559 life with a man of outstanding moral uprightness. Pierre Curie was already established in his field, and
560 did not conform to recommendations. He went as far as refusing the Nobel prize until the award included
561 Marie. Marie Curie relied on the support of her father-in-law to raise her daughter while she worked in the
562 laboratory. Short maternity leaves and lack of available childcare on campus, force women scientists to rely
563 on similar solutions today. Yet the extended family support system is shakier than in the past. Retirement
564 has been pushed back, and if a grandparent is healthy, they will often work themselves instead of carrying
565 for grandchildren. People also choose to have children later when their parents may be too old to help and
566 in geographic locations that are far from where their family is.

Albert Einstein and Mileva Maric were graduate students when they started their family. They were also both immigrants. Zürich's Politechnic institute did not support them. Einstein received his PhD, but could not find work within the university. After searching for work for a long time, he was hired by a patent office. While Albert searched for work, Mileva returned to Serbia where their daughter Lisslerl was born and is believed to have died or been given away a year or two later after she became ill. Mileva never received her PhD. Today, infant mortality is still correlated with lack of maternity leave and stress during pregnancy. Later Mileva worked with Albert to produce relativity while receiving no credit for it, and was quoted for saying that they were but one stone, and that with fame often one takes the pearl and the other the shell (Gagnon, 2016).

Below we quote a series of prominent scientists regarding motherhood in science. The Head of the Gender Equality office at the Swiss national science foundation writes "I am myself a mother of two kids and left research for this reason." A colleague with four children who is a prominent scientist at an ivy league university in the US comments "I have never had a paid maternity leave, except for my first child in which case it was not official. My adviser was extremely supportive and I keep thinking of him with the highest respect. For the other three kids I was in transitioning between cities/positions and planned so that the break would not show on my CV. Financially it was definitely negative." She succeeded to stay in science because her parents and in-laws took turns in providing child-care. Another colleague was cautiously optimistic "Things are getting better slowly in terms of maternity leave both in Europe and the US, but this does not mean perceptions in physics with our male colleagues are changing as fast. I waited to have a baby after I was 35 and I wouldn't recommend this choice (coupled with the risk of health problems and fighting against your biological clock). The main reason was that my husband and I were doing long distance [commutes]/not in stable positions". A Cornell PhD who has returned to India with her husband when he obtained a professorship there writes "I have a 3 year research grant from the government, but after that things are again a bit up in the air. The money for this 3 year cycle has also not been sanctioned - so all my work currently is unpaid ! Pay or not, academia is pretty ruthless so, one has to keep working" (she had a 7-months old daughter at the time).

To remove some of the toxicity of the STEM environment, employees should have access to at least 40 weeks of maternal and/or paternal leave (Ruhm, 2000), and have sick leave, childcare and elderly care available on campus. It should not be the norm that women forego having children to advance in a field or wait until their career stabilizes and it is too late. Combined child-care and elderly-care facilities could exist where the children of employees can participate in various activities with their grandparent or with another elderly person. While such policies might indirectly decrease the gender gap, their primary role would be to enforce basic human rights.

Ruxandra Bondarescu describes highschool in Romania, college at the University of Illinois at Urbana-Champaign (UIUC), graduate school at Cornell University, and mixing postdoctoral studies at Penn State University and the University of Zürich (UZH) with motherhood.

I attended the Grigore Mosil Highschool in Timisoara. It was considered the best highschool in the city for studying STEM. All students had the same curricula and had to study informatics for 8 hours every week, mathematics for 5 hours and physics for four hours a week in slight detriment to general education (e.g., music was not taught; geography, history and biology were reduced from two to one hour a week, etc). The 30 students in my class happened to be equally divided between sexes: we were 15 young women and 15 young men. Out of these students, three went to college and graduate school in the US and all happened to be female. Today, the class graduating in 2018, has 141 students (which are divided in 5

610 groups or classes) and is about 45% female. When I went to Zürich as a Dr. Tomalla postdoctoral fellow,
611 the only female faculty in Particle and Astrophysics at UZH was a graduate of Grigore Moisil.

612 My bachelor degree is from the University of Illinois at Urbana-Champaign. As an international student
613 in a state university, it was difficult to obtain funds to pay for tuition. I was a full time student for only
614 one year when I was awarded a teaching assistantship that included a tuition waiver. The assistantship was
615 obtained with help from physics advisor Linda Lorenz and office-mate Galina Wind. I was also working in
616 research at National Center for Supercomputing Applications (NCSA) with a supportive advisor. At the
617 graduation ceremony, we were 4 women, which constituted about 14% of the physics students graduating
618 in 2003. Of my class, I was the only woman going onto physics graduate school. Today, among the faculty,
619 the UIUC physics department has 9 women out of 57 professors, and is 15.8% female.

620 I then joined Cornell University's physics department and graduated five years later. I was one of the 6
621 women entering physics graduate school that year out of 40 students. I started on a two year fellowship
622 with the support of the department head who ended up being one of my two thesis advisors. I support
623 the multiple advisor system. My two advisors made a superb team that helped me stay in science and
624 excel. From the women colleagues in my year: 4 graduated with a PhD, one took personal leave and never
625 returned, and one was a transfer student who obtained a Masters from Cornell and went on to finish her
626 PhD at her home institution. Three of those four women who succeeded to obtain a PhD in physics from
627 Cornell went on to pursue STEM careers, and two are still working in STEM today.

628 Cornell's physics and astronomy departments are known across the US as non-toxic and particularly
629 supportive of their students. Over a 20 year period, the graduation rate is 73% for the physics students who
630 are women, which is higher than national graduation rate of 59% for PhDs over all fields. As part of the
631 graduate women in physics group, we received funding from the graduate school, and from the physics
632 department to invite one woman speaker of our choice per semester for the main physics colloquium and
633 to meet with existent female faculty and speakers for lunch or dinner. We were given the opportunity to
634 propose and invite leaders in the field for seminars. This was particularly empowering for graduate students.
635 We also had a panel meeting per semester where Cornell's few women faculty would give us advice on how
636 to succeed. Beyond this, all Cornell graduate students can apply and receive funding from the graduate
637 school to partially fund travel to conferences, which, combined with funds for students from APS, made
638 my presence at all major meetings in my field possible. Today, the physics department at Cornell is 17%
639 female boasting 8 women professors out of the 45 tenured and tenure-track faculty. The number of women
640 professors is still low enough that in the five years I was there I have never taken a science class taught by
641 a woman and I have taken over 20 courses in graduate school. This was also true for my undergraduate
642 period at UIUC.

643 After completing my PhD, I started a postdoctoral position at Penn State University. Two years later
644 my first child was born. My postdoctoral advisor was extremely supportive. He worked with staff to find
645 ways to pay me for the next year and provide leave for me. The H-1 B visa requirements were of such a
646 nature that he had to explicitly write how unqualified I was to be able to keep me on because postdoctoral
647 scholars are at the bottom of the salary bracket. I had a month of unpaid leave, and was encouraged to
648 come to work only for meetings and to bring my child to work. My salary was also increased. The day
649 care on campus had a long waiting list, and I ended up enlisting the help of extended family members to
650 care for my son. I also had a private office where I could breast-feed if needed. At Penn State, we were
651 encouraged to invite speakers for the seminar of the center there, go to lunch and dinner with speakers, and
652 funding was available to support one or two yearly visits from collaborators. This helped me write articles
653 with colleagues at Caltech, the University of Mississippi, and Syracuse University. As the only woman in

654 the institute at the time, I had the opportunity to be at dinner with primary donors for the university, and I
655 also led the team of postdoctoral scholars and students in presenting our research to representatives of the
656 National Science Foundation.

657 I was next awarded a postdoctoral fellowship at the University of Zürich (UZH) that lasted five years.
658 When I arrived with my one-year old son, I first tried taking my son to work with me. This was not feasible
659 since the office was shared and it was disturbing to my colleagues. The small day-care on campus was very
660 friendly, but had a waiting time of more than one year after registering with priority given to permanent
661 staff (postdoctoral scholars are temporary employees). So, my mother retired from her job as a doctor,
662 and came to help care for my son. The environment was supportive. I was allowed to invite one or two
663 collaborators per year for the Particles and Astrophysics Seminar at UZH, and in my last year, I received
664 partial funding to give invited seminars at universities across the US. My research at UZH was featured
665 several times in various journals across the world, which included the IEEE Spectrum, the R&D Magazine,
666 New Scientist, and the MIT Technology Review. The professor I worked with was praised by the university
667 for our joint work, and, while I was there, he was promoted to the US equivalent of associate professor
668 after 20 years of being an assistant professor, which is tenured in Switzerland, but comes with lower pay.

669 When my UZH position ended, I was eight month pregnant with my second child. I gave birth about
670 6 weeks after my appointment ended, and as temporary staff I had no right to maternity leave since my
671 appointment would have ended at that time even if I had not been pregnant. When I returned to my home
672 country without health insurance and unemployed, I explained to my mother that I had been temporary
673 staff even though I had been employed for five years in the same place. My mother saw this as a violation
674 of not only my rights, but also of those of my child, which should not happen, and was outraged as a
675 doctor, a woman and a mother by the rules that are commonly applied in STEM. So, eventually, I gathered
676 enough courage to contact Human Resources (HR) after encouragement from a program for fixing the
677 leaking pipeline who had no funding to help, and I was told that indeed if the delivery is 6 weeks or more
678 after the contract ends, the university has no obligation towards temporary employees. However, they
679 said that if I had reported the pregnancy early enough they might have been able to find a work around.
680 They also emphasized that departments and advisors have *no* requirement to report the pregnancy of their
681 employees to HR. I was then advised to contact the Swiss National Science Foundation. The head of the
682 equality office personally responded to my questions and said there was no funding she could access for
683 such situations, and that she quit science because she has two children herself, but was optimistic about
684 the future. Overall, it was clearly explained to me that it was my fault that nothing could be done for not
685 reporting the pregnancy early enough and for not investigating a potential work-around. I was also told
686 I could have legally staid unpaid in Switzerland for three months after my contract ended, and since I
687 chose to not avail myself of this opportunity, it was my fault for potentially being without health insurance
688 elsewhere. I still stand by my choice since I do not think I would have found a job with a newborn child in
689 those three months and to return home with no savings, a baby and young child would not have been a
690 better solution.

691 I was the second woman to give birth from my group. The other colleague was in a similar situation
692 where no extension or maternity leave was awarded. Her position had only been one year long. She asked
693 our advisor and the program officers if she could get an extension, but when the answer was 'no' she never
694 followed up with HR. She was not able to come to work often because she had a high risk pregnancy, and
695 her previous child died a few days after birth. She had also suffered a number of miscarriages before that.
696 It was assumed that as the only other woman in the group I could advise. When she looked ill, I sent her to
697 the hospital, and emphasized the importance of prenatal care over work. Once she delivered her baby there

698 was no available day-care, but her husband was eventually allowed to come from Pakistan to help. She
699 did finish a technical article based on work performed at UZH after returning to Pakistan. She told us the
700 environment was less toxic in Switzerland than in Pakistan where her female colleague was not allowed to
701 skip work to be with her very young child, and often came to work crying.

702 **Prof. Jayashree Balakrishna discusses her education in India, graduate school in the US, and**
703 **teaching experience at Harris Stowe State University.** My education started in India. My father was
704 an engineer and my mother stayed home to raise my two siblings and me on a single income. When I
705 graduated high school my field was STEM-biology (Math, Physics, Chemistry, Biology, English). In my
706 class there were about 24 boys and 16 girls. There was a definite bias from faculty and students that males
707 were better at math and engineering than they had no qualms displaying. People were comfortable with
708 women wanting to be doctors, but not engineers. This bias was also exhibited by some of the women. In the
709 STEM-engineering class (Math, Chemistry, Physics, Engineering-Drawing, English) there was only one
710 woman and the rest were men. She ended up studying English in college. There was an option of choosing
711 domestic-science instead of Mathematics even in the STEM field. Two women took this option from my
712 class and one of them ended up becoming a doctor. Two male student in the next batch took that option and
713 created a hue and cry in the school with even some of the women saying they did not know what they were
714 doing.

715 However, at home the expectation was that STEM is important and that one should do STEM. Nobody
716 at home could change prevalent attitudes and so they would not empathize with the situation. You were
717 supposed to play the best hand you could with the cards you were dealt. It always seemed that guys in
718 class could talk to each other and bounce off ideas but the few women aspiring for Math-Engineering glory
719 were isolated. Since it was a preposterous idea for a woman to think she was able to excel in these fields,
720 this meant the women in STEM tried to avoid the public eye. Some even seemed to underperform for fear
721 of offending the norm. I attended a women's college for my undergraduate degree. One thing to note is
722 that hostel accommodation for undergraduate women was available in women's colleges with a few seats
723 in a postgraduate women's hostel. The co-ed colleges that had hostels had men's only hostels. Thus far
724 more undergraduate male students stayed in on-campus accommodations than women. In the graduate
725 master's program in India there was a higher relative percentage of women in theoretical physics streams
726 like particle physics than in applied fields like electronics. I graduated from high school and college in India
727 in the 80s. These incidents highlight attitudes from when I went to highschool and college in India. The job
728 market has since grown and multinational companies and growing Indian companies in the technology
729 sector have created many more STEM related jobs. Since then the biases may have become more subtle,
730 but the attitude in the home is similar in that it is still assumed that STEM fields are the important ones to
731 study.

732 In the US I attended Washington University in St Louis for graduate studies. The enrollment of women
733 in the physics graduate program was low with no women faculty outside the earth and planetary-science
734 department. Now (from going through the listings on their website and the ratio of male:female graduate
735 students is about 3:1). There are 33 current faculty listed out of whom there is 1 female Research Assistant
736 Professor from Earth and Planetary Science, 1 female Research Associate Professor from earth and
737 Planetary Science, 1 female Research Professor from Earth and Planetary Science, and 1 female Senior
738 Lecturer. The rest are males.

739 While finishing my research at Washington University, I taught as a full time lab instructor (Sabbatical
740 replacement position) at Saint Louis University for 1 semester (I had 5 male and 4 female teaching assistants
741 mostly undergraduates). My Electricity and Magnetism, Mechanics, and Physics for pilots labs, had a very

high male to female ratio. After graduate school I obtained a tenure-track faculty position at an HBCU college where I was an adjunct instructor when I was writing my thesis. I have gone through the stages of assistant, associate, and I am now a full professor. Our highest enrollment is of minority women. In HBCUs the ratio of black women: black men is close to parity (Simms, 2014).

Many of our students come from underserved communities, and likely went to public schools with a high number of minorities. This community is underserved from elementary school onwards and so the issues are different from being a woman in STEM. African-Americans have been kept from higher education longer than women in the US. Women were first admitted into Washington University in Saint Louis's medical school in 1918, while it was 1947 before the first African-Americans were allowed in the medical school. Washington university was fully desegregated only in 1954. There is a need for more science and math teachers in public schools and for after school programs that focus on math and science, and work in collaboration with colleges. This would be a good intervention program and should include competitions to encourage the students who have STEM aptitude that are similar to the athletics programs.

Christine Moran describes high school in Columbus, Ohio, USA, college at the MIT, graduate school at the University of Zürich (UZH), postdoc work at Caltech, and work in industry. In my experience in high school, I wanted to fit in, so I often played up my absent minded professor side to the point of being thought a "ditz" (a term primarily applied to women). Math and science always came easy to me, but I would hide the fact I often had the highest grade in the class. I had a small group of personal friends, most of whom were highly intelligent artists and activists, and none of whom were in my classes. I was in the robotics club, and had a part time job when I was 16 working at an engineering firm, but I thought math and science were boring because they were so easy and I wanted study philosophy then go to law school like my dad.

I knew I could go to college for free if I went to an elite institution (Harvard, Stanford, MIT etc.) because of my single mother's finances and the financial aid these institutions provide. I read up on the typical profile of the student who was admitted to these colleges, and tried to fit it. Luckily I did well on standardized tests and although I found school boring, with a goal in mind it was easy to focus. I went to the information sessions for the elite colleges, and found most of them off putting in their elitism (I am not sure what I expected), except for MIT which I found down to earth, wacky and fun. The MIT spirit reminded me a lot of my friends and I thought it would be "funny" for a person who wanted to study philosophy and was known as a ditz to go to MIT. I applied early action, and was accepted. I often would get people reacting in surprise at the fact I would be attending MIT. One former physics teacher told me "I hear they are letting in artsy people now". As a teenager I enjoyed surprising people or catching people off guard with my intelligence; as I became an adult this "comedy" routine wore me down, because the humor came from people underestimating me, which was usually because of my gender, appearance, and affect.

At MIT I found a place I felt home. Everyone took the same common mathematics and science core, which quickly lead me to realize these subjects could be challenging and rewarding and that I wanted to study more. My admitted class was approximately 50% women, and although my two majors (Physics, Computer Science and Engineering) were a smaller percentage, it was never small enough that I felt out of place. I think had I gone to any other college, I would not have entered the sciences and I'm thankful that my high school sense of humor brought me to MIT. At MIT I had many summer internships and chances to work in teams. In one summer internship, I traveled to a software engineering company in Norway where I was the first woman ever hired in any department by the office in which I worked. This didn't feel off, although I recognize in retrospect I did a lot to seem "one of the guys". After graduation, I worked at a local company called BBN Technologies doing machine translation research. I made an excellent salary

786 and saved a lot of money. My team had several senior women on it, and was diverse in terms of age and
787 cultural background. I ultimately decided to go to graduate school, and moved on to pursue my Master's
788 and later Ph.D. at the University of Zürich (UZH).

789 It is not usual to receive funding as a Master's student in Europe where I had set my mind on going, but I
790 was offered funding for 1 year (2/3 of my time) as a Master's student at the onset with the understanding
791 the final 6 months of funding would follow at UZH. This clinched my decision to begin at the UZH. At
792 UZH there was just one other woman studying for a Master's in my field at the same time. She and I
793 bonded and did much of our studying together. I picked my Master's thesis with the understanding I would
794 be working with the same supervisor as a Ph.D. During a meeting with this supervisor, it came out that he
795 wanted me to work as the assistant to his secretary (who he happened to be dating) and do menial work for
796 her in exchange for the final 1/3 of my funding, which I found demeaning given my skillset and refused.
797 He offered the same "opportunity" to the only other woman in my program, who despite my advice, took it.
798 I am convinced this offer was related to my gender. At the same time, despite the fact I was doing well on
799 my Master's thesis (I would receive the highest possible grade for its execution), he made clear that he
800 would not be hiring me as a Ph.D. student. The same professor had also previously fired his only female
801 Ph.D. student ever, and had hired another female Ph.D. physics student to clean his apartment (the rumor
802 was, naked). The woman who took the job as the assistant to the secretary, struggled to be taken seriously
803 in a scientific role because of her administrative duties, although working with her I can testify that she
804 was equally talented as the men and myself in the department.

805 This sent me in a big scramble for money and into a crisis of grief and wondering what I would do next, I
806 found it difficult to go to work. Another Professor in the department offered me a Ph.D. project, but as he
807 was not the Professor I had set on working with and he had a rumor of being difficult with students and
808 now I felt the environment to be toxic, I was unsure whether I wanted to stay. I began to eat into my USD
809 savings to cover my living expenses, at the time that the USD was very weak, and quickly began consulting
810 to make more money, while I finished my Master's. I went to a nearby University, the ETH, to work for a
811 professor there for a few months while I decided whether I wanted to return. Ultimately I did return and
812 accepted the Ph.D. offer of the second professor. I kept up my consulting projects, and took several unpaid
813 leaves of absence to continue them, as well as to do scientific outreach projects. I graduated with my Ph.D.
814 Many years later, my consulting work produced more than half a million dollars of revenue for me over
815 my Ph.D., as I collected equity in the companies for which I worked, which when the companies were
816 successful made me successful. I was happy I didn't take the job serving as a secretary's assistant. The
817 woman who did was refused a Ph.D. position and ultimately dropped out of science.

818 Myself and my advisors assumed with my consulting work, that I would likely enter industry after
819 graduation and I did not actively seek or receive counsel on postdoctoral fellowships. I did indeed begin
820 to apply to industry, but as I had a budding interest in numerical relativity and had made some stabs at
821 research in that direction and contacted professors abroad, decided to reach out to some of my contacts.
822 One of them offered me a 1 year postdoctoral position at Caltech. I was delighted, and ended up deciding
823 to move to LA to first work at SpaceX and later take the postdoctoral position. I was also excited because
824 this supervisor was an avowed feminist and seemed to have many talented women working in his group.
825 I moved to LA and worked for SpaceX for 3 months in an internship. There were very few women at
826 SpaceX and none on my small team, although there were many among the intern class their numbers were
827 diluted throughout the company. During my time at SpaceX I received active mentoring on submitting
828 proposals and on potential postdoctoral fellowships to apply for by my future supervisor at Caltech, and
829 I aided in submitting proposals and submitted my own. I started at Caltech, and the very next day heard

830 that I had won one of the most prestigious: the NSF Astronomy and Astrophysics postdoctoral fellowship,
831 which would fund me for a full 3 years at Caltech at roughly double my initial salary, with a mandate to do
832 outreach work with a percentage of my time. I was delighted, and set off to make a big contribution and
833 learn as much as I could about numerical relativity.

834 When I started at Caltech, within the first few weeks I began to hear rumors of my new advisor being
835 difficult to work with. These rumors were never concrete and I am ashamed to say I didn't take them
836 seriously. My Ph.D. advisor had been rumored to be difficult to work with, which I attributed to his
837 hands off style, but it in the end worked out very well for me with my consulting schedule. I had the
838 mistaking impression my postdoc advisor might have a similar situation, where some people had issues
839 due to working styles, but I might find working with him just fine. I began my work, finally getting the
840 chance to work with numerical relativity in depth, and collaborated mainly with another postdoc in the lab.
841 The rumors intensified, and I was taken aside by a man in the department to explain that my advisor was
842 especially bad news, and that he had tried to bully this man out of the field. The women in my advisors
843 group began to leave, and they would make references to him making unreasonable demands. I began
844 avoiding him entirely, preferring to work with the postdoc. I needed mentorship to progress as numerical
845 relativity was a new branch of science to me, and when the postdoc left for a job in industry, and I found
846 myself actively avoiding my postdoc advisor as it became clearer the extent of his bullying and harassment,
847 and that it was targeting women, I thought about leaving and made plans to interview and take a sabbatical
848 position at the South Pole. My postdoc advisor was put on leave while a harassment investigation was
849 underway. Shortly after that I left for Antarctica, hoping that the situation would be clearer when I returned
850 a year later.

851 In Antarctica I ran the South Pole Telescope for 10 and 1/2 months together with a Ph.D. student, who
852 also happened to be a woman. It was an amazing experience being in charge of such an impressive machine
853 in a hostile environment and I was proud and comfortable to work with my colleague to do so. Partway
854 through the year, Caltech wrote me that they had agreed with my former advisor to move the person
855 who signed off on my grant to another professor in the department. When I returned from Antarctica, the
856 situation at Caltech was still complicated. My former advisor was on leave, but was slated to return. He
857 was prohibited from working with students, but could work with postdocs. I hadn't spoken to him for more
858 than a year, he or Caltech had apparently requested the relationship be formally severed, and by now the
859 rumors around his conduct were substantiated findings: he had engaged in gender based harassment of
860 several of his students. The professor who signed off on my grant did very similar research to what I did in
861 my Ph.D. and I worked to find common ground with my NSF proposal so that I could be more in line with
862 his research. I then searched for a collaborator for my numerical relativity work, who ended up being a
863 former Caltech postdoc with my former postdoc advisor, now working in the bay area. Collaboration at a
864 distance was slow, and the numerical relativity work ground to a halt. I enjoyed and made progress with my
865 research with the new advisor, but it wasn't what I had come to Caltech to do. I began to make preparations
866 to leave my grant at Caltech early. I didn't feel like I could in good faith finish the research I set out to do
867 on the grant, given the mess. I was able to fully execute on my outreach project as part of the grant, as well
868 as publish a paper with my new advisor, before leaving the grant almost a year early to work at NASA JPL.

869 Without a system to report harassment, and with people being required to be silent about ongoing
870 investigations, I felt that it became clear to me much too late that the problems students had with the
871 advisor had nothing to do with differences of personality, and everything to do with the advisor. I wish I
872 had known about these problems before coming to Caltech, and that afterwards I had not been so quick

873 to map the problems to differences in personality. In reality, I should have switched research topics and
874 advisors right away.

875 My decision to leave my postdoc grant early was also impacted by my desire to start a family with my
876 husband, who happened to have been the man who warned me my advisor was a bully. At this point I was
877 in my early thirties, and my schedule dictated in another 2 to 3 years I may want to apply to a similar
878 opportunity to the South Pole where being pregnant was not an option. So the next 2-3 years were ideal for
879 pregnancy. But if we started a family while I was on my research grant, I would be searching for a new
880 academic or industry job shortly before or after giving birth, and my maternity leave situation would be
881 nebulous. My research grant offered unpaid leaves of up to three months, or the flexibility to work from
882 home (some women did this throughout their maternity leave) at a self-decided pace while getting paid
883 during this period. However, given how far I was behind on my grant work already, I couldn't see taking
884 additional time from research as being possible, nor could I see going back full time to research days after
885 giving birth as being practical. So I applied for and found a job at JPL. JPL has the advantage in that for
886 many family leave options in the US you have to be working at an employer for more than a year to receive
887 maternity leave outside of medical disability (approximately 6 weeks), but since JPL was managed by
888 Caltech I would count as working there for more than a year were I to get pregnant, so I would be eligible
889 for 12 weeks of leave (a combination of a percentage of my pay and unpaid leave) on top of approximately
890 6 weeks of disability. I went to my new postdoc advisor, shared with him the opportunity, and we agreed I
891 would take it. I negotiated to keep my office at Caltech and to continue to finish some of the work we had
892 begun since I returned from the South Pole.

893 I had no idea how long it might take to get pregnant, but we began to hope our family dreams might
894 come true within the 2-3 year window. Shortly after I started at JPL what my husband and I suspected was
895 confirmed, I was pregnant. I chose to wait until the fetus was considered less likely to miscarry to share
896 the good news with my new boss. By that point, my husband had also switched jobs to join JPL as well. At
897 first the HR told us that my husband and I would need to split a portion of our partially paid leave with
898 each other because we shared the same employer. This is indeed the letter of the law in California. Later,
899 we were told that Caltech had changed its policy to go above and beyond the law to allow us each a full 6
900 weeks of partially paid baby bonding leave. My husband and I sketched out a plan where we would each
901 take 80 days off over the course of the baby's first year. My husband wasn't entitled to his leave until a
902 year after his start date, as he didn't work for Caltech in his job immediately previous, so the majority of
903 his leave would have to be taken after the baby was about 6 months old. However we were both glad we
904 had stable jobs with leave provisions, as well as a wonderful daycare that we were admitted to for 3 days
905 a week when the baby was 6 weeks or older. JPL is very diverse as far as the physics academia or tech
906 industry standards go with respect to age, race, gender, and more, and is known to be highly supportive of
907 families. We have found this to be the case thusfar. My group at JPL has a female principle investigator and
908 a male manager, although the team has been for most of my time 100% male otherwise. However, I work
909 with a variety of missions, and most of them have heavy female representation. One particular mission I
910 work with is majority female. I recall a meeting with 8+ women where a single man walked in late. I didn't
911 not know who he was, so I introduced myself, he said his name was Guy, and I said "oh the token Guy."
912 It's an honor and often relaxing to work with majority or all female teams, and one I have enjoyed rarely in
913 my career.

914 I work out of my office at Caltech on research projects every other week now. Science will always be a
915 part of my life. I have 13 refereed publications over the past 11 years, with more than 5000 citations in
916 multiple academic disciplines. I can also publish as part of my job at JPL. I have a book in the works,

917 as well as several papers underway. My story became much more complicated and nebulous due to the
918 intersection with male bullies, harassers, or other issues, but I have always found a creative way to make
919 that into some sort of positive outcome. I hope I have learned more along the way so that I can be a better
920 ally to those experience harassment.

921 **Anuja De Silva discusses her experience on single sex education in highschool in Sri Lanka and in**
922 **the US at Mount Holyoke, graduate school at Cornell University, and industry work at IBM. She is**
923 **also the mother of two children born while she was working in the semiconductor industry.** In Sri
924 Lanka, I attended a girls only high school where out of 400 in the graduating class more than 50% are
925 pursuing a career in the STEM fields. I was among the 23 Mount Holyoke alumnae who went on to receive
926 U.S. doctorates in life and physical sciences from 2000 to 2004, 22 of them are minority women, the
927 highest number along first tier liberal arts colleges in the United States. As a minority Mount Holyoke
928 graduate from class of 2004 who earned my PhD from Cornell University in 2009, I'm proud to be featured
929 in this statistic and still continue to work in the STEM field almost 10 years later.

930 The chemistry and chemical biology department of Cornell boasts more women than the physics
931 department in keeping with the trends across universities. In 2003 the incoming class was about 35%
932 women and the numbers stayed consistent through graduation. The number of women in the department
933 played a significant role in improving the graduate school experience for women. Friendship and support
934 are key criteria that help minorities succeed. I was fortunate to be a part of a research group led by an
935 advisor who has consistently supported women graduates (our group was always 25-30% women; 5-6
936 personnel) and hence kept faith in me after I ended up with unsatisfactory performance on certain classes
937 that I had no study group support for. It was a turning point for me that bolstered more ambition and focus
938 for me where as it could have easily turned into my giving up on the path towards a doctorate. During my
939 thesis work, I learned that perseverance is key as I struggled for the first few years to attain meaningful
940 results. But the support of my group members along with opportunities to interact with industry enabled me
941 to stay motivated and focused. My graduate research was funded through an industry consortium through
942 the Semiconductor Research Corporation (SRC), which included opportunities to attend conferences and
943 well as an internship at IBM. This internship led to the start of my career as a post-doctoral associate at the
944 IBM Almaden Research Center.

945 Working in the research and development area in a major tech company, diversity and inclusion of women
946 is seen as a business imperative. During my tenure at IBM I have seen improvements to maternal leave
947 policies and work life integration policies that enable both men and women to share the workload of child
948 rearing. Due my background in women's only environments, I'm more secure about my potential and
949 contributions in a male dominated industry. But unlike in a women's ecosystem, I'm also keenly aware of
950 how much more assertive I need to be and how actively I need to seek recognition and promotion. As I
951 enter the mid-career phase (around 10 years post graduate school), I'm faced with the lack of women in
952 technical and leadership roles first hand. Women constitute about 25-35% of these roles in most leading
953 tech companies in the United States (Richter, 2018). As a mid-career woman my greatest challenge I face
954 today to is to beat that statistic and continue my prominence in my technical field.

955 I do notice an active effort in corporate recruiting to emphasize the pipeline of women entering corporate
956 research roles. Currently I'm one of the senior technical staff who is also on a project lead role within my
957 group. IBM is similar to other tech companies where the female technical staff is around 25-30%. Several
958 initiatives in our division have gained management support and continue to bridge the gender disparity.
959 They include gender bias training for all employees, an yearly all-day event that focuses on women's
960 empowerment, regular round tables with senior women engineers, and special assignments where women

961 can spend up to 20% time learning a new skill/working on a project with a mentor outside of their regular
962 role. I have been in my current group for the past four years and I have seen an increase in contribution
963 from women engineers in papers and patents published. As a senior woman in my group I have continued
964 to seek out and engage women engineers and we have a high 50% or more contribution from women in our
965 published work. The women engineers also represent a variety of minorities (about 50%).

966 Since my pregnancies were during my tenure in industry, I was eligible for paid maternity leave. With
967 both children, I opted to stay home for 10 weeks post cesarean delivery and ease back to work. I was
968 fortunate for the work life integration policies at my company which enabled me to take time off for
969 doctor's appointments and sudden child care emergencies. While I enlisted help from my mother, I also
970 invested in paid child care, which was about 15-20% of my salary. My childcare arrangements during work
971 and work travel for conferences have been incurred on my personal income. I have considered them a
972 longterm investment in myself and my family. I believe in consistently trying to find the best fit for my
973 child as well as for my career. The childcare costs tend to be the highest between ages 0 and 5. When
974 children turn 5 in the United States, they start kindergarten. At that point parents who work full time will
975 still incur costs of additional child-care at the beginning and at the end of the work day since a full day
976 in school is only about 6 hours. I am part of a dual income family. This has made a big difference in my
977 ability to have two children relatively early in my career. For single income families, child rearing is a
978 bigger financial strain. My current job also provides health benefits, lactation facilities and counseling
979 which are necessities for working mothers.

7 CONCLUSIONS

980 The gender gap in STEM is attributed to the toxic climate that exists in male dominated fields. The attitude
981 of colleagues is less overt against women and minorities than it was in the past, but it is still problematic
982 and the numbers are changing slowly enough that gender parity will not be reached in fields like physics
983 and engineering without intervention programs. Intervention programs have been shown to work. MIT
984 succeeded in reaching gender parity in its undergraduate population in mechanical engineering. This was
985 achieved through deliberate structural changes that included (1) reaching out to find and invite talented
986 women and then hiring them as faculty instead of waiting for them to find the courage to apply to MIT,
987 (2) promoting intervention programs like Women in Technology that invite talented highschool women to
988 campus for a summer to take part in laboratories and courses, and (3) modernizing their curriculum in both
989 content and pedagogy.

990 To remove some of the toxicity of the environment, intervention programs have to go hand in hand with
991 enforcing basic human rights that allow for sick leave and maternity/paternity leave for employees in
992 industry and academia. Not providing such leaves is an infringement on human rights that should no longer
993 be the norm. It has been shown that providing employees with maternity leave and adequate day-care
994 can be life-saving for both the mother and the child. In the academia, graduate students and postdoctoral
995 students are temporary employees. They are expected to have worked abroad to qualify for faculty positions.
996 Temporary employees do not have the same rights as staff, and if they hold a visa, they are not eligible for
997 maternity and sick leave available to citizens even in countries where such leaves are the norm. Changes
998 have to occur to support not only faculty in top universities to have families. All grants have to include
999 provisions for basic human rights for graduate students and postdoctoral scholars so that universities do not
1000 rely on work-arounds that allow many women to fall through the cracks.

1001 More than half of the women who obtain a STEM degree switch to other fields mid-career. To lose less
 1002 talent, it is necessary to no longer see a degree as an end, and (1) create a network that connects students
 1003 to the next level, (2) allow for maternity/paternity leave and return to work, (3) build support networks
 1004 for students and employees and (4) actively train employees to facilitate a switch between projects when
 1005 needed.

1006 The exposure of children to science is larger in Asia and Eastern Europe where the primary and secondary
 1007 education focus on this end and families pressure both men and women to succeed in these fields. The result
 1008 is that almost 50% of women obtain science degrees, but the number of women who attain engineering and
 1009 technology degrees is under 30%. The latter number appears to be lower due to hidden and overt biases
 1010 coupled with the expectation that men should be the providers of the family. We advocate gender neutral
 1011 toys and the exposure of all children to science from the very beginning. The final goal, however, should
 1012 be to have as many people as possible choosing what they would like to pursue and to be productive and
 1013 innovative in their chosen fields.

1014 In the end intervention programs must include the education of males as well. One reason all girls
 1015 programs are going to only be part and not the whole solution is that at the moment the STEM technical
 1016 knowledge and skills are mostly acquired by men. Women must be able to partake of the knowledge gained
 1017 so far through interactions with both genders. However, women are often made to feel they are not capable
 1018 of gaining this knowledge and there is hostility and ridicule when they try to gain it. This isolation can be
 1019 removed in all female settings, however, the full benefit of access to the knowledge community will not be
 1020 there. Hence changes in attitudes of both men and women are needed so that women feel comfortable as
 1021 equal learning and working partners in STEM.

1022 Ultimately, an increase in diversity where teams are not dominated by a single gender and by one or two
 1023 national identities has been shown to lead to increased productivity, and to decrease the likelihood of abuse.
 1024 To achieve diversity in STEM, we advocate exposing all children to science from kindergarten onwards and
 1025 providing mentoring that evolves with age. Particular support is needed in the period post-graduate school.
 1026 While attaining the PhD may seem as the end goal, it is just the beginning of a professional STEM career.

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