Is Gender Equality Still an Issue? Gender (Im)balances in STEM

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In recent years, considerable efforts have been made to support women to study and work in STEM fields. Nevertheless, inequalities remain, and women are clearly underrepresented in STEM. There is still a pervasive issue with the retention and progression of women in academia. How big is this problem actually, how can we promote diversity, equality and inclusion in academia, and how can we counteract unconscious bias?

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Despite recent perceived setbacks and public discussions [1], the proportion of women is generally increasing at all academic qualification levels in Germany. Overall, male and female students at universities are close to gender parity and 45 % of graduated students who opt for further academic careers are women [2]. This development is very positive, as this share was still 35 % in the year 2000. A gender-specific choice of study program is still common. Female students are mostly enrolled in subjects such as the humanities, health sciences and arts, while they are underrepresented in engineering and sports [2]. Furthermore, the proportion of women is decreasing from one qualification level to the next, commonly referred to as the leaky pipeline [3]. Globally considered, 53 % bachelor's and master's degrees graduates are female. However, only 43 % PhD graduates are female and just 28 % of researchers in all fields are female [4]. The drain of female talent starts with the PhD and rises with further qualification. In the status group of professors, 25 % are women in Germany, with only 20 % achieving the highest endowed professorship (W3 professorship) [2]. Despite the fact that many universities strive for diversity, equality and inclusion, these numbers are even worse in the STEM-related subjects with 30 % of students being female and 20 % of post-doctoral lecturers. Women fill only 19 % of the professorships in mathematics and natural sciences and 14 % in engineering science [2]. Globally, female professors are significantly underrepresented as well; in India, 27 % of full professors are female, in Canada 28 % and in the U.S. 34 % [5].

In order to decrease gender inequality in academics, a number of measures should be implemented to close the gender gap. Examples of quality-assured equal opportunity measures can be found in the portal INKA [6], which provides a searchable collection of good practice measures for research-oriented equality standards from German scientific institutions and, worth mentioning, the STEM and Gender Advancement (SAGA) project, which is a global UNESCO project with the goal to reduce the gender gap in STEM fields [7]. Since a lack of information and existing gender stereotypes continue to influence girls' choice of studies or profession, female students are severely underrepresented in STEM subjects at university. The usual aspects such as information on choice of study, mentoring and coaching, as well as networking are recommended in order to inspire them to study STEM courses [8]. In addition, the establishment of new courses of study, which are not stereotypically divided by gender, seems to lead to a parity of choice of study [9]. The closer the name of a course of study comes to technology or engineering, the fewer women participate. In contrast, the more the interdisciplinary, application or social context is emphasized, the more women show interest. This is less dependent on the actual content of a course of study, even if the content is predominantly technical. This is a known effect and was also observed at TU Dortmund University during the reorientation of the former Department of Chemical Engineering towards Biochemical and Chemical Engineering. At the beginning of the 2000s, in order to stop the dramatic decline in the number of students, a new biotechnology course was established [10]. This led to a considerable increase in the number of students with 48.5 % female students [11]. This proportion of women has been maintained through the present with an almost balanced proportion of female students in Biochemical Engineering and 33 % women overall in the department of Biochemical and Chemical Engineering. The department

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can almost maintain these numbers for PhD students. This gives one best practice example for a sustainable increase in female students and underlines the importance of offering adequate study programs. That the adaptation of curricula makes it possible to significantly increase the proportion of female students was also shown by a few universities in the U.S. The Harvey Mudd College in Claremont, California, achieved parity of computer science graduates by integrating interdisciplinary programming problems with, e.g., societal relevance [12]. This revamped computer science program led to a more accessible course in comparison to the previously offered course that mainly based on writing mysterious codes, difficult to understand for beginners. The same was observed at Dartmouth College's Thayer School of Engineering in Hanover, New Hampshire [13]. By starting with the motivation to solve an issue, female student became more motivated to develop the tools and skills required to solve these problems. The interdisciplinary connection of disciplines in order to build collaborative research programs by merging STEM with non-STEM courses also reduces gender-bias practices as it has been shown at Concordia University in Montreal, Canada [14]. There are a wide variety of initiatives to encourage young female students to pursue STEM professions. Offering free courses for women only is an approach to encourage female student to participate courses that are biased as demonstrated in Asia Pacific [15].

Furthermore, the specific integration of female role models in lectures and workshops, mentoring programs for students, PhD students and postdocs, and early promotion of female candidates for academic careers certainly contribute to increase the proportion of women in academics. The recruitment and employment of female student assistants by specifically addressing very good candidates and introducing them to the research fields at an early stage stimulates their interest in scientific issues and a possible university career. A further career step is keeping interest high enough and offering attractive conditions for PhD studies, during which the establishment of networks are extremely important for young scientists to contribute to career advantages. However, professional networks are often formed and composed by men [16]. This imbalance causes structural exclusion of women and personal hesitation to join networking. The individual promotion of female PhD students through mentoring programs and (inter)national travel grants is therefore important to support their network expansion. Mentoring programs by women for women have proven to be particularly successful [17]. Interestingly, women are often better at self-assessment and tend to overestimate themselves less than men [18]. To compensate for this, training courses are often offered in which women learn to promote themselves more strongly. And although it is certainly not a mistake to learn this, women should not be changed and adapt to male-dominated structures in order to be successful. Instead, best practices have to be implemented at all qualifications levels and the overall social acceptance has to be promoted.

Conferences and publications are key pieces of the career puzzle from the PhD to the professorship. At conferences, innovative ideas are presented, and crucial networks are formed. However, the speaking opportunities for scientists in STEM from racial and ethnic minorities are relatively lower compared to male participants who do not belong to any underrepresented minority group [19]. Women are underrepresented not only at conferences but also in publishing [20]. This gender gap can be displayed by the publication productivity and the number of citations. Although the total number of female authors has increased, the productivity and citation gaps have simultaneously increased in recent years. The gap in total citations was partly due to the fact that men having longer careers on average.

Underrepresented groups are obviously less recognized as experts in their field. This is difficult to understand if one actually considers that diversity promotes a much broader view and more innovative thinking [21]. In addition to this waste of creative potential, this gap also definitely leads to a critical lack of role models. It is inspiring and motivating to see other successful people with whom you can identify. The more women appear as leading female scientist and therefore act as role models, the more women will continue their career path and succeed. Whether consciously or unconsciously, the Matthew effect (success breeds success) certainly plays a role during the evaluation of publications and research grants and in filling the next professorship. In order to overcome this system of closed networks, we must be aware that this effect exists and take active measures against it. These measures have to be the promotion of underrepresented groups, an increase in their equity at all career levels and an increase of their visibility at every career stage.

Detractors argue that current developments now put men at a disadvantage in application procedures. "*Female scientists have achieved everything they wanted, they have reached these high positions from the professorship to the rectorate. Isn't this enough?*" Actually, the traditional image of leaders is becoming more fragile. Female scientists can run a university; at least 25 % of German universities are managed by women [22]. Furthermore, the number of role models in leadership positions is increasing. Nevertheless, the fact that female scientists are in leading positions is still not a matter of course or should be taken for granted for the future. I argue that men are not discriminated by the preference of women with equal suitability, competence and professional performance in application procedures. The qualification and quality of an applicant is of utmost importance and is the decisive requirement for the allocation of job positions.

In addition to the inequality in the filling of professorships, there is a remarkable gender pay gap in Germany [2]. The fact that women and men are unequally paid for their work at universities might be rather surprising since the universities are part of the public sector. It is assumed that all employment relationships are subject to corresponding

civil service and collective bargaining provisions regarding pay and remuneration. An analysis of official data of the state of North Rhine-Westphalia in Germany showed that on average across all professorships, female professors earn € 521 less than male professors monthly [3]. This gender pay gap can be explained by the fact that female professors receive significantly lower or no performance-related pay. Moreover, women in mid-level scientific positions are less likely to be found in higher paid, permanent or career-orientated positions. In the U.S., the economic compensation of women in STEM workforce is also not the same as their male counterparts. Women receive only about 79 % of the earnings that men receive [23]. The same applies to the salaries of female professors, which are significantly lower than those of their male colleagues [24]. In sum, implicit gender-bias in STEM are globally present.

Overall, these analyses indicate that equal participation opportunities for women and men have not yet been achieved at all levels, and that diversity, equality and inclusion efforts are still indispensable [25]. We are progressing in the right direction, but we have yet to achieve our goal. Gender equality is still an issue.

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