Physics and Humanity: the advancement of women in physics at universities

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Abstract. The physics community of practice has been active at many levels in promoting the advancement of women. However, the percentages of women in university departments remain generally lower in physics than in the life sciences. Arguments relating to teaching and research loads and work-life balance are comparable in these disciplines. This paper addresses the questions of why the advancement of women is relatively slow in physics, and why comparative numbers return to their former levels at the conclusion of initiatives to improve gender balance. Several useful concepts and recent changes are summarised. It is suggested that two relevant dominant factors that differ across these fields are perceived gender bias in the fields, and belief that innate talent is a prerequisite, combined with the stereotype that women do not possess this talent. Two global projects are cited, one of which is currently in progress.

1. Introduction
The proportions of women in physics across the globe are in most cases lower than the proportions of women in the life sciences. An example of the contrast among first qualifications may be provided from the Integrated Postsecondary Data Collection System of fractions of bachelor's degrees earned at universities in the United States of America (USA), showing that in 2015, the fraction of women earning degrees in physics was below 20%, while the percentage of women obtaining degrees in the biological sciences was approximately 60% [1]. As a complementary example at senior career levels, a survey of 69 national academies showed that the mean share of membership numbers by women in the biological sciences is 22%, while for physical and chemical sciences the mean share is 9% [2].

Vigorous initiatives have been in action across the globe for several decades within the physics community to increase and encourage the participation in physics by women. Summaries of the status and progress of women in physics may be found in the proceedings of many conferences, notably those held by the International Union of Pure and Applied Physics [3,4,5,6,7]. These cover a landscape of interventions, ranging from national laws, institutional policy, and departmental charters, through actions to improve the attractiveness of the workplace and improve selection practices, to finding best practice in teaching and learning to encourage girls to enter science and physics.
In this paper, we suggest a way forward for answering three questions: 1. What fundamental concepts are useful for physicists in understanding gender in science, and particularly, for increasing the participation of women in university physics through teaching and learning? 2. There appears to be a larger fraction of women in the biosciences, in comparison with physics. What can the physics community learn from the contrasts? 3. Why does the situation with respect to gender balance snap back towards a minority of women when initiatives come to an end?

A set of fundamental concepts is proposed for the first question. The focus of this work is on global or universal applicability, and is not the aim of this work to provide a detailed review of the many helpful practices that have been developed in different regions; these will be addressed in section 5.3. Two answers emerging from the literature are highlighted for the second question. A hypothesis for answering the third question is suggested as a basis for formal studies in the future.

2. Some useful concepts

In seeking to understand the difference between life sciences and physical sciences, a set of concepts from the broader literature prove to be useful. A few preliminary remarks are made at this stage.

In this paper, only binary gender is addressed. Many of the concepts affecting women and gender are applicable to other identities including race, and intersectionality. These are not addressed here.

Generalisation can be useful in achieving broad aims for women or men, but can also be offensive or polarizing. It is recognized that distributions of attributes and opinions exist within the broad group of women, and also that general conclusions drawn from the broader literature may be inapplicable to scientists, as a subset, but might form a reasonable starting point for enquiry.

The deep differences in culture across the globe have an influence on access to, and participation in, science. It has been stated that “knowledge of science and technology is universal, but it is shaped by local culture” [8]. Statements on the Universality of Science have been made by the International Council for Science and the International Union of Pure and Applied Physics. Broader aims are declared in Sustainable Development Goal 5 [9]. These statements are useful in understanding and motivating the participation of women in science.

It is essential in surveys of this kind for natural scientists to work with social scientists, and this has been done in the Global Survey of Physicists, through the Statistics Division of the American Institute of Physics, and in the current survey described below.

In contrasting the experiences of women and men, both groups should be considered; this is a point that is sometimes not taken into account in surveys. Both men and women become parents. The sharing of the responsibility of parenthood is one of the most controversial issues across the world. Change cannot be achieved by women alone; nor is the point of change to achieve dominance. The aim is to achieve better work environments for both men and women.

A concept that has been found to be particularly useful as a basis for understanding gender gaps is that of the schema. Gender schemas are hypotheses that affect the expectations of men and women, and their performance at work [10]. Negative aspects of schemas are familiar as stereotypes, but schema is a neutral term. Humans seek explanations of the physical and social phenomena around them; in physics, hypotheses are formed and tested, but in interpersonal interaction, schemas may go untested and unrecognized, even by physicists. The process of forming identity through social interaction is well captured by the saying known in South Africa: "Umuntu ngumuntu ngabantu" in Zulu, which conveys, in one interpretation, that we learn who we are through others. Two relevant schemas are the "agentic" schema, characterized by behavior that is proactive, independent, and assertive, and the "nurturative" schema, describing association with children, nurturing behaviour, and connection with soft issues. These two schemas may, in the work environment, be confused with gender schemas, leading to the assumption that the female physicists present should take the nurturing role rather than the agentic role. In the university context, an example may be given of the professor. The professor is expected to exhibit independence in research and teaching, assertiveness in relations with students, and proactivity on
behalf of the university and the department. The professor also guides young people, mentors students, and builds the collegial environment, and therefore fulfils nurturative roles. Being under-represented, or a minority, in the workplace enhances the possibility of encountering conflicting schemas. Misplaced schemas lead to under-evaluation, particularly of women [10].

Women are socialized with the same schemas as men. Unconscious bias has been shown to be exhibited by women as well as by men in selection of university staff. A frequently cited early study on this topic was carried out within the psychology community, in which curricula vitae were sent to university psychologists across the USA for consideration for a junior academic job, and for tenure [11]. Results showed that both men and women were significantly more likely to hire a man than a woman with an identical record for a junior post, at the time of the paper.

A particularly useful concept for minorities in the workplace is that of cumulative disadvantage [10]: minor inequities add up to long term consequences. Examples occurring in meetings are frequently related in anecdotal form by women, where their voices and contributions may be ignored – sometimes unconsciously – by a chair. More serious occurrences include allocating less challenging assignments to women, often with benevolent intentions.

Changes in academic circles and in the underlying society take place, and interventions that were historically important may no longer be relevant. A review in 2011 [12], aimed at understanding the underrepresentation of women in mathematics-related fields, encompassed discrimination in journal reviewing, grant allocation, and job selection in North America and Europe. Although change had been achieved by 2011 in comparison with 1970, numbers remained low in mathematics-related fields. Discrimination against women as authors of papers, grant holders, and in selection processes has been cited in earlier studies, but evidence in this study in 2011 indicated that these factors were no longer dominant. The authors concluded that in the region reviewed initiatives to combat discrimination against women had been successful; that given equal resources, men and women do equally well under review, in publishing, and in career development, but that underrepresentation could be attributed to differences in resources, abilities, and choices.

Choice, whether free or constrained by gendered expectations, is a critical factor in career development. The dominant issue identified in North America and Europe [12], in health sciences and sciences, at the time of publication was that women occupied positions with lower availability of resources. The authors link this to choices made by women of whether to raise children and when, whether to follow relocations of their spouses, whether to take on elder care, and how to manage work-home balance.

A plot of the percentage of women in a field against seniority or age is an informative tool. The present author has not yet seen data from any country in which the fraction of women in physics does not decline with seniority. The reasons why women leave fields at a higher rate than men are critical to this discussion and are part of the key to the debate.

It will be noted that the association of the nurturative schema solely with women is perpetuated in the work cited above. The implicit assumption that women are responsible for family care is prevalent in most societies. It is relatively rare to find national laws and institutional policies that do not assume that women are solely responsible for child care [13]. Interventions such as career breaks for child care, and "stopping the clock" for career breaks, are made available to women more frequently than to parents of either sex. Gender stereotyping is reinforced, rather than mitigated, in this way.

To combat the "outsider" identity often encountered by women, the "physics identity" concept has been used to cover the developing understanding of one's own learning and the transition from "physics student" to "physicist" (a review will be found in [14]). Physics identity overcomes the "outsider" identity for many women.

A critical part of developing a sense of belonging in the field and ownership of the physics program is related to the welcoming atmosphere in the departments encountered. The concepts were well-set out in the Spin-Up review [15], which established workable guidelines and interventions.
for encouraging women and underrepresented populations to study physics in the USA. In the United Kingdom (UK), Project Juno developed a Code of Practice that may be voluntarily adopted by departments. The International Union of Pure and Applied Physics (IUPAP) Working Group on Women in Physics is developing the Waterloo Charter, and the Baltimore Charter has been formulated for astronomy. A number of physical societies have developed helpful guidelines on, for example, career break management [16].

The field of intersectionality examines how systems of power interact in the marginalization of communities. An example is found in the work of Buolamwini and Gebru [17] cited below, in which the confidence with face recognition makes correct identification varies with both sex and skin tone.

Many physicists live and work in countries with significant poverty. In many cases, they have succeeded in making a new life for themselves and their families through engagement with the sciences. Inclusion of countries with diverse economic conditions in the scientific community, through international organizations, publishing practices, conferences and collaboration, is an important part of the development of science as a whole.

Once again, it is important to emphasize the interventions fail if they do not make the work environment better for all, and not just for women. The factors identified by Jordan et al. in 2003 [18] are still relevant today, and specifically include respect for people and commitment to critical thinking.

3. The Global Survey of Physicists, 2011

Although a large literature on gender in science exists, there is very little globally consistent information. It has been the practice of the IUPAP Working Group on Women in Physics to make sure that as many countries are represented at conferences as possible, especially including developing countries, countries with few physicists, and island states. In parallel, a limit has been placed on the size of teams from developed countries, unless the said team raises funds for developing country travel grants. In this manner the voices across the globe are heard in an equitable manner.

As a result of discussions in this environment, a global survey of the experiences of both men and women in the field of physics was undertaken in 2010-2011 [19], and forms part of the background for this paper. The survey was available in eight languages. The final number of respondents was 14,934, covering 130 countries. Results were contrasted for less developed and very highly developed countries, using the prevailing United Nations definitions for those terms.

The survey addressed educational background, early career experiences and current employment, and the balances between marriage, career, family and housework. The results provide valuable data on which to base decisions. For example, there was a stark contrast between the percentages of women and men who has significant breaks in their doctoral studies, the data being limited to those who had their first child during these studies. Career breaks affected 55-65% of women, and 15-30% of men. The implications include the recognition of career breaks, the provision of advice on how to manage career breaks, and care in the definitions of "Young Scientist" awards. It had also been suggested that excellence can be assessed using performance proxies other than counting papers. These and similar factors, however, do not address the difference between life science and physical science numbers.

Work on the reasons why the percentages of women fall with seniority prompted questions on the resources available to the respondents. Even when data are corrected for cohorts, this survey showed that women reported significantly fewer opportunities to give an invited talk, attend a conference abroad, conduct research abroad, act as a manager, serve as a journal editor, serve on grant agency committees or institute or company committees or organizing committees, advise graduate students, or serve on thesis committees. Women and men reported comparable opportunities to advise undergraduate students, confirming the nurturative schema for professional women.
The Global Survey of Physicists did not provide numbers and percentages of women in physics, except in cases where a physical society or country worked with the surveying social scientists to provide an acceptable sample, but was focussed on similarities and contrasts in the experiences of women and men in the field. This survey did not seek to contrast disciplines, but this is a goal of the next project, covered in section 5 below.

A new global survey is needed to guide actions. Eight years have passed since the Global Survey of Physics. Many, many initiatives have been directed towards increasing the participation of women in science and physics, and it is hoped that they have had impact.

4. Recent developments

4.1. Global

The global environment for women, and for women in science, is changing. The effects are felt in both highly developed and less developed countries.

Some key geopolitical issues that affect women are as follows [20]. An "abandonment of the liberal order" is observed in many countries. A political culture in which debate is framed largely by appeals to emotion, disconnected from the details of policy, and by the repeated assertion of talking points to which factual rebuttals are ignored ("post-truth politics"), makes evidence-based reasoning difficult in some contexts.

Science funding has dropped in some of the leading nations of the highly developed world. During times of high economic threat, prejudice rises significantly. It is likely that in countries where evidence-based reasoning is deprecated a return to conservative gender schemas in allocating science funding will be experienced.

The Middle East has suffered renewed violence, as has the "conflict belt" in Africa. These have resulted in the need for academics to relocate, particularly when cultural changes mean that educated women and girls are in danger.

There is now clear evidence that the earth's climate is changing rapidly. Climate change has been shown to have more impact on the lives of women than on men [21]; disasters kill more women than men, especially where the socioeconomic status of women is low. Health risks show gender differences, and women and girls disproportionately suffer malnutrition when food security and water security are affected. It is expected that mass displacement will exhibit a gender gap as well.

A growing voice against sexual harassment is being heard across the globe. A recent inter-academy report recommends going beyond compliance responses, and focusing on culture in academia; scientific societies have a role to play in changing this aspect of culture [22].

4.2. Selected recent developments of interest

It appears that the percentages of bachelor's degrees awarded to women is declining. This trend is visible from 2005 onwards in, for example, data collected by the American Physical Society for universities in the USA [1].

A recent study on college choices in the USA sought the common attributes that cut across academic disciplines that are predictive of the choice of major subjects in bachelor's degrees [23]. While only 20 university subjects participated, the results may be of interest in wider studies. Choice was explored based on the extent to which each major was perceived to exhibit each of six specific traits: maths orientation, science orientation, gender bias against women, helpful orientation, money orientation, and creativity orientation. Perceived gender bias against women was the dominant predictor for choice of majors in this study.

Comments on the nature of prejudice have been made above, but new developments are taking place with the increased use of Artificial Intelligence (AI). It has been demonstrated that the accuracy of gender classification in machine vision applications is dependent on the diversity of the training sets [17]. Machine bias, programming that assumes the prejudice of its human creators through its algorithms or data sets, may be having effects in AI applications. Examples are in
screening job applicants, or in providing browser advertisements online. The consequences are that women may be presented with more opportunities for nursing while men are provided with openings for doctors, because "nurse" correlates with "female", and "doctor" with "male", in the training sets. Similarly, it may be assumed that "John will make a better computer programmer than Mary". A body of work on the subject is growing through groups such as FATE: Fairness, Accountability, Transparency and Ethics in AI.

The assumptions built into AI are examples of logical fallacies, notably the appeal to tradition ("this is right because we have always done it this way") and the appeal to probability ("we can take this for granted because it is probably the case"). Both fallacies have surfaced in recent debates about the inclusion of women in high-energy particle physics [24].

The availability of jobs across disciplines is of rising importance in the choice of a career. The transformation of society in Africa is at present centred on escaping the experience of poverty. Funding for degrees across disciplines is keenly researched by students in terms of supporting an extended family, and the possibility of bringing income home is a paramount consideration. Students are vocal about their needs for entrepreneurship skills, analytic skills and strategic career skills. These needs can in part be met by showing how jobs are reachable, emphasizing local relevance, and providing industry speakers and site visits. Students want to know what research is being done, and how it gets done.

Several publications have dealt specifically with the contrast between physics and the life sciences. Ecklund et al. [25] performed a wide survey of scientists in the two fields. The study explored sex-typing (the notion that some jobs are more appropriate for men or women only) and master status (status that has exceptional importance for social identity). In terms of explanations of the difference in numbers related to choice, the study found that men and women had few differences in terms of natural aptitude, but that women were inclined to rate their own performance lower than men with the same aptitude. Professional role confidence plays a significant role in career selection.

Perception of the time commitment required differed between physics and biology; there is a perception that a career in life sciences may be more compatible with family than one in physics. A sense of isolation was reported for the physics environments, while there was certainly a perception that women were evaluated less favourably than men due to implicit bias in physics. Fields with a low fraction of women may present fewer role models, and therefore may present a different view of the career environment to students. The conclusions of the study were the following. First, gender was a salient predictor of the biology-physics choice, and that this is influenced by perceptions of mentoring and discrimination. Secondly, more than half the women in the study had experienced attempted discouragement form pursuing physics at some stage. Third, gender appeared to be the master status influencing the choice of major, rather than scientist identity. In terms of the loss of women from the fields, it was suggested that juniors may not encounter discrimination until they decide to start a family, and that having then encountered significant discrimination, they quickly decide to leave.

It is critical that interventions make the environment better for both women and men. It is rare, at present, to find publications that consider the experiences of men in terms of gender. However, the changing roles of men in the USA, specifically in biology and physics, have been explored by Damaske et al. [26]. The authors have found changing norms of fatherhood among men in the USA, with an increasing belief that that home life is not the sole concern of women. A growing number of men seek egalitarian relationships at home. They experience difficulty in finding work-family balance, and seek flexible academic environments.

It is not yet clear whether the relative fractions of women in biology and physics are related to differing attrition rates. Martinez et al. (2017) [27] have found that women report more gender-based discrimination and sometimes harassment, fewer external job offers, and fewer internal retention offers than their male counterparts.
New work has been performed which implies that expectations of a cardinal role for innate talent are higher in physics than in biosciences. These combine with stereotypes that women lack the high-end aptitude for mathematics and physics [28]. The study surveyed practitioners across academic disciplines and concluded that the perception of the requirement for brilliance outweighed both the ability to work long hours, and the perception of a field as systemizing or empathizing in nature. A correlation was found between the representation of women in a field and the extent to which practitioners believed that success depends on sheer brilliance in that field. Prejudice related to innate talent also surfaces in work by UNESCO [29].

5. The Gender Gap in Science Project

In 2016 the International Council for Science (then ICSU, and now ISC) funded three collaborative projects. One of these is "A Global Approach to the Gender Gap in Mathematical, Computational and Natural Sciences: How to Measure it, How to Reduce it?". This project has eleven international partners. The project [30] is led by the International Mathematical Union IMU, with IUPAC (the International Union of Pure and Applied Chemistry) and IUPAP as executive partners. The project partners include in addition IAU (Astronomy), ICIAM (Industrial and Applied Mathematics), IUBS (Biological Sciences), UNESCO (United Nations Educational, Scientific and Cultural Organization), IUPHPST (History and Philosophy of Science and Technology), ACM (Computer Science), GenderInSite (Gender in Science, Innovation, Technology and Engineering) and OWSD (Organization of Women for Science for the Developing World).

The project consists of a global survey of mathematical, computing and natural scientists, a joint data-backed study of publication patterns, and a database of good practice for girls and young women, parents, and organisations. It may well shed light on similarities and contrasts in the experiences of women and men in different disciplines, and provide insight into the questions asked above – particularly about contrasts between the life sciences and the physical sciences.

5.1. Survey

The survey is designed to provide longitudinal results in conjunction with the earlier Global Survey of Physicists, described above. Particular care was taken to expand the earlier survey. Both surveys are based on snowball samples, and are not intended to provide percentages of women in disciplines or fields. It is noted that this role is complementary to that of quantitative surveys, including the UNESCO SAGA surveys [31, 32], and work on comparing the types of survey is likely to yield insight.

The survey was translated onto English, French, Chinese, Japanese, Russian, Spanish, and Arabic. Because this work covers global cultures and diverse scientific communities, particular care was taken to make sure that the questions were likely to reflect the realities of life across the continents. Three regional workshops were held, in Africa, Asia, and Latin-America and the Caribbean. A principle of the project is that it includes men as participants, organizers and representatives at the workshops. The participating countries were, in South Africa: Algeria, Burkina Faso, Botswana, Cameroon, Ethiopia, France, Kenya, Lesotho, Morocco, Madagascar, Malawi, Nigeria, South Africa, Swaziland, Uganda, United States and Zimbabwe; in Taiwan: Australia, China, France, India, Israel, Japan, Korea, Nepal, Malaysia, Taiwan, Thailand, and United States; and in Colombia: Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, El Salvador, Mexico, Peru and United States.

Each workshop provided additional insight to relevant questions. In Africa, participants requested that questions on career disruptions should include health, conflict, natural disasters, and other continent-specific answers, and Arabic was added as a language. In Asia, an emphasis on participants in industry emerged and the survey was expanded to included professionals and industrialists. In Latin America and the Caribbean, a focus on youth and young scientists emerged from an exchange session on the special needs of young people.

The survey was released in May 2018 [30]. Translation and analysis will take place in 2019.
5.2. Joint data-backed study on publishing patterns
The Gender Gap project is also based on recent work by data scientists Mihaljević-Brandt et al. (2016) [33]. In this recently published study, the relatively low percentage of women publishing in mathematical journals was highlighted. The new study covers all the collaborating disciplines, and once again it is hoped that insights about the gender gap in different disciplines will emerge. Since the gender of authors is rarely among required or volunteered data in scientific publications, the project uses gender inference application programming interfaces (APIs) to deduce estimated gender from the names of authors, together with a weighted certainty of assignment. In the first study, acceptable confidence for 61% of the authors identified was achieved. A significant part of the work is the evaluation of the methods used, as stressed in section 4.2 above, and new error metrics and constraints have been devised.

5.3. Database of good practices
The communication of the findings from the tasks above is intended to support good choices of interventions and initiatives, with relevance to the culture from which the data in the surveys is drawn. At the same time, it is recognized that initiatives are routinely reinvented, and seldom professionally evaluated. Therefore, as task to collect and maintain a database of published evaluated interventions aimed at increasing the participation of girls and women in science. This is motivated by the desire to make the efforts of one region available to another, to share the effort involved, and to increase confidence in the choice of interventions.

Better career guidance is an additional aim of this task, with emphasis on how to reach the key advisors in the career choices of girls: parents and teachers. This third task is deeply challenging.

6. Conclusions
Three questions were posed above, in the context of teaching and learning at universities, and particularly the representation and progress of women in university departments in physics.

The first question asked what fundamental concepts are useful for physicists in understanding gender in science, and particularly, for increasing the participation of women in university physics through teaching and learning. The set of concepts introduced above was aimed at providing a basis for the next two questions.

For the second question, there are indubitably lessons to be learned by the physics community from its life sciences counterpart. The deterring factor of perceived bias in physical science departments has been explored in an early study and warrants further investigation. The studies cited above comparing physics and biology provide direct suggestions for physics. The need for a welcoming environment in physics departments is clear; the nature of the department needs to become attractive to students. Policy is useful, but may not be as immediately influential from the point of view of the students as the apparent character of the department. Policy can be made when necessary, if the atmosphere is one in which issues can be raised. The principles in the Spin-Up review are recommended for helping students to join the discipline and take ownership of physics for themselves, as well as developing a physics identity that grows in relation to the gender identity.

Departments are able to improve and assess their own progress with respect to success in reducing the gender gap with the aid of Codes of Conduct, such as the Juno Code, the Waterloo Charter, or the Baltimore Charter in astronomy.

An emphasis on the practical application of physics is critical for students who love the subject but must support an extended family in order to escape from economic hardship. In these cases, graduate bursaries that are competitive help students to complete higher degrees before they are forced into the labour market. Field trips and industrial speakers, as well as early exposure to research, assist students to assess the marketability of their skills and their career prospects. Physics departments can help by offering introductions to entrepreneurship skills, analytic skills and strategic career skills. Some knowledge of employment opportunities can be provided by
emphasizing local relevance, sourcing industry speakers, providing site visits, and introducing research at early stages.

Recognition that female students in physics have a greater need for support and mentorship than their male colleagues is an important point. This does not imply that men should receive less support; on the contrary, as masculine schemas change, and the role of men in fatherhood evolves, both men and women need support in a changing world. Work-family balance is important for both.

It would be of interest in future studies to locate data for comparison of the rate of academic turnover across the two disciplines [25]. Certainly, it has been concluded that reducing discrimination, preventing and addressing harassment, and increasing retention offers will assist in reducing the attrition rate for women. Serious searches for female candidates to increase the selection pool has been shown to be successful. These actions are firmly in the province of departmental leadership.

The expectations of innate brilliance in a field, combined with a stereotype that women lack innate ability in mathematical sciences, appear to affect the career choices of women. Studies in this field recommend de-emphasizing brilliance in physics and highlighting sustained effort. The present author suggests serious efforts to encourage women to express brilliance, combined with objective recognition of their successes.

In connection with the third question, evidence concerning the fact that the participation of women snaps back to earlier levels once initiatives cease is largely anecdotal. Evidence-based studies would be useful. However, exploration using the concepts above suggests that the hypothesis might be that the participation of women declines for several reasons: (1) the underlying culture has not changed in terms of its former gender schemas, (2) former schemas have been given new expression in a shifting political landscape, or (3) the incursion or imposition of a culture which denies freedom and education to women has reduced opportunities for women, and in the worst case has caused academics to flee from conflict. The results of Ceci et al. [12] not only indicate that the underlying causes of underrepresentation had changed from 1970 to 2011, but imply that changes must be considered as time passes and that effort should not be wasted on initiatives based on historical data. Similarly, it can be noted that different cultures and countries are facing different challenges, and may be at different stages in the evolution of the entry of women into science. Current initiatives should not be directed toward solving problems of the past, rather than current problems, and evidence is necessary in order to choose relevant initiatives. The evidence that men are assuming different roles in parenthood is an indicator that benevolent intentions directed toward parents should not be limited to women. Gender stereotyping should not be perpetuated; unintended consequences should always be investigated before policy or law is promulgated.

Scientific societies have significant roles to play in nurturing a developing culture of inclusion in physics.

The Global Survey of Physicists indicated significant gaps in access to resources and experience between women and men. It will be of considerable interest to discover how this gap has evolved in the years from 2011 to 2019. It is hoped that it will be possible to discern, from the results of the Gender Gap survey, which aspects are dominant in contrasts between physics and biology, and what has occurred when initiatives to support women are known to have ceased. It is hoped that the Gender Gap project will shed light on what interventions are appropriate for the next decade in different cultures and regions.

The vision for the future of physics in terms of gender is that welcoming departments will succeed in maintain a gender balance among staff and students, across the global community.

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