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PERSPECTIVE

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Making gender diversity work for scientific discovery and innovation

Mathias Wullum Nielsen[1]*, Carter Walter Bloch[1] and Londa Schiebinger[2]

Gender diversity has the potential to drive scientific discovery and innovation. Here, we distinguish three approaches to gender diversity: diversity in research teams, diversity in research methods and diversity in research questions. While gender diversity is commonly understood to refer only to the gender composition of research teams, fully realizing the potential of diversity for science and innovation also requires attention to the methods employed and questions raised in scientific knowledge-making. We provide a framework for understanding the best ways to support the three approaches to gender diversity across four interdependent domains — from research teams to the broader disciplines in which they are embedded to research organizations and ultimately to the different societies that shape them through specific gender norms and policies. Our analysis demonstrates that realizing the benefits of diversity for science requires careful management of these four interdependent domains.

Gender diversity is increasingly the norm in scientific work. Women and men already share laboratories, research facilities and work spaces in most disciplines, and universities and science policymakers see gender diversity as a key driver of excellence and innovation[1–6]. Yet, gender diversity comes with both challenges and opportunities. Careful management is required to maximize the benefits of diversity for scientific discovery.

This Perspective distinguishes three approaches to gender diversity: diversity in research teams, diversity in research methods and diversity in research questions (Fig. 1). Gender diversity is commonly understood to refer to the gender composition of research teams. However, fully realizing the potential of diversity for science and innovation also requires attention to diversity in research methods and in research questions.

Importantly, gender diversity functions within larger research contexts. In the second half of this paper, we provide a framework to understand how the three approaches to gender diversity function across four interdependent domains: research teams, disciplines, research organizations and societies at large (Fig. 2). In each of the four domains, we evaluate potential drivers and barriers to gender diversity. Understanding the interplay between our three approaches to diversity and how they function within institutional frameworks will assist universities, funding agencies, industries and governments to harness the power of diversity for discovery and innovation.

This Perspective integrates insights from multiple disciplines, including social psychology, management and social studies of science and innovation (search methods are specified in the Supplementary Notes and Supplementary Tables 1 and 2).

Many organizations understand the importance of increasing women's participation in science and technology, and, increasingly, funding agencies are emphasizing the value of bringing diverse methods, such as integrating sex and gender analysis, into research design. Crucially important also is being attuned to the novel research questions newcomers to traditional disciplines might bring. This attention to diversity goes well beyond the dynamics of the research team itself and needs to be fostered by disciplines, research organizations and societies at large.

Three approaches to gender diversity

In this section, we distinguish three approaches to gender diversity: diversity in research teams, diversity in research methods and diversity in research questions.

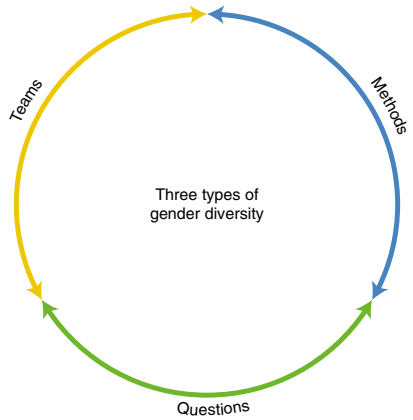
Diversity in research teams. The best-understood approach to gender diversity concerns the composition of research teams. Diversity refers here to the different ideas, beliefs and perspectives that women, men and gender-diverse people bring to the team. The possible benefits of gender diversity are linked to cognitive diversity, conceptualized here as the different ways in which "people represent problems and go about solving them in team work"[7]. Research suggests that cognitive diversity can heighten creativity and encourage the search for novel solutions[8,9]. Experiments indicate that teams comprised of diverse problem-solvers can outperform teams that prioritize best-performing individuals[7].

Gender-diverse teams may, however, encounter higher levels of conflict than more homogeneous teams[10]. Careful team management is therefore imperative to reap the possible benefits of diversity (we return to this in the discussion of the four interdependent domains for scientific discovery and innovation).

The impact of gender diversity on team performance has been analysed extensively in laboratory studies and in corporate and public organizations, but not in science[11–13]. The few existing studies focusing on gender diversity in scientific teams typically evaluate research outcomes based on citation rates, publication productivity and patents. Surveying research from 2006 to 2015, we found eleven studies on team performance in research and innovation. Six studies examined research in for-profit research and development (R&D) firms[14–19] (Table 1), and, of these, five found possible benefits of team gender diversity for innovation and technological performance (measured by patents). Five of the original eleven studies focused on academic science[20–24], and two of these found possible benefits of gender diversity — one with respect to citation impact; another with respect to publication productivity. The remaining studies showed no notable effects of gender diversity.

Yet, gender diversity in teams may influence research outcomes in important ways not captured using traditional, bibliometric

[1]Danish Centre for Studies in Research and Research Policy, Department of Political Science, Aarhus University, Aarhus, Denmark. [2]History of Science, Stanford University, Stanford, CA, USA. *e-mail: mwn@ps.au.dk



	Teams	Methods	Questions
Focus	Gender composition of research teams	Integration of GSA into research design	Changes in research questions and priorities
Evaluation	Assess the numbers of citations, publications, patents, and so on	Analyse the proportion and quality of GSA in funding proposals and publications	Map large-scale patterns in the topics addressed and questions raised in research
Future research	How does team diversity contribute to the social impact of research?	What is the value of GSA to society in terms of human well-being and economic impact?	Will increasing the numbers of women change research questions, or will changing questions increase the numbers of women in research?

Fig. 1 | Three approaches to gender diversity. Each approach to diversity — diversity in research teams, diversity in research methods and diversity in research questions — has a distinct focus, modes of evaluation and opportunities for future research. The double-ended arrows indicate that these three approaches mutually influence one another; improvements in one likely lead to improvements in the others.

approaches to science evaluation. An underexplored avenue for evaluation concerns the societal relevance of research. The past 20 years have seen increasing emphasis on socially responsible science. The European Commission (EC) has, for instance, increased its emphasis on 'responsible research and innovation' as a cross-cutting theme in its funding programmes. Similarly, the US National Science Foundation combines the assessment of scientific quality with 'broader impacts' in funding proposals. Both agencies call for increased attention to the societal benefits of research, including disseminating results to a broad public, involving potential end-users in scientific knowledge-making and addressing pressing societal challenges. Future research should investigate whether and how team diversity, given its potential for integrating different ideas, beliefs and perspectives into scientific team work, contributes to these agendas.

Diversity in research methods. A second approach to gender diversity concerns diversifying research methods through gender and sex analysis (GSA). An increasing body of literature develops state-of-the art methods for GSA. The best known is the Gendered Innovations project (http://genderedinnovations.stanford.edu/; see also refs [25–29]). Integrating GSA into research design can lead to new insights that enhance the external validity and precision of scientific research with human outcomes. For example, osteoporosis was traditionally considered a disease of post-menopausal women — an assumption that has shaped its screening, diagnosis and treatment. Considering GSA has led to reconceptualizing osteoporosis research to include men. After age 75, men account for one-third of osteoporosis-related hip fractures[30]. Other well-known examples (or case studies) include heart disease in women, pregnant crash test dummies, machine translation, genetics of sex determination and water infrastructure for sustainable development (http://genderedinnovations.stanford.edu/).

There are numerous ways to evaluate how GSA may influence research outcomes. First, granting agencies' policies can be examined to see whether GSA is included as a funding criterion. A review of agencies in Europe, the United States and Canada reveals that at least 12 public and private foundations have GSA policies in place[31]. Drilling deeper, reviewers can calculate the proportion of proposals submitted to these agencies that integrate GSA. The Canadian Institutes of Health Research, for example, found that 48% of submitted proposals included GSA in 2011 (one year after the Canadian Institutes of Health Research implemented their policy encouraging GSA), with the proportion increasing over time. Importantly, this evaluation found that the prevalence of GSA varied across disciplines, with the highest in clinical and population health research and the lowest in biomedical research[32]. The EC is taking the further step of developing processes for evaluating the quality of the GSA in submitted proposals[33].

Second, peer-reviewed publications can be analysed for GSA. The EC has evaluated publications for GSA by scientific field and country[34]. As might be expected, the highest proportion for 2010–2013 was found in the social sciences (7%), health sciences (4%) and humanities (3%), with the natural sciences and engineering showing 0%. The Nordic countries (Denmark, Finland, Iceland, Norway and Sweden), recognized as global leaders with respect to societal gender equality, stood out as top performers, especially in the health sciences and social sciences. In comparison, large European countries such as France, Germany and Italy scored below the European country average on this measure.

Third, future research might develop methods to evaluate the value of GSA to society — in terms of human well-being and economic impact. Doing research wrong costs lives and money. Between 1997 and 2000, ten drugs were withdrawn from the US market because of life-threatening health effects. Eight of these

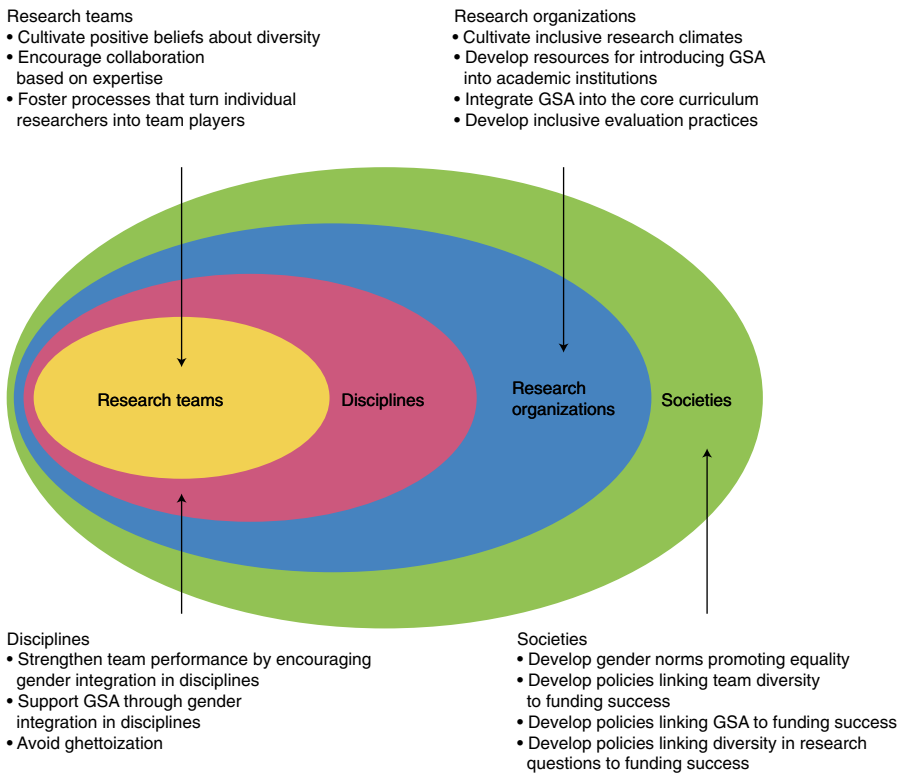


Fig. 2 | Four interdependent domains. Specific management techniques in each domain — research teams, disciplines, research organizations and societies at large — are crucial to foster the benefits associated with gender diversity in research teams, in research methods and in research questions.

posed "greater health risks for women than for men"[35]. Not only does developing a drug in the current market cost billions, but also when drugs fail, they cause human suffering and death. By contrast, an analysis of the US Women's Health Initiative Hormone Therapy Trial — a large government-funded trial in the 1990s to determine the benefits and risks of oestrogen supplements in postmenopausal women — found that for every $1 spent, $140 were returned to US taxpayers in healthcare savings. Study findings also saved lives: there were 76,000 fewer cases of cardiovascular disease, 126,000 fewer diagnoses of breast cancers and 145,000 more quality-adjusted life years. While most of the results were positive, the analysis did find 263,000 more osteoporotic fractures[36]. As demonstrated by these examples, careful attention to the societal benefits of GSA represents a promising area for future assessments of research impact[37].

Diversity in research questions. The third and final approach to gender diversity concerns diversity in research questions. Here diversity is evaluated by exploring how the entrance of new actors into scientific disciplines (whether women into traditionally male disciplines, such as biomedicine, or men into traditionally female disciplines, such as nursing) influences research priorities and agendas (or vice versa). This approach measures links between changing gender demographics and changes in research questions and priorities. It rests on the assumption that social norms and expectations cultivate variations in the interests and perspectives of women, men and gender-diverse individuals, and that increased variation in interests and perspectives can broaden agendas and discoveries[38].

While existing research demonstrates notable gender differences in primary areas of specialization within disciplines[39–43] (Supplementary Table 3), no studies have (to our knowledge) systematically investigated to what extent increasing gender diversity can be linked to developments in the types of research questions asked.

Answering this question would require careful attention to confounding factors, such as changing societal gender ideologies, changing funding priorities, the role played by social movements in altering scholarly agendas, and differences in the social and intellectual organization of disciplines.

Historical examples, however, suggest that women's headway into traditionally male-dominated disciplines has coincided with expanding research agendas. For instance, during the 1980s and 1990s, the proportion of women entering US academic medical research accelerated[44] and the attention increased to traditionally under-researched areas of women's health, such as heart disease, breast cancer, urology and autoimmune diseases[45,46]. Similarly, the rapid growth in women primatologists in the 1970s and 1980s coincided with key scientific breakthroughs and new paradigms debunking traditional sex-based stereotypes about primate behaviour[47]. Social science areas have also seen the emergence of new topics (and reconsiderations of existing research questions) over the past 30 years as women entered the disciplines. History, for instance, now includes topics such as women's history, gender history, history of the household and history of sexuality.

Which came first, the openness of disciplines to new questions or the increase of women in these fields[48]? Presumably, the influence flows in both directions; but we need carefully designed longitudinal studies, comparing stepwise developments over time, to resolve these questions empirically. Recent advances in computational text analysis show great promise in quantifying the effects of gender diversity on research questions.

As demonstrated by the double-ended arrows in Fig. 1, the three approaches to diversity outlined above mutually influence one another: improving one likely leads to improvements in the others. A new observational study focusing on the medical sciences, for instance, demonstrates that research papers systematically deploying GSA typically involve more women authors

Table 1 | Literature on gender diversity in research teams focusing on for-profit R&D work settings and academic work settings, 2006–2015

Reference	Discipline and sector	Country	Sample	Focus	Period	Data	Result
[14]	R&D: multiple sectors	Spain	4,277 firms	Gender diversity in R&D teams and innovation performance	2007	National panel data on the technological innovation activities of research-intensive companies	Accounts for contextual factors such as external R&D expenses, technology intensity, and team and firm size, and finds a positive, statistically significant correlation between gender diversity and radical innovativeness (that is, the creation of innovations that are new to market).
[15]	R&D: multiple sectors	Singapore	938 firms	Gender diversity in R&D teams and technological performance	2008	National survey of R&D in Singapore. Dependent variable: ability of firms to apply for patents	Fails to detect a statistically significant link between gender diversity and technological performance. Yet, when team gender diversity increases, the positive impact of having an educationally diverse workforce decreases.
[16]	R&D: manufacturing	Spain	30,327 team observations	Gender diversity in R&D teams and product, service and process innovation	2005–2011	National panel data on the technological innovation activities of Spanish manufacturing firms	Controls for variations in functional expertise and finds a positive correlation between gender diversity and service innovation. Moreover, the study reports a statistical association between group gender diversity, product and process innovation assuming the form of an inverted U: when gender diversity reaches a certain threshold, its influence will change from positive to negative. The study does not provide exact estimates for this threshold.
[17]	R&D: multiple sectors	Denmark	1,775 firms	Gender diversity in R&D teams and innovation	2003–2005	Survey and register data on organizations, employees and R&D strategies in Danish firms	Shows a strong positive correlation between gender diversity and innovation.
[18]	R&D: manufacturing	Spain	17,748 observations	Gender diversity in R&D teams and work performance, service, product and process innovation	2008–2011	Panel data on the technological innovation activities of Spanish companies	Shows a positive association between gender diversity and service, product and process innovation. However, the association assumes the form of an inverted U. When gender diversity reaches a certain threshold, its influence will change from positive to negative.
[19]	R&D: multiple sectors	International	3,812 observations	Gender diversity in R&D teams and work performance	2004	Archival data concerning individual bonuses for successful research achievements and annual ratings of project and team efforts in Air Liquide, Électricité de France, Shell and Schlumberger	Finds that gender diversity is positively associated with both individual and collective performance, but the statistical effects are modest.

Continued

Table 1 | Literature on gender diversity in research teams focusing on for-profit R&D work settings and academic work settings, 2006–2015 (Continued)

Reference	Discipline and sector	Country	Sample	Focus	Period	Data	Result
[20]	Academic: environmental studies	United States	157 research groups	Citation performance	1996–1998, 2005–2007	Citation data from papers authored by gender-diverse and same-gender research teams	Finds that gender-diverse author groups, on average, receive 34% more citations per paper than same-gender author groups.
[21]	Academic: natural sciences and engineering	United States	311 scientists distributed on 52 teams	Utilization of women's expertise in scientific team work	Two years	Survey questionnaire and performance data (publications, conference proceedings, presentations and citations)	Finds that women's participation in team collaboration is a statistically insignificant predictor of team performance. Finds that women researchers are more productive and more likely to contribute towards team goals in disciplines with relatively high proportions of women faculty. Does not establish a clear direction of causality.
[22]	Academic: medicine	International	469 articles, 1,354 authors	The emergence of the new biomedical subfield 'oncofertility'	2007–2010	Article metadata from PubMed and Web of Science	Finds that innovation, operationalized as early publications in the emerging research area 'oncofertility', does not benefit from group gender diversity or group gender homogeneity.
[23]	Academic: multiple disciplines	Spain	Approximately 155 teams	Publication rates	2006–2009	Publication data for 155 teams at a Spanish university	Reports a moderate, positive link between gender diversity and number of publications in national peer-reviewed journals. Finds no notable diversity effect for international journals.
[24]	Academic: physics	United States	1,415 experiments	Publication rates	2005–2009	Research outcomes (publications) from 1,415 experiments at the National High Magnetic Field Laboratory	Does not find a statistically significant association between team gender diversity and publication productivity.

(including first and last authors) than papers not capturing this dimension[49].

Yet, getting the most out of gender diversity requires careful management. As elaborated below, inclusive research teams, disciplines, organizations and societies foster work settings where both gender diversity and scientific discovery flourish.

Four interdependent domains for discovery and innovation

Gender diversity functions within broader contexts. In this section, we analyse research processes in four interdependent domains (Fig. 2): research teams, disciplines, research organizations and societies at large. In each of the four domains, we highlight what can be done to achieve the benefits associated with gender diversity in research teams, in research methods and in research questions. We provide further detail on the empirical literature concerning gender diversity reviewed in this section in Supplementary Table 4.

Research teams. Social psychological and management research suggest that demographic diversity — in terms of gender, ethnicity and age — can incur potential costs to organizations by increasing conflict among team members. Scholars subscribing to this argument typically emphasize the interpersonal biases (for example, negative stereotyping and in-group favouritism) spurring friction in gender-diverse collaborations (for a review of studies pertaining to the 'diversity-as-process-loss argument'[50] see refs [51–53]). A growing body of research, however, finds that careful team management can mitigate such effects and support positive outcomes.

Cultivate positive beliefs about diversity. Research suggests that team members' beliefs about the potential benefits of gender diversity are crucial for positive performance outcomes. One experimental study found that gender-diverse teams persuaded to believe in the benefits of group diversity were better at solving complex problems based on heterogeneous information than gender-diverse teams persuaded to believe in the benefits of group homogeneity[54]. Another study based on survey data found that openness to diversity was strongly associated with performance in gender-diverse research teams[55]. Likewise, survey-based research has demonstrated a positive link between team members' openness to diversity and the functioning of collaboration processes in gender-diverse groups[56,57]. These examples highlight the importance of cultivating positive beliefs about diversity in research collaborations.

Encourage collaboration based on expertise. In a study of 55 interdisciplinary research groups, Joshi and Knight[58] examined associations

between different motivations for team-member interaction — recognition of expertise versus social affinities — and team productivity. Combining survey data, archival data and publication data, they found that team productivity was higher where team members deferred to other team members based on expertise and experience than in units where team interactions were driven by members' social affinities, such as gender or ethnicity[58]. Managers need to keep teams focused on the contributions each member has to make in terms of task-specific expertise.

Foster processes that turn individuals into team players. Experimental and survey-based research has also demonstrated the importance of turning individual researchers into team players. Four processes in particular have been shown to mitigate potential conflicts in gender-diverse groups: team identification (that is, members' compliance with team norms and conventions), transparent team processes (that is, teamwork characterized by clear coordination and communication), team efficacy (that is, team members' belief in their combined collaborative ability to solve a given problem) and openness to experience (that is, team members' openness to new and unfamiliar ideas and experiences)[59–61].

Future directions. Careful management of research teams is crucial for reaping the greatest benefits from gender diversity. Yet, most literature on the importance of management is based on social psychological experiments and field studies in corporate and public organizations. Future studies should devote attention to the specific team-level conditions and leadership practices required to harness the creative potential of team diversity for scientific discovery and innovation.

Disciplines. Research teams function within larger disciplines, each with unique norms and cultures. This section analyses discipline-specific contextual factors that can support gender diversity in research teams, research methods and research questions.

Strengthen team performance by encouraging gender integration in disciplines. Encouraging gender integration in male-dominated disciplines may reduce tokenism and negative stereotypes that lead to in-group and out-group biases, thereby increasing the likelihood of seeing positive effects of team diversity. Indeed, research indicates that team diversity is more likely to benefit fields that have already achieved some degree of gender integration. A survey-based study following 52 scientific research collaborations at a US university found that women researchers were more productive and more likely to contribute towards team goals in disciplines with relatively high proportions of women faculty[21].

Support GSA through gender integration in disciplines. A recent observational study linking women's participation as authors in medical research to GSA also found that author groups working in disease-specific research areas and specialties with a good general representation of women were more likely to integrate GSA into their work[49]. However, the influence may flow in both directions: more women may lead to increased interest in GSA, but GSA may also attract more women into the relevant research areas.

Avoid ghettoization. Increasing women's general participation in disciplines may be beneficial for research-related outcomes; however, it may also lead to new forms of stratification. Sociological literature on sex segregation suggests that when women enter male-dominated occupations, subtle forms of gender inequality tend to persist[62]. Women may be ghettoized into lower rank jobs or less prestigious areas within a given field. In medicine, for example, men dominate general surgery, neurosurgery and orthopaedics, while women dominate gynaecology, paediatrics and family medicine[63]. This underlines how horizontal stratification can hinder realizing the benefits of gender diversity for research outcomes. Gender integration may broaden research agendas and enable teams to maximize human resources. It may, however, also create new forms of gendered knowledge hierarchies within disciplines[39,40]. Ensuring good career and funding opportunities in both male- and female-dominated sub-areas and recognizing the value of non-mainstream perspectives may help to reduce such ghettoization effects.

Future directions. Disciplinary cultures tend to vary on parameters such as levels of competitiveness, task orientation, team interaction and emphasis on professional values[64]. Carefully crafted comparative research could deepen the understanding of how such disciplinary characteristics influence the link between team gender diversity and research performance.

Further, while GSA has opened important new areas for scientific discovery in the life sciences and the medical sciences, attention to GSA in engineering research is still restricted[34], although in computer science, gender analysis is newly being applied in machine learning, natural language processing and algorithmic fairness in extremely promising ways[65]. Future studies could investigate why the uptake of GSA differs by discipline by analysing factors encouraging or discouraging GSA at the disciplinary level.

Finally, future research should investigate whether links between team diversity and diversity in research questions are discipline specific. Researchers' adherence to specific paradigms, epistemic cultures and notions of excellence varies across disciplines[66–68]. Compared with the social sciences, the natural sciences typically have narrower standards for what are considered suitable research topics, legitimate theories and valid methods. Future research might explore how differing disciplinary norms and epistemic cultures encourage or discourage possible links between gender diversity in research teams and diversity in research questions.

Research organizations. Broader organizational factors and practices may also encourage or discourage our three approaches to diversity. The focus here is not on the many programmes developed to 'fix the institutions', such as unconscious bias training, dual-career hiring or family-friendly policies that function to increase the numbers of women[69]. These are important, but the question here is what practices and policies within research organizations support the benefits of diversity in terms of team performance, research methods and questions asked.

Cultivate inclusive research climates. To fully harness the potential benefits of gender diversity in teams, organizations must cultivate inclusive research climates. A recent survey of 100 work environments in a large biomedical company spells out the key components involved[10]. First, gender diversity thrives in work climates where all employees experience fair and equal treatment, for example, with respect to salaries, promotion and workloads. Second, diversity flourishes in work settings where employees feel free to openly express aspects of their social identities, whether this be sexual orientation or diverse gender identities. Finally, diversity can be supported through democratic approaches to decision-making that encourage wide-ranging insights and viewpoints. Such approaches mitigate interpersonal conflicts by establishing open-minded, mutual understandings among employees, potentially leading to increased performance.

Develop resources for introducing GSA into research organizations. Organizational leaders need to devise practical strategies to introduce researchers to relevant gender and sex analytics. Funding agencies have developed GSA trainings for universities and research institutes. For example, the US National Institutes of Health and the Canadian Institutes of Health Research both provide online modules

on GSA in biomedical and health research, and the Gendered Innovations project at Stanford University offers interactive workshops for researchers in science, engineering and health research[70,71].

In the long run, mainstreaming such trainings in academic organizations may prove crucial for researchers' publication success, given the increasing number of peer-reviewed journals with editorial guidelines requiring sophisticated GSA[72]. *Circulation Research*[73] and the *American Journal of Physiology*[74] were early adapters of such guidelines, and other journals, such as *The Lancet*, quickly followed suit[75]. Importantly, the International Committee of Medical Journal Editors also developed recommendations for GSA in 2016 (ref. [76]).

Integrate GSA into the core curriculum. Making GSA a part of the core curriculum in science, engineering and medical education represents another promising strategy for introducing future researchers to GSA. We are aware of only a handful of universities that have successfully integrated GSA into their science and engineering curriculum. Among them is the Charité – Universitätsmedizin Berlin, Germany. The Charité's process included support from the dean and intensive work by well-respected faculty members to assist professors to integrate top findings about sex and gender into their courses[77].

Develop inclusive evaluation practices. Finally, fostering gender diversity in research questions may require rethinking evaluation practices. Numerous studies have demonstrated that the use of standardized proxies of performance, such as journal ratings and impact factors, can reinforce existing gender inequalities in scientific organizations[78–80]. It has been suggested that this is because a disproportionate share of women researchers, especially in the social sciences, tend to engage in topics with a lower likelihood of being published in what are deemed the most prestigious journals[39,40,80]. If organizations seek to harness the benefits of gender diversity in research questions, performance metrics used in scientific assessments must be broadened to recognize the value of new, non-mainstream research areas and approaches.

Future directions. We need to know much more about how organizational factors shape team diversity in research settings. Specifically, we need studies comparing the outcomes of team diversity in different types of scientific organizations with varying organizational climates, staff policies and human resource management practices. Further, while we see an increasing emphasis on GSA training for science, engineering and medical research, we know little about the impact of such initiatives. Carefully crafted field experiments might prove useful in analysing whether and to what extent GSA training increases researchers' attention to issues of GSA in their work.

Societies. Finally, the potential benefits of gender diversity (in all three senses) tend to vary across geographical regions, countries and cultures. Hence, careful attention is required to the factors encouraging the positive effects of diversity at the societal level. Factors that differ across countries include national and supranational policies and legislations, historically and culturally embedded gender norms and ideologies and research-related funding priorities.

Develop gender norms promoting equality. Encouraging gender egalitarian ideologies and norms at the societal level may help to foster research collaborations where gender diversity thrives. A recent meta-analysis of 68 diversity studies found that gender egalitarian societies, such as Canada, Finland and Sweden, are more likely to see positive effects of team diversity on task performance than less egalitarian societies[81].

Develop policies linking team diversity to funding success. Policymakers' support for gender diversity in research varies across countries and geographical regions. Such variations can affect how scientific organizations approach gender diversity and may ultimately influence research processes. Recent data from Europe, for instance, demonstrate that policy can support the link between gender diversity and funding success. In 2014, the EC identified gender diversity in research teams as a key ranking factor for evaluating proposals in its Horizon 2020 funding scheme[82]. Since then, the EC has seen a general increase in women's participation in EC-funded projects from 27% in the period 2007–2013 to 36% in the period 2014–2015 (ref. [83]).

Develop policies linking GSA to funding success. To meet its grand societal challenges, the EC has also introduced GSA as a quality criterion when evaluating proposals for Horizon 2020. The EC asks applicants seeking funding, "where relevant, [to] describe how sex and/or gender analysis is taken into account in the project's content"[84]. In 2015, the EC identified over 130 areas of science and technology where GSA could benefit research, including health and biomedicine, computer hardware and architecture, nanotechnology, oceanography, geosciences, organic chemistry, aeronautics, space medicine, biodiversity, ecology and biophysics[85]. The US National Institutes of Health also recently recommended that public-funded research "account for the possible role of sex as a biological variable in vertebrate animal and human studies"[86]. Such recommendations and requirements may prove instrumental in mainstreaming GSA in science, engineering and medical research[33].

Develop policies linking diversity in research questions to funding success. Even in the most egalitarian societies, specific funding policies can undermine gender diversity. Observational studies focusing on the Scandinavian countries, for instance, found that policies favouring large research grants, such as 'centres of excellence', reinforce gender inequalities by reallocating resources to prestigious mega-projects with few women[87,88]. Such research priorities may have negative implications for both gender diversity in teams and research questions. To fully harness the potential benefits of diversity, funding agencies should share their resources across numerous projects and focus areas rather than concentrating them on a few large-scale grants.

Future directions. Like the broader diversity literature, existing research on gender diversity in science focuses primarily on the United States, Canada and Western Europe, often with little regard for the specific socio-cultural characteristics of each region. Hence, comparative studies, with broad international overviews, are needed to fully understand how varying societal norms and values, policy frameworks and research systems can cultivate the link between gender diversity and innovative research outcomes.

Conclusion

Gender diversity in research teams, research methods and research questions has the potential to drive scientific discovery and innovation. Demographic diversity, including age, class, ethnicity and nationality, may also influence research in important ways. While this Perspective has focused on gender diversity, we hope it will contribute to a better understanding of the possible benefits associated with other types of diversity as well.

Our Perspective demonstrates that to realize its full potential, gender diversity needs to be supported by careful stewardship and management techniques across four interdependent domains — from research teams to the broader disciplines in which they are embedded to research organizations and ultimately to the larger societies that shape them through specific gender norms and policies. Understanding how these domains interact — that is, how policies and practices in one domain shape developments in the other domains — is crucial to maximizing the benefits of diversity for science.

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Author contributions

M.W.N., L.S. and C.W.B. conceptualized and wrote the paper. M.W.N. and L.S. carried out literature searches, and M.W.N. and C.W.B. prepared tables. L.S. and M.W.N. conceptualized Figs. 1 and 2.

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The authors declare no competing interests.

Additional information

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Correspondence should be addressed to M.W.N.

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