

Exposing Gender Bias in the Mathematics and Operational Research Professions

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Introduction

Gender bias is the preferential treatment or discrimination of individuals based on gender. It can influence our decisions in the workplace, the opportunities offered to individuals, our choices and even how we perceive one another. Gender bias can be both conscious or unconscious and it can impact people differently depending on their upbringing, social norms, socioeconomic background, or professional sector. Caroline Criado Perez (2019) reveals how gender data gaps, ranging from healthcare to urban planning systematically disadvantage women as a result of treating the male experience as the default.

Common examples of gender bias include the gender pay gap, or the way assertiveness is judged, seen as leadership in men, yet often perceived negatively in women. While historically, it has meant that men were favoured over women, men can be also disadvantaged, especially when they deviate from traditional gender expectations. Men may be discouraged from pursuing roles traditionally seen as “female”. Non-binary individuals might be excluded from opportunities as traditional gender roles don’t accommodate their identities. While such cases appear to be less frequently reported in the Mathematics and Operational Research (OR) fields, they are not absent. In this piece, however, our primary focus is gender bias experienced by women.

This article reflects on a session held at the recent, 5th Institute of Mathematics and its Applications (IMA) & Operational Research Society (ORS) conference, where we brought together academics, practitioners, and early-career professionals to discuss gender bias in mathematics and OR. What emerged was not only a space for shared experience, but a call for structural and cultural transformation.

Gender bias in Mathematics and OR, starts early on with school where girls are often discouraged from pursuing science and maths subjects. It continues throughout women’s careers, with recruitment, progression, recognition, and retention. Women and gender-diverse individuals encounter systemic barriers at nearly every stage. These obstacles are not always explicit, but their effects are deeply felt: fewer women in leadership roles, limited visibility at conferences, underrepresentation on editorial boards, and fewer awards or recognitions.

This is not just a matter of fairness. When only certain voices are heard and valued, we limit the scope of our inquiry, stifle creativity and progression. Diversity strengthens our work, it sharpens questions, broadens perspectives, and improves the relevance and impact of our research.

As two senior academics in our respective fields, AT in Operational Research and CC in Mathematics, we bring different lived experiences to the discussion, but share a common observation: gender bias remains embedded in our professional lives and communities!

Influenced by our commitment to gender bias, our session at the 5th IMA & ORS Conference aimed to surface uncomfortable truths, share research and data, and most importantly, create a space for solidarity and strategising. The event was well attended, and participants expressed a need for more similar conversations. It became clear that while the problems are systemic, so too can be the solutions.

Manifestations of Gender Bias in the OR and Maths Professions

We drew on recent research and lived experience to highlight specific ways in which gender bias manifests in Mathematics and OR, influencing women's participation, recognition, and advancement.

1. Cultural Stereotypes and Educational Bias

From a young age, girls encounter stereotypes suggesting they lack aptitude in mathematics. UNICEF reports that boys have up to 1.3 times the odds of acquiring mathematics skills compared to girls, attributing this disparity to negative gender norms and stereotypes held by teachers, parents, and peers (UNICEF, 2022). This bias can discourage girls from pursuing STEM subjects at higher education levels and in advanced mathematics courses. Ingrained stereotypes that STEM subjects, which includes maths and OR, are perceived as male domain were not long ago exposed when Katharine Birbalsingh, chair of the Social Mobility Commission, said that fewer girls study physics because “there’s a lot of hard maths” involved during an evidence session at the House of Commons on 26 April 2022.

However, we now see more women entering into OR, maths and data science programs. According to an Office for Students report, nearly half (46%) of students enrolled in AI and data science postgraduate conversion courses in 2020-2021 in the UK were women, a significant increase from a previously reported 27% in computing postgraduate taught master's courses (Office for Students, 2021). Although these trends can help broaden women’s participation at entry level, it is important to maintain progression along the career pipeline.

2. Underrepresentation and Invisibility of Women

In many University departments, women make up less than a third of the academic or professional staff. At senior levels, this percentage drops even further. In the UK, women are significantly

underrepresented in Mathematics and OR. In academia, lack of diversity is hindered by the promotion criteria and the fact that women are expected to perform in a similar way as their men counterparts, which hold them back. Athena Swan helped identify some of the barriers that women face to succeed. Hiring panels and promotion criteria undervalue teaching, mentorship, and service—areas where women are disproportionately active.

The London Mathematics Society (LMS) has long made efforts to uncover the lack of women in the Maths professions and in 2013 presented evidence in the House of Commons (UK Parliament 2013). There is a research gap in OR and Mathematics fields on the topic of gender equality. A recent article examines the persistent gender inequalities and highlights the historical underrepresentation of women in the field of OR (Carroll and Amideo 2024). The study uses a survey questionnaire to capture the current state of the OR community and the ongoing challenges women face in career progression. It reveals a number of systemic issues such as limited access to leadership roles, implicit biases, and a lack of supportive policies that hinder women's advancement in the field.

Similarly, researchers from Germany, Brohi and Heinold (2024), explore the key factors contributing to women's underrepresentation in the OR professions. They identify a scarcity of role models, organizational culture, societal norms, competitive environments, and family responsibilities holding women back in their career progression. Interestingly, they also note that many participants were unaware of the significant contributions made by women in OR, highlighting the need for increased visibility and recognition.

3. Professional Recognition and Leadership Gaps

Women in Mathematics and OR face systemic disadvantages, particularly in terms of professional recognition and leadership opportunities. One simple example is the gender imbalance in prestigious awards. Many of the most respected awards in OR are named after men and have historically been awarded predominantly to male recipients. Carroll and Amideo (2024) highlight that among the top 100 most cited OR academics, only one woman was listed, demonstrating a significant gap in research recognition. Similarly, the UK OR Society's Beale Medal, established in 1992, was first awarded to a woman only in 2019.

Citation patterns also reflect this disparity. Studies show that women tend to accumulate fewer citations than their male peers, often linked to lower research productivity. Wu (2024) attributes this to a range of structural challenges, including women's shorter publishing careers, higher attrition rates, greater family responsibilities, and reduced access to research collaborations. Yet productivity alone doesn't explain the gap. Research by Ross et al. (2022) finds that women are systematically credited less for their contributions in scientific publications, pointing to persistent bias in attribution and authorship.

This lack of recognition was also evident in a recent encyclopedic issue published in the *Journal of the Operational Research Society* (JORS), to mark the 75th anniversary of the OR Society. Set to

reflect the breadth of the discipline, the issue featured contributions from 80 authors, of which only around 20% were women. For an article intended to represent the scope and evolution of the field, the gender imbalance unveils a troubling message about women's visibility and inclusion.

Editorial leadership in academic journals further mirrors these disparities. Some exemplary OR journals, feature a more balanced leadership, with Health Systems and Journal of Simulation, reporting a 50:50 ratio of men vs women as Editors in Chief (EiC). Others remain heavily male-dominated. For example, leading journals such as the European Journal of Operational Research (EJOR) and JORS are currently led by six and four men Editors in Chief respectively. Among journals led by a single-handed EiC, Operations Research is led by a woman, with a 27% female representation in its editorial board, while the IMA Journal of Management Mathematics (IMAMAN) is led by a single man EiC, currently reporting a 41% women representation, with an ambition to reach parity by 2026. While these examples show progress in some areas, the persistence of all-male editorial teams in leading academic journals in the field is a cause for concern.

4. Leaky pipeline

The "leaky pipeline" phenomenon is about the diminishing women's representation at successive stages of the academic and professional ladder. While women make up about half of PhD candidates, they account for only approximately 30% of researchers and a mere 20% of full professorships in Europe. In the UK, women represent 44.5% of academic staff across higher education institutions, but only 20.5% of professors are women (Gines e Fabrellas 2024, UK Parliament, 2014). The "motherhood penalty", caring responsibilities, physiological problems, periods and menopause pose challenges that women need to overcome at the same time when they are expected to perform at their highest and compared against criteria that suit a male academic. The stereotypical image of a professor spending most hours of the day at their desk, is not a realistic expectation for women academics with a family, who juggle a lot more than a professional career. Similarly the IMA acknowledges that the "leaky pipeline" problem still exists in both academia and industry, with a shortage of females in senior positions¹. These are not isolated problems. They are patterns, embedded in the very fabric of our societies.

5. Workplace culture norms and microaggressions

Unconscious biases and male-dominated cultures can create environments where women feel undervalued or excluded. As many as 81% of women report experiencing some form of sexual harassment during their careers, while between 58% and 72% of sexual harassments go unreported due to fears of the consequences that come with it (Zippia, 2023). Gendered microaggressions in the form of subtle, unintentional, discriminatory comments or actions are prevalent in STEM settings. Women often experience subtle expressions of gender stereotyping, such as being talked over in meetings or their ideas being attributed to others (Sekaquaptewa,

¹ <https://ima.org.uk/about-us/equity-diversity-and-inclusion/gender-diversity/>.

2019). Microaggressions can undermine women's confidence and contribute to an unpleasant work environment. These issues not only affect women's mental health but also their career advancement, leading to a vicious cycle of inequality.

In an autobiographical reflection, Inge Bleijenbergh, explores organisational resistance to embedding sustainable and effective strategies to support gender equality in Dutch Higher Education organizations (Bleijenbergh, 2018). The article poses that resistance manifests in various forms, denial, trivialization, or opposition, which can impede or catalyse transformational change. The study emphasizes calls for organisations to engage with resistance constructively, which can help to gain deeper insights into the underlying power structures and cultural norms that sustain gender inequalities, leading to developing more effective strategies for change.

Claiming Space: Towards Gender Equity

What can be done? Gender bias is a wicked societal problem. While no single solution will tackle gender bias overnight, based on our participant discussion at our session, we outline some strategies that can lead to sustainable change.

Build Networks that Amplify Women's Voices

Formal and informal networks can make a significant impact on women's careers. Effective mentoring programmes with built-in accountability can significantly enhance career progression particularly for women and underrepresented individuals. Similarly, sponsorship, where a more senior person advocates for another person not present in the room, can accelerate careers. This is about encouraging women and gender-diverse professionals to take up visible roles and amplify their voices, not as a ***token gesture***, but as a deliberate strategy to reshape societal norms, ***grounded in merit and integrity***. Increasing the visibility of women challenges stereotypes about who "belongs" in Mathematics and Operational Research. This includes inviting underrepresented professionals to deliver keynote talks, serve on editorial boards, lead committees, and appear in public science communication. It also means creating platforms—journals, speaker series, blogs, and awards—that explicitly seek to uplift diverse voices. Amplifying voices means also active allyship: citing the work of women and non-binary colleagues, publicly crediting their contributions, and redirecting attention when their ideas are overlooked.

The Women in Operational Research and Analytics Network (WORAN), EURO Women In Society Doing Operational Research and Management Science (WISDOM) Forum, the US forum for Women in OR/MS (WORMS) and the IMA are already actively raising visibility of women researchers and professionals in OR and maths through their dedicated event series. Visible role models are essential to retaining women in Mathematics and OR. They show that success is possible across diverse life experiences and career paths.

Change the Rules

Current evaluation and promotions processes often reward a narrow definition of excellence. In academia, for example, promotion panels primarily prioritise research outputs, that fit a small subset of scientists. However, the outdated image of the lone, emotionless, apolitical mathematician or operational research practitioner no longer reflects the reality of our field.

The need to cultivate a professional culture that sees emotion, care, collaboration, community engagement and difference is not a distraction from rigour, but an integral part of it. Just as objective and optimised solutions do not equate to universal truths, a more holistic approach is necessary (Mingers and Rosenhead 2004). It is time to rethink what we value and how we measure it. Without redefining our criteria, we will keep reproducing the same hierarchies.

Claiming Space with Confidence and Purpose

Creating meaningful change requires more than policy changes, it calls for bold and intentional action to challenge ingrained behaviours and norms. In traditionally white, male-dominated environments, claiming space means affirming that women's presence is valid, their voices essential, and their contributions valuable. This can take many forms: leading a research project, stepping forward for speaking opportunities, or ensuring ideas are not downplayed in meetings. It also involves setting clear boundaries, such as saying no to unacknowledged "*office housework*" and resisting pressures to conform to outdated expectations.

Claiming space is not arrogance, it is a necessary assertion that women deserve visibility, respect, and recognition.

Supporting Flexible Career Paths

Gender bias in mathematics and OR often manifests in the undervaluing or penalization of part-time work, which disproportionately affects women due to caregiving roles. Institutions should revisit how progression and promotion criteria are applied to part-time workers, ensuring that career trajectories remain accessible and fair. Recognizing achievements based on impact rather than time-based metrics could help dismantle this bias.

Creating Inclusive Professional Environments

Inclusive practices can contribute in making a broader cultural shift toward valuing all professionals, regardless of family status. For example, editorial boards hold prestige and influence, yet exploring and making the criteria for such roles more transparent and inclusive, can open leadership pathways to a more diverse range of candidates. This also involves critically examining whether traditional expectations inadvertently favour certain demographics over others.

Family-friendly measures, like dedicated family rooms or child-friendly activities at academic conferences, are small but powerful steps toward inclusion. These accommodations allow parents—especially women who are often primary caregivers—to fully engage in professional

development and networking opportunities.

Our call to action

The limited research on gender inequality highlights the urgent need to expose and address the systemic issues and biases that sustain it. These biases function as wicked problems, which are deeply embedded, complex, and resistant to simple solutions (Rittel and Webber, 1973). In our unpublished research, we (AT et al) apply system dynamics causal mapping, a particularly valuable tool in identifying the interrelated barriers and enablers that shape women's career paths, to identify more sustainable and impactful change (Moolkol, 2022).

We call for targeted interventions, which resonate with those suggested by other researchers, including enhancing the visibility of women in the OR and Mathematics fields, establishing robust mentorship programs, and implementing institutional policies aimed at fostering a more inclusive and equitable professional environment (Carol and Amideo, 2024; Brohi and Heinold 2024). Tackling gender bias requires more than isolated efforts or simple reporting of metrics to achieve Athena Swan recognition, it demands systemic approaches and engaged discussions with diverse system actors both men and women to uncover hidden biases, challenge existing norms, and foster a shared commitment to implementing equitable practices (Bleijenbergh and Van Engen, 2015).

A lasting solution requires a cultural shift that not only tolerates but celebrates the different ways men and women contribute to our communities. Recognizing the value of diversity and variety of approaches can ensure that our professions thrive.

We leave our readers with a thought-provoking quote from Anne-Marie Slaughter, a US writer, politician and academic:

"If women are ever to achieve real equality as leaders, then we have to stop accepting male behavior and male choices as the default and the ideal. We must insist on changing social policies and bending career tracks to accommodate our choices, too.

We have the power to do it if we decide to, and we have many men standing beside us."
(Slaughter, 2012)

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