We mathematicians would like to think that our discipline is free from bias, and not to have to ponder too much about possible injustice in our comfortable, logical realm. And yet: in our graduate programs, women are still noticeably in the minority. We have a significant shortage of female mathematicians in our departments, particularly in senior positions. And where conferences are concerned, it is unfortunately quite common to have so few female speakers that they stand out from the homogeneously male pack. The pace of progress seems to be slowing, if we are continuing to improve at all. In short, we have too few women in our discipline, and there is good reason to doubt whether the problem is simply going to fix itself any time soon.

The purpose of this article is to examine the issue of underrepresentation of women in mathematics departments, as speakers and organizers of mathematics conferences, and as recipients of mathematical prizes. We believe that it is our ethical responsibility to equitably represent all members of our profession and to dismantle any obstacles to advancement in that profession, particularly when those obstacles disproportionately burden a minority group. In particular, we argue that it should be an explicit priority for any organizers of mathematics conferences to address appropriate representation of women in their lists of speakers; we further assert that we are not currently succeeding at meeting that priority.

1. Implicit Biases and the Perpetuation of Gender Inequity

The shortfall of women in fields related to science, technology, engineering, and mathematics (abbreviated STEM) is easy to observe. Clearly, our current system is not living up to our standards where gender diversity is concerned. What, we should ask, are the causes of this shortfall?

Certainly there is no genetic predisposition that favors males over females in STEM fields (despite how often such claims are made). Indeed, such a refutation has appeared recently in the Notices of the American Mathematical Society [22], so we restrict ourselves to a brief summary here. Girls and boys have always performed comparably on all measures other than standardized tests; on these tests, the achievement gap has dramatically decreased, to a nearly insignificant size, over the last generation. Internationally, furthermore, gaps in standardized test scores are significantly correlated to measures of gender inequality in the students’ cultures. These effects manifest themselves in the set of high-achieving mathematics students, not just in the entire population, refuting “more males at the top” theories as well. (See [2, 11, 16, 18, 19] for detailed descriptions of these findings.) None of this data is consistent with innate gender-based differences in mathematics ability.

What, then, can be causing this underrepresentation of female mathematicians? It arises, in fact, from an assemblage of deeply entrenched biases that our culture has surreptitiously inserted into our perceptions and reactions. Because of these implicit biases, we internally associate STEM careers (and many other things, such as positions of authority) with male defaults. Without realizing

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it, we call to mind the achievements of male mathematicians more readily than those of female mathematicians, and our cognitive dissonance at seeing women doing mathematics causes us to evaluate them more negatively.

Our culture’s insertion of these biases into our subconscious, sadly, begins extremely early in our lives. Schoolteachers, through unconscious differences in the way they respond to girls and boys, reinforce assertive behavior and (over)confidence in boys, but passiveness and math anxiety in girls. For example, when girls do answer questions, they are more likely to receive a brief response that merely recognizes the fact that they answered, whereas boys are more often given follow-up questions or time to expand upon their answer [40]. Children are unwittingly trained to perceive women as less mathematically able than men [26], and girls become less likely to volunteer for mathematical enrichment than boys [32]. These erroneous attitudes are compounded by a pervasive categorization of mathematical ability as being fixed and innate, rather than malleable and able to be strengthened [14]—a categorization that our professional community unintentionally perpetuates.

Once these implicit biases are in place (and they are indeed present, in all of us, our good intentions notwithstanding), they lead to further measurable discrimination that happens right under our noses. Experiments with dual versions of applications, CVs, and promotion files—identical except for the gender of the name—consistently demonstrate that women are rated lower than men even when there is literally no difference between them.

For example, professors who are contacted by students interested in their doctoral program respond more frequently to men than to women—and this propensity is exaggerated in more lucrative fields and at more prestigious institutions [29]. Both female and male faculty members rate students’ application materials differently when the applicant is female or male: even with identical files, the female applicant is judged to be less competent, and male applicants are offered a 14% higher starting salary and more mentoring on average than female applicants [30]. When evaluating the research records of female and male scientists by their number of publications and the journals in which they appear, evaluators devalued the work of the women to the extent that a woman’s file had to contain 2.5 times as much productivity and impact as a man’s file for the woman to be considered as competent as the man [41].

Teaching evaluations display the same gender differential [24, 31], as do multiple other evaluation instruments both inside and outside STEM. When women and men give feedback to others, “the evaluation of women depended more on the favorability of the feedback they provided than was the case for men”, and women (but not men) who gave negative feedback were judged less competent by the people they criticized [34]. The vaguer and less concrete the evaluation criteria are, the more our unconscious biases manifest.

The gender-related implicit biases of those around us also socialize us into choosing different behavior patterns. Without realizing it, we interpret a man’s assertive demeanor as confidence but a woman’s assertive demeanor as abrasiveness [12]; we notice when men interrupt men but not when men interrupt women. The corresponding negative reinforcement indoctrinates women into undervaluing their own ability (and socializes men into overestimating their own). When conferences require submission of proposals, for instance, women are quick to dismiss their own

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1It is worth remarking that statements of this type are statistical statements, about large-scale trends of behavior. Of course there are individual exceptions to any such trend. However, unlike a proof in an axiomatic system, the existence of specific counterexamples does not invalidate the larger trends described in this article. Scientific research involving human behavior in complex societies does not look like theoretical mathematics, but it is completely appropriate for its subject.
ability to offer high-quality proposals, thus tending to submit in much smaller numbers in the
absence of specific invitations; on the other hand, men are very quick to submit—even when the
quality of their proposals is well below average for the conference—because they overestimate
their own abilities [21, 36].

In fact, the aggregate effects of these socialization biases are so powerful that they manifest
in psychologically significant ways. The phrase “impostor phenomenon” was used by Clance
and Imes [8] to “designate an internal experience of intellectual [phoniness], which appears to be
particularly prevalent and intense among a select sample of high achieving women. ... Despite
outstanding academic and professional accomplishments, women who experience the impostor
phenomenon persists [sic] in believing that they are really not bright and have fooled anyone who
thinks otherwise.” This phenomenon affects a large and diverse group of women with fantastic
career accomplishments [23]. Another internalized obstacle to success for women (and other mi-
norities) is “stereotype threat”, described by Spencer, Steele, and Quinn [35] in this way: “When
women perform math, unlike men, they risk being judged by the negative stereotype that women
have weaker math ability. We call this predicament stereotype threat and hypothesize that the
apprehension it causes may disrupt women’s math performance.” The effect of stereotype threat
on actual measurable performance has been pointed out multiple times: for example, “ability-
impugning stereotypes such as these can trigger psychological processes that can undermine
the performance of stereotyped individuals, including females in math” [14].

In light of this sociological negative reinforcement of female scientists, we cannot judge the
choices that individual women make in isolation from our social context. In our current society,
with its gender-based implicit biases, it is naive to think that women can simply change the way
they react to their environment and dissolve all this inequity themselves. There are deeply en-
trenched reasons why resolving our underrepresentation problem will not be possible until all of
us, not just the affected population, decide to devote effort towards recognizing and addressing the
causes of inequity.

And gender inequity is clearly present in mathematics; indeed, the inequity becomes worse and
worse as the stakes get higher. The fact that biases exist at every stage of students’ and profession-
als’ careers causes a “leaky pipeline”: the higher the academic rank, the smaller the percentage of
women (see [9] and [42]). In the business world, well-documented analogues include the persistent
wage gap between women and men and the poor record of top companies promoting women to
the executive level [5]. For example, women are socialized to less frequently negotiate for raises
and promotions than men do; but when women do in fact negotiate, the culture of many companies
disproportionately punishes them [3, 4]. Similar attrition can be seen in mathematics when looking
at grant funding, tenure decisions, and awardee selection. For example, biased evaluations lead to
smaller grants for women, which lead to somewhat curtailed research opportunities, which lead to
artificially diminished research records that penalize them further for the next grant applications
[6, 25]. Inequities of this type are categorized in sociology literature as the “theory of cumulative
advantage” [10].

Experiments in which identical conference abstracts were attributed to women or men show that
peers (of both genders) perceived higher scientific merit, and were more likely to want to collabo-
rate, when a male name was attached. Similarly, actual recommendation letters of contemporaries
in STEM fields have been shown to exhibit different patterns of language usage in a way that
benefits men over women [25]. Tenure cases are more harshly judged for female professors than
for male professors; even when a woman’s tenure file is evaluated positively, the evaluators are
four times as likely to volunteer “cautionary comments”, saying that they would need to be given additional information to make a final judgment, than for a man’s file [37].

We are mostly unable to perceive, in individual situations, this pervasive pattern of invisible discrimination (that is the definition of invisible!); as a result, we fool ourselves into thinking that academic mathematics is a pure meritocracy [13, 25]. Upon closer examination, however, we find that our current system (academic and societal) has been sullied with extraneous features that consistently discount merit where disadvantaged populations are concerned. It can be an eye-opening experience to take an implicit-biases test [15] and see that each of us is far from a perfect specimen of objectivity. Indeed, being aware of our personal biases is far superior to the alternative, since people who consider themselves extremely objective can actually be more prone to act in a biased fashion [39].

Making an effort to address underrepresentation of women in mathematics, therefore, is not some extra component that introduces injustice; rather, it is an attempt to recognize and do away with the injustice that is already present. In other words, we are not simply trying to react to a perceived shortage of female mathematicians—we are, unintentionally and against our wishes, maintaining the shortage ourselves. So let us frame the issue of appropriate representation of women in mathematics, not in terms of some additional constraints that we must add in, but rather in terms of how to take out (or at least circumvent) the extraneous biases that are already there.

2. Striving for Gender Equity at Conferences

In mathematics, just as in other STEM fields, graduate schools have been producing a steady source of female PhDs for a generation. For example, every year for the last quarter century, the percentage of PhDs in mathematics granted by US institutions to women has been 24% or greater, with a peak as high as 34% [1]. Even this modestly equitable level of representation, however, fails to persist in many aspects of our discipline, as we will demonstrate shortly with several quantitative examples. It is worth reiterating what we saw from the previous discussion: even in the absence of overt discrimination against women, implicit gender biases are powerful enough to introduce and reinforce inequity at every single stage of an academic career: producing PhDs in the first place, allocating postdoctoral positions, faculty hiring and promotion, evaluation of research records, awarding of prizes, and selection processes for conferences.

Regarding this last point: shortfalls of female conference speakers are, unfortunately, extremely common in all STEM fields. Even in scientific disciplines that currently have greater gender parity than mathematics, women are less likely than men to be invited to speak, particularly when the organizing team does not include women [7, 20]. Underrepresentation of women as conference speakers is a symptom of these biases, but it also serves to perpetuate them; therefore, addressing the inequity at conferences is valuable and necessary for countering this underrepresentation.

To see a high-profile example of such underrepresentation, we may examine the most recent International Congress of Mathematicians (ICM), held in August 2014 in Seoul, South Korea. Counting directly from the program on the ICM’s official website, we find that only one of the twenty plenary speakers (5%) was female. Overall, among the plenary and invited speakers, there were 35 female speakers out of a total of 237, or 14.8%. Easy statistical arguments confirm, moreover, that this pronounced gender inequity cannot reasonably be ascribed to chance selection from the relevant generation of PhD recipients.

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2 All the data gathered for this section can be examined in more detail in the author’s annotated bibliography [28].
Another example, the 2014 Joint Mathematics Meetings of the AMS and the MAA held in January 2014 in Baltimore, Maryland, exemplifies alarming internal disparities in gender inequity. The percentage of speakers in contributed paper sessions who were female was 36.8%, while the percentage of invited speakers who were female was only 25.6%; this echoes the lower percentage of invited participants observed in other sciences [20]. When we restrict to AMS-organized invited sessions, there were only 24.8% female speakers and 22.0% female organizers. Among the JMM sessions that had their organizers listed explicitly, sessions with at least one female organizer had an average of 38.3% female speakers, yet sessions with no female organizers had only 19.8% female speakers, or half as many.

Differential representation of women can be found in employment statistics as well [9]: as we pass from part-time faculty to full-time non-tenure-track faculty, to tenured faculty at non-PhD-granting institutions, the percentage of women decreases steadily. Where mathematics journals are concerned, a sample of ten of the most prestigious journals yields only 6.6% of editors who are female; six of these ten journals have no women at all on their editorial boards. Among the prizes and awards offered by the American Mathematical Society in its history (not counting the Satter Prize for women in mathematics), the percentage of recipients who are female is a paltry 3.3%. And while it was legitimately exciting when M. Mirzakhani became the first woman to be awarded the Fields Medal in August 2014, it is hard not to wonder, given the fact that less than 2% of all Fields Medalists and 0% of all Abel Prize winners to date are female, how many outstanding female mathematicians have not had their work sufficiently recognized.\(^3\)

It behooves us, then, to consider explicit actions we can take to mitigate the current unfairness in our discipline. Underrepresentation of women at conferences is a symptom of this unfairness, but it also contributes significantly to perpetuating it; for this reason, we find it extremely important for this particular symptom to be treated (in conjunction with efforts to point out and address the inequities on larger scales). Our goal should be to implement guidelines for compensating for all the bias inherent in the system, with the hope that conscious attention to those biases will also help reduce them in the future.

We should ponder briefly that inviting speakers to conferences is about more than just rewarding a few already established people: we want to enrich the research of attendees and speakers alike. And one aspect of that enrichment is to expose ourselves to as many new and different viewpoints as possible; limiting our speaker pool (however unintentionally) is directly at odds with this goal. Research has shown that demographic diversity has measurable positive effects on the outcomes of group enterprises [38]; conversely, lack of diversity, in addition to perpetuating harmful stereotypes about mathematics, actually diminishes our ability to evaluate unfamiliar ideas [33]. Moreover, people unconsciously evaluate women less favorably in settings where they make up a small fraction of the participants, all the more so when gender-typing (the process in which our society trains us to associate certain activities or qualities with a single gender) is present [17]. In other words, continuing to create conferences with an underrepresentation of female mathematicians actually makes us worse at recognizing women as skilled mathematicians.

Once we include gender diversity among our explicit goals for conference organization, we become motivated to plan our conferences with equitable gender representation in mind from the very beginning.

\(^3\)A recurring rationalization for such disparities is “there hasn’t been enough time for the women to progress through the system”. Let us observe here that over a quarter of mathematics PhDs have been earned by women, for so long that the earlier cohorts are now too old to be eligible for the Fields Medal!
start, and explicitly communicate with other conference organizers our expectation of meeting this goal. We should be extremely attentive to the way we select speakers, particularly keeping in mind that we are prone to misevaluating academic records of women and to overlooking qualified female candidates. We should recognize that women are forced to turn down conference invitations more often than men, due to inequities in funding and out-of-work responsibilities, and that logistical choices (such as childcare arrangements) can make conferences less welcoming to women if we are not careful. Moreover, we should publicly commit to equitable gender representation at our conferences, display this commitment visibly in conference materials and through our actions during the conference, and track over time how well we are (or are not) succeeding. Finally, we should simply talk more openly about underrepresentation of female mathematicians, not only in the context of conferences but in all aspects of the academic career; and we should ensure that our words (and our attention to others’ words) reflect the reality that mathematics is for women as well as for men. See [27, Section 4] for a more comprehensive list of guidelines for organizers striving to equitably include women in their conferences.

REFERENCES


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