# The global Gender Gap project: fair treatment, and some recommendations for South Africa

**I M A Gledhill**[1,5,6], **G Butcher**[2], **S Ponce-Dawson**[3], **R Ivie**[4] **and S White**[4]
[1]Flow Research Unit, School of Mechanical, Industrial and Aeronautical Engineering, Wits University, South Africa
E-mail: Igle.Gledhill@wits.ac.za
[2] Space Research Centre, Department of Physics and Astronomy, University of Leicester, United Kingdom
[3] Departamento de Física, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, and Instituto de Física de Buenos Aires (Consejo Nacional de Investigaciones Científicas y Técnicas), Argentina
[4] Statistical Research Center, American Institute of Physics, College Park, Maryland, United States of America

**Abstract.** This short paper describes selected results from an international project on the gender gap in science, with a focus on fair treatment at work in physics in South Africa. The three-year project was a collaboration of eight international unions, including the International Union of Pure and Applied Physics, and three global organisations. Among the tasks was a worldwide survey, to which there were 32 346 respondents. The most significant difference was seen in reporting on sexual harassment, with 29% of women and 2% of men in physics indicating that they personally encountered sexual harassment at school or work. In physics there is a significant gender gap in response to the statement "My employer treats everyone fairly", with which 62% of women and 73% of men agreed. Recommendations from the final project conference offered to combat harassment include significantly improved campus security for women, to which we add the development of a culture in physics that combats harassment and violence. In terms of fairness at work, several recommendations from the conference are offered. These include replacing the usual method of assessing an individual's output by counting published papers by nomination of their best papers. We also recommend recognising the contributions of men in attaining gender equality in physics.

## 1. Introduction

The design of initiatives for reducing the gender gap should be based on evidence. The resolution on which the International Union of Pure and Applied Physics (IUPAP) Working Group on Women in Physics was founded was to "to survey the situation of women physicists in IUPAP member countries, to analyze and report the data collected along with suggestions on how to improve the situation…". A major step in this direction was the Global Survey of Physicists of 2010 [1].

However, changes occur in the global academic, scientific and social environment, and in 2016 a successful application was made to the International Science Council for the project "A Global

[5] This project was funded as described in the Acknowledgements
[6] To whom all correspondence should be addressed

Approach to the Gender Gap in Mathematical, Computing, and Natural Sciences: How to Measure It, How to Reduce It?". This project disaggregated results across the disciplines involved, and across geographical regions. The aim of this paper is to consider selected responses relevant to fair treatment, relevant to physics and to Africa and South Africa, and to prioritise recommendations which are relevant to the physics community of practice.

### *1.1. The Gender Gap project and the South African context*

The project involved eight international unions: mathematics (lead partner), chemistry (co-lead), physics through IUPAP, astronomy, industrial and applied mathematics, biosciences, history and philosophy of science, and computing machinery, together with three international organisations: UNESCO, GenderInSITE, and OWSD[7]. The project undertook three tasks: a global survey, a data-backed study of publication patterns, and the collection of initiatives known to have successfully addressed the gender gap in science [2]. An important aspect was the collaboration of social scientists and mathematical, computing, and natural scientists to ensure that the social science aspects of the project were professionally undertaken, and to introduce concepts of social science to their colleagues.

In terms of the South African context, is said that South African women experience the highest levels of Gender-Based Violence (GBV) in the world (Dlamini, 2021 [3]). Many positive actions have been taken, but the problem persists. In an environment and context where GBV is so prevalent, and femicide and assault have occurred at universities, it is important to take note of data that may indicate whether sexual harassment takes place in the workplace of physicists.

The South African physics community has taken a highly participative view of its own transformation. This ranges from the community prompting of a nation-wide review when the discipline was in crisis [4], to the generation of a benchmark curriculum statement in which almost all physics departments in the country participated, to transformative actions in terms of race and gender. Although a specific study was not found in the literature, it is possible that a strong physics identity [5] may exist among many South African physicists. A physics identity is understood as a self-view that includes recognition within the community, self-efficacy, and self-determination. These aspects of self-awareness may be helpful both in countering harassment, and in refraining from harassing.

## 2. Methodology: Gender Gap project

The survey was carried out by the American Institute of Physics Statistical Research Center. The interested reader is referred to the description by Ivie and White, 2020 [6]. The term "gender gap" describes any difference "between women and men in terms of their levels of participation, access, rights, remuneration or benefits" [7]. The research questions are: to improve understanding of scientists' development of interest in science, experiences in education and careers, work-life balance, family support, demographics, access to resources needed to conduct science, and opportunities to contribute to the scientific enterprise, and the survey covered early years, university studies, doctoral studies, and careers. Among the dimensions investigated were contrasts across disciplines, regions, and Human Development Index (HDI) [8]. The questionnaire [9] was based largely on the previously used Global Survey of Physicists [1] and the UNESCO SAGA[8] framework. The first draft of the questionnaire was provided at workshops in 2017 in Bogotá, Cape Town and Taipei, reviewing specific questions to collect feedback on regional implications of wording and topics, apply special consideration to ensure that the questions work for the region and for all disciplines, and to outline the

[7] IMU, the International Mathematical Union; IUPAC, the International Union of Pure and Applied Chemistry; IUPAP; IAU, the International Astronomical Union; ICIAM, the International Council of Industrial and Applied Mathematics; IUBS, the International Union of Biological Sciences; IUHPST, the International Union of History and Philosophy of Science and Technology; ACM, the Association for Computing Machinery; UNESCO, the United Nations Educational, Scientific and Cultural Organisation; GenderInSITE, Gender in Science, Innovation, Technology and Engineering and OWSD, the Organisation of Women in Science for the Developing World.

[8] UNESCO STEM and Gender Advancement; STEM: Science, Technology, Engineering and Mathematics

distribution plan. The questionnaire was translated by a professional service, with advice from scientists, into Spanish, Russian, French, Chinese, Japanese, and Arabic. Given the absence of a single method of contacting and sampling scientists across the globe, the snowball sampling method was used, in which the eleven partnering organisations distributed the survey, and participants provided referrals through their networks to recruit further participants. Because this is not a probabilistic sampling method, results apply only to the respondents. Ivie and White [6] conducted multivariate analyses that allow the inclusion of potential confounding factors, such as HDI, employment sector, discipline, geographic region, and age. Because of the large number of models tested, a difference was considered statistically significant if the *p*-value[9] was less than 0.002 [6].

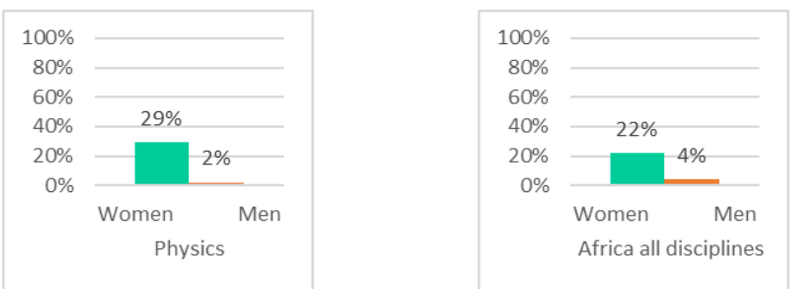
## 3. Responses

The total number of respondents was 32 346, identifying themselves as from 150 countries. In physics 7 570 responses were received. In astronomy 2 597 responses were received. In Africa, the total response from all disciplines was 1 265, of whom 61% identified themselves as women and 39% as men. This response was somewhat disappointing in view of the fact that the African workshop discussed distribution methods. Given these numbers it is not worthwhile to disaggregate physics in terms of Africa or South Africa.

In the following figures and tables, green and orange indicate that a statistically significant gender gap was found in the multivariate model which accounts for confounding factors including age, geographic region, employment sector, HDI, and academic discipline. The results quoted in sections 3.1 to 3.3 are among those published to date [6]. Of the results across eight disciplines, only "Physics" is shown as a discipline, for all regions, in the present short paper. Of results across twelve geographical regions, only "Africa", for all disciplines, is shown here. These specific results were selected for a short paper as potentially illustrative for South Africa in exploring fair treatment at work, in the context of a country plagued by gender violence, but in which the physics community is seeking active transformation in terms of gender.

### *3.1. Harassment*

For the question "Have you ever encountered sexual harassment at school or work?", responses for "yes, it happened to me" are shown in figure 1. Given these data, it is likely that women in physics in Africa are likely to encounter sexual harassment more frequently than men. Global figures for astronomy, considered as a separate discipline, were 30% for women and 3% for men. Further analysis has recently been published [10] which provides comparison of the data on harassment across the dimensions of discipline, region, HDI and employment. The evidence shows that significant numbers of women in physics are experiencing harassment.




(a) Physics discipline, global (b) Africa, all disciplines

**Figure 1**. Respondents indicating that they personally encountered sexual harassment at school or work.

[9] Probability that the dependent variable of interest is 1 in a binary test.

*3.2. Fair treatment in the Doctoral Programme and in the Workplace*

Table 1 shows respondents' agreement with statements [6] about the doctoral programme and the workplace. In a separate question, respondents from physics were more likely to agree that they had respectful co-workers than any of the other disciplines studied.

In the analysis for the region Africa, it is possible that a significant gender gap was not identified either due to the relatively small number of respondents, or due to a relatively small existing gender gap. To investigate this, we show the results for countries with HDI ≥ 0.7 ("high HDI") and those with HDI < 0.7 "lower HDI" (table 2). South Africa, at the time of the study, had HDI = 0.704.

**Table 1.** Responses to questions on fair treatment in terms of Physics and Africa.

| Statement | Dimension | Agree | | Neutral | | Disagree | |
|---|---|---|---|---|---|---|---|
| | | w | m | w | m | w | m |
| "My program treated everyone fairly" | Physics | 63% | 76% | 19% | 14% | 18% | 11% |
| | Africa | 65% | 62% | 18% | 22% | 18% | 16% |
| "My employer treats everyone fairly" | Physics | 62% | 73% | 17% | 14% | 22% | 14% |
| | Africa | 53% | 60% | 20% | 15% | 27% | 21% |
| "My co-workers are respectful of everyone" | Physics | 68% | 79% | 16% | 12% | 15% | 9% |
| | Africa | 68% | 70% | 15% | 15% | 17% | 15% |

**Table 2.** Responses to questions on fair treatment in terms of Human Development Index.

| Statement | HDI | Agree | | Neutral | | Disagree | |
|---|---|---|---|---|---|---|---|
| | | w | m | w | m | w | m |
| "My program treated everyone fairly" | High | 62% | 74% | 18% | 14% | 20% | 12% |
| | Lower | 64% | 70% | 19% | 17% | 18% | 13% |
| "My employer treats everyone fairly" | High | 60% | 71% | 17% | 15% | 23% | 15% |
| | Lower | 52% | 60% | 21% | 19% | 28% | 21% |
| "My co-workers are respectful of everyone" | High | 68% | 78% | 14% | 12% | 18% | 10% |
| | Lower | 61% | 69% | 19% | 18% | 21% | 13% |

While other factors, for example race and class, may be embraced by the term "everyone", significantly more men (69%) than women (61%) in lower HDI countries agreed that "My co-workers are respectful of everyone": this constitutes a gender gap in the response from men and women, in the sense that respondents who are women are indicating that less respect (in a general sense) is exercised in their environment than is indicated by men. A significant gender gap in responses exists in both high HDI and in lower HDI countries in terms of fair treatment at work, and respect between co-workers. Because over 80% of African countries fall in the lower HDI category, this may be indicative of a gender gap in Africa.

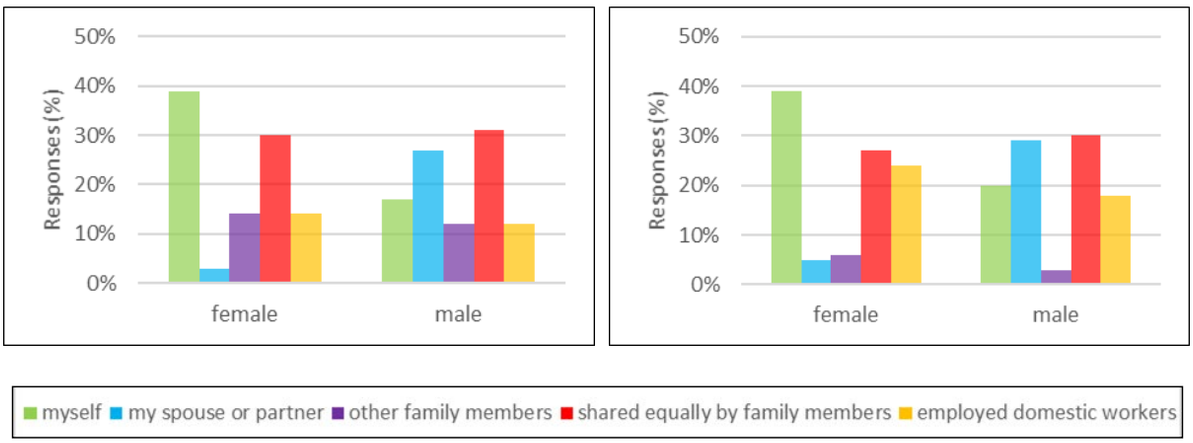
*3.3. Access to resources*

Access to resources was considered through a series of questions covering office space, laboratory space, equipment, travel funds, clerical (administrative) support, employees or students, computing capability, technical support, access to data, access to scientific literature, and support as a working parent. While detailed data exist for each of these resources, a simple single proxy is the average number of these resources available. In the global study of all disciplines, the average number of the listed resources per year for women is 7.2 and for men is 7.6, with a statistically significant gender gap in the multivariate model accounting for confounding factors including age, geographic region, employment sector, academic discipline, and HDI. A difference of this kind is likely to have an effect

of cumulative disadvantage that grows exponentially over the years of a career, as well as providing a source of discouragement, as discussed by Valian [11].

3.4. *Housework*

Further light may be thrown on fair treatment and work-life balance among physicists by a question asked both in the global survey of physicists [1] and the global survey of scientists [6, 14]: "Who is responsible for the majority of the housekeeping in your household?" Responses are shown in figure 2. Because the 2010 survey used HDI > 0.8 as the cut-off to distinguish very highly developed countries from less developed, we have used the same cut-off in Figure 2. All countries in Africa had HDI < 0.8. It is possible that more men in physics may be undertaking more household work themselves in 2018 than in 2010 (the years of the surveys). However, it is difficult to be certain because the same respondents did not necessarily answer both surveys. There appears to be more employment of domestic workers apparent in the 2018 survey.




(a) 010 Physicists, HDI < 0.8 [1] (b) 2018 Physicists, HDI < 0.8 [14]

**Figure 2.** Household work in responses from physicists only. Colours indicate the same responses in (b) s in (a).

## 4. Conclusions and recommendations

We have shown some results which are relevant to fair treatment of physicists and of people in Africa from the Gender Gap project global survey of scientists. About a quarter of women in physics (29%) and in Africa (22%) report that they have encountered sexual harassment at first hand at school or at work. Given South Africa's history of gender-based violence, it is critical to overcome this problem, or to pre-empt it. The Gender Gap book contains a number of recommendations made at the final conference [2], from which, in the South African context, we select improved provision of safety for women on campus and at work, especially in circumstances where wi-fi is needed for study. The provision of both physical safety, and reliable bandwidth, in libraries, laboratories, offices and residences is vital in protecting women without compromising their education or work. From the same source, we recommend an ombudsperson, within universities or companies, who is a woman. Given the transformative nature of the physics community in South Africa and the concept of physics identity, we recommend building a culture within the physics community that combats harassment and violence of any kind.

It is heartening to note that in the survey of multiple disciplines, physicists reported the highest levels of respect from their colleagues. At the same time, women in physics are less likely than men to report that they are treated fairly in the doctoral programme or in employment, and less likely to report fair treatment by, and respect from, their co-workers. This extends to a reported lower availability of resources for women. Straightforward measures are recommended: monitor support, wellbeing,

mentoring and progress of female academics and students; make the selection processes transparent; noting that both female and male representatives on recruitment committees may have unconscious bias in favour of men, provide unconscious bias training; and make the gender lens the responsibility of a dedicated person on each selection or allocation committee. We recommend replacing the assessment of publications using a count of the papers of an individual by nomination of her or his 5 best papers [12]. In addition, charters and accreditations have proved to be successful aids to a welcoming departmental atmosphere [13], and the exploration of the concept of gender budgeting, which has already been used in sub-Saharan Africa by governments [3], should be encouraged.

Comparison of the 2010 and 2018 surveys for physicists indicate that, for lower HDI countries, there is a slightly larger percentage of men in 2018 indicating that they do their own housework. While the respondents may not be the same individuals in the two surveys, the evidence suggests a shift in the approach of male physicists to household responsibilities. The contributions of men in all aspects of improving the environment for women in physics are welcomed.

**Acknowledgments**

Figure 1 and tables 1 and 2 are adapted from the final report which appeared under a Creative Commons Attribution 4.0 International License. All authors were part of the project team. The funding for this project was provided by the ISC, IMU, IUPAC, IUPAP, IAU, IUBS, ICIAM, IUHPST, UNESCO, GenderInSITE, OWSD, and ACM[7]. The African Workshop was enabled by the African Institute of Mathematical Sciences and the ISC Regional Office for Africa. The authors thank their friends and colleagues across many countries who made this project possible.

**References**

[1] Ivie R and Tesfaye T L 2012 *Physics Today* **65** 47–50 http://dx.doi.org/10.1063/PT.3.1439
[2] Roy M-F et al. 2020 *A Global Approach to the Gender Gap in Mathematical, Computing, and Natural Sciences: How to Measure It, How to Reduce It?* (Berlin: IMU) DOI https://zenodo.org/record/3882609#.YQ_u-4gzY2w [Accessed 9 June 2020]
[3] Dlamini NJ 2021 *Critical Sociology* **474** 583–590
[4] Hellberg MA et al. 2004 *Report of the International Panel appointed by the Department of Science and Technology, the National Research Foundation, and the SA Institute for Physics, (Shaping the Future of Physics in South Africa)* (NRF: Pretoria)
[5] Hazari Z, Sonnert G, Sadler P M and Shanahan M-C 2010 *Journal of Research in Science Teaching* **47** 978–1003
[6] Ivie R and White S 2020 Measuring and analyzing the gender gap in science through the global survey of scientists, in [2] (Berlin: IMU) Chapter 2 pp 39–81
[7] World Economic Forum 2020 *The Global Gender Gap Index 2020* (Geneva: WEF) http://reports.weforum.org/global-gender-gap-report-2020/the-global-gender-gap-index-2020/
[8] United Nations Development Programme 2018 *United Nations Human Development Index* (New York: UNDP) http://hdr.undp.org/en/content/human-development-index-hdi
[9] Gender Gap in Science 2020 *Task 1: Global Survey of Mathematical, Computing, and Natural Scientists* https://gender-gap-in-science.org/work-packages/global-survey/
[10] White S and Ivie R 2021 *Pure and Applied Chemistry* https://doi.org/10.1515/pac-2021-0304
[11] Valian V 1998 *Why So Slow? The Advancement of Women* (Cambridge Mass: The MIT Press)
[12] Bjorkquist R, Gabrys B J and Gledhill I 2019 AIP Conference Proceedings **2109** 040003
[13] Working Group 5 IUPAP 2021 *The Waterloo Charter for Women in Physics* https://iupap.org/strategic-plan/diversity-in-physics-2/waterloo-charter-for-women-in-physics/
[14] Ivie R and White S 2021 Global Survey of Scientists: Results for Physics. Presented at 7th Int. Conf. on Women in Physics 11-16 July 2021 Melbourne, Australia