# REPORT:

Giving Women a Public Voice Helps Tackle Gender Inequality in Science

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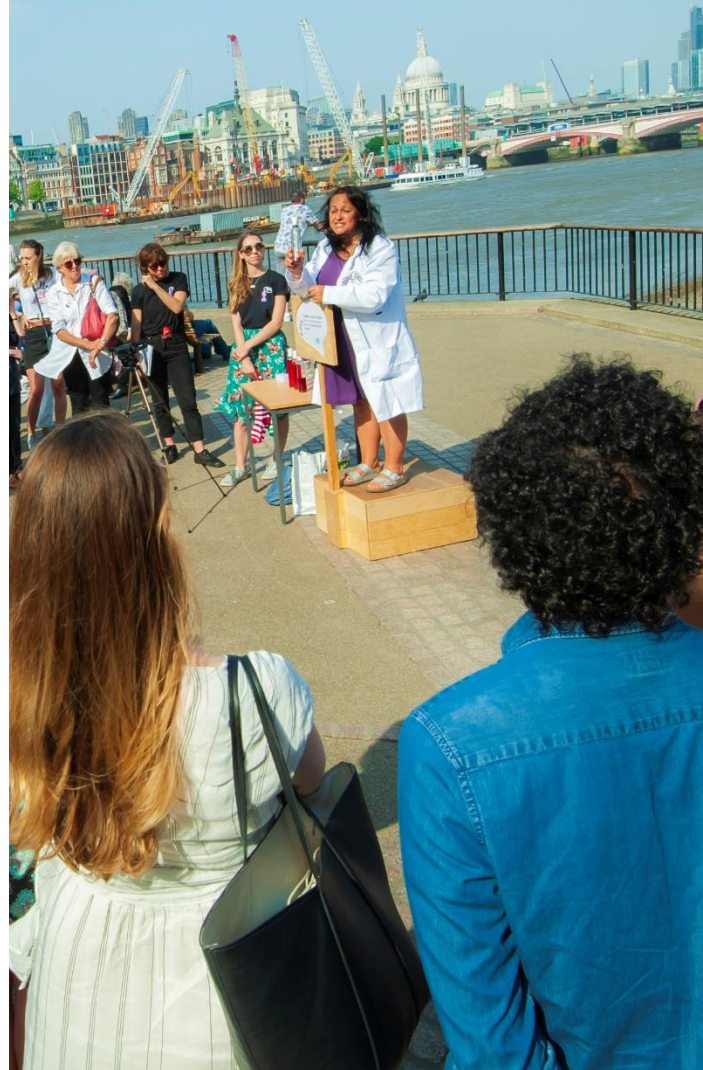
Summary

Women are systemically under-represented in Science, Technology, Engineering and Mathematics (STEM). The reasons behind the gender imbalance include low confidence and the stereotype of the male scientist.

We test the hypothesis that giving women in STEM a public voice increases their confidence and public engagement profiles, thus reducing gender inequity. We use data from an international female-only, public speaking platform (Soapbox Science) in which over 1,000 women in STEM have participated. We interviewed 357 Speakers from 2011-2017 via on-line questionnaires.

Participation in Soapbox significantly boosted women's self-reported confidence in public speaking, in their work environment and in networking. Speakers believe that their participation has had a positive impact on their career progression.

The 'gender-agenda' of this female-only platform motivated participation more than the promotion of Speakers' research; this motivation has had a positive feedback on Speakers' subsequent public speaking portfolio. The impact of the female-only platform was especially significant for women with low confidence.

Colleagues were generally perceived as supportive of the 'gender agenda' of Soapbox, but male colleagues less so.

Giving women a public voice can help tackle some of the cultural and societal issues that may be responsible for gender inequality in STEM.

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Introduction

Women are generally under-represented in science, technology, engineering and mathematics (STEM), both at the educational and professional level: recent UNESCO studies show that, globally, only 35% of students in higher education in STEM [1] and 28% of the world's researchers are women [2]. The gender composition of STEM varies regionally [e.g. 3] and by discipline [e.g. 4]; within the UK (which provides the majority of this study's data), in 2018, 52% of STEM undergraduates were female [4] but only 43% of the UK STEM workforce was female, falling to as low as 12% in engineering [5]. The causes of STEM's gender disparity and its disproportionate drop-out rate by females are complex [6-8]. One contributing factor is the strong cultural stereotype of the male scientist [9] which can lead to a perception that women lack the attributes necessary to succeed in STEM [10]. Another factor is lack of self-confidence [11], a trait which

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appears to affect women more than men [12]. Entwining these two influences is 'stereotype threat,' a phenomenon by which there is a negative stereotype about a person's group, such that they are concerned about being judged negatively on the basis of this stereotype [13]. Indeed, stereotype threat has been shown to undermine females' performance in mathematics [14, 15], and there is evidence that women and girls shy away from activities which they associate with male excellence [16, 17]. Women are thus under more pressure to persist and succeed in a field such as STEM which society views as 'male', and where women need to be several times more productive than men in order to achieve the same recognition [18, 19]. Given the unprecedented demand for skilled STEM workers, it is paramount that we act to remove the barrier of stereotype threat from women [20] and the low confidence and self-esteem which it exacerbates.

One approach to break the link between masculinity and STEM [21], increase the visibility of women and simultaneously boost women's confidence may be to give women a public voice. The historian Mary Beard writes that, in classical times, "public speech was a – if not the – defining attribute of maleness" and that one of the reasons behind gender inequality today is that women remain "voiceless"; she notes that applauded speeches by women, both current and historical, tend to be restricted to the subject of women's rights [22]. Indeed, public speech in STEM related areas remains male-biased to this day. Women are less likely to contact the media than men about their work [23] and male scientists receive up to 5 times more media contact than females [24, 25]. This phenomenon (the under-recognition of women scientists and their contributions) has been coined as the "Matilda effect" [26], and is complementary to the "Matthew effect" (a Biblical reference to Matthew 13:12: the over-recognition of those who are already prominent). The combined result of

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"Matthew and Matilda" is that female scientists are less likely to get their voices heard; this is further exacerbated by university press officers who do not necessarily feel they have a specific remit to promote women in STEM [27].

The effect is also evident within the academic community: for example, at academic conferences plenary speakers are more likely to be male [28-30], women have been found to be more likely than men to opt for a shorter talk [31] or a poster presentation [30, 32], although see [29], and women ask fewer questions [33]. Conference organisers are increasingly aware of these issues and indeed taking gender into account when choosing invited speakers has been shown to positively affect the proportion of female speakers [34].

A simple step towards achieving parity, therefore, may be to provide female scientists with better opportunities to be seen and heard by the public and their academic peers, via public engagement [35]. This type of enhanced exposure has the potential to achieve impact on the women themselves (e.g. by gaining public speaking experience and boosting confidence), their working environment/colleagues (e.g. by raising awareness about gender issues in the science workplace), and

the general public (e.g. by providing role models for a more equitable STEM workforce in the future). Providing women with opportunities for high profile public speaking, training them and helping them develop confidence in public speaking are key recommendations for boosting the public profiles of women in STEM [27].   As a profession, science communication and journalism tends to be female-biased [36, 37] is often described as an attractive field for women as an alternative to 'bench work' [27]. However, among research scientists and academics, men are more likely to engage in STEM outreach activities than women [24, 27] Giving women a public voice [22, 27, 35], and excluding male competition [18, 19] through female-only platforms, might therefore help sever the links that bind success in STEM with masculinity (Fig. 1). We suggest that such simple actions have the potential to deliver rapid, wide-spread impact on achieving parity in STEM careers.
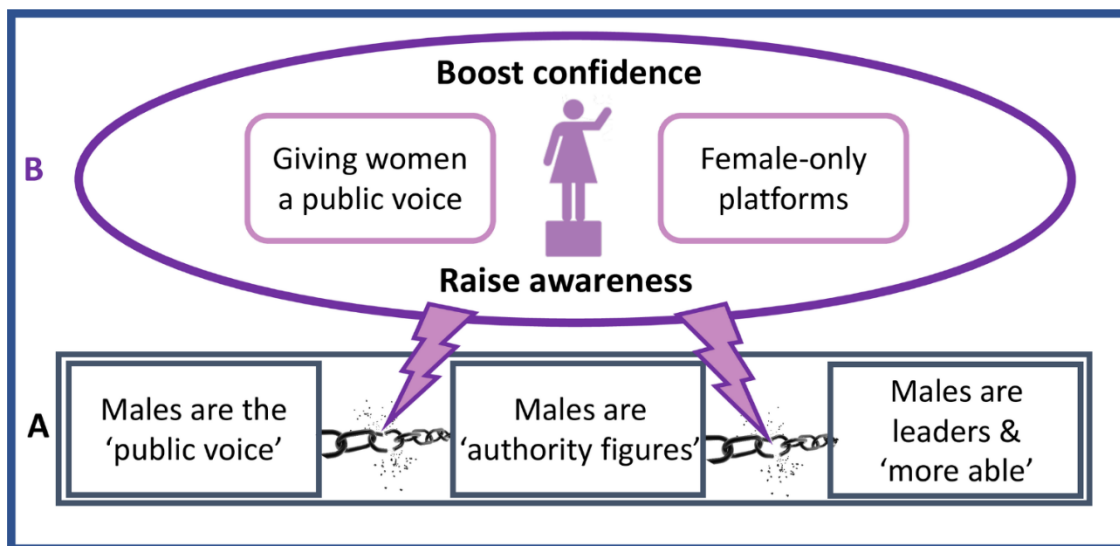

Figure 1. Giving women a public voice can help break the links between masculinity and leadership. a) The gender stereotype status-quo. Males outnumber females in public speaking roles [24, 28-30]; this reinforces our implicit bias to regard males as authority figures [19] and leads to a perception that males are the leaders and are 'more able' in science [18]. b) Female-only platforms that give women a public voice have the potential to break the links (purple arrows) between male dominance in the public arena, and reset implicit bias on authority and leadership. They do this by boosting women's confidence and raising awareness of gender issues among those women and also their communities.

Here we use data from a female-only, public speaking platform which has promoted the visibility of over 1000 women in STEM via public engagement across the globe over the last 9 years.

1. **We examine the project's impact on the confidence of the 570 Speakers from 2011-2017 (Aim 1)**

2. **Their further public speaking activities (Aim 2)**

3. **Their career prospects (Aim 3)**

4. **We ask to what extent a female-only platform influenced the Speakers' decisions to take part (Aim 4),**

5. **and explore their perception of their colleagues' support of their partaking in a female-only event (Aim 5).**

Materials & Methods

Soapbox Science

Soapbox Science (www.soapboxscience.org) (hereafter 'Soapbox') is an outreach initiative which provides female scientists with a physical pedestal (literally, a 'soapbox') to stand on the streets and engage the passers-by with their science. It was set up in 2011 to provide training for women in public engagement, promote the visibility of female scientists, break down gender stereotypes, and provide accessible role models for the next generation of female scientists. Soapbox invites applications from research-active women in STEM employed in public (e.g. academia) and private (e.g. industry) sectors. Speakers are selected to highlight a diversity of career paths, seniority levels, disciplines, and personal backgrounds. Soapbox events are non-ticketed and take place in public areas, with high footfall (e.g. shopping centres), meaning the events attract passers-by and are not limited to the subset of the public that have a prior interest in science. A typical event showcases 12 scientists who stand on wooden soapboxes on the street, in three one-hour sessions, with four speakers per session. Prior to their event, Speakers are offered training in public speaking and media relations, and given a grounding on the current literature on gender equity issues in STEM. Speakers are also invited to engage with online activities, e.g. blogs, social media. Fifty Soapbox events took place in the period

2011-2017, hosting 570 Speakers across 24 cities (18 UK; 2 Australia; 2 Ireland; 1 Canada; 1 Germany) and engaging over 100,000 members of the public.

Speaker questionnaires and sample sizes

We collected data on the impact of Soapbox on Speakers via on-line questionnaires between 19.01.18 and 20.02.18, hosted by Google Forms (www.google.co.uk/forms) (Fig. 2). The Speaker questionnaire asked 41 questions including binomial (yes/no), multiple choice (inclusive and exclusive) and Likert scale and open response questions, pertaining to Speakers' participation in Soapbox and to career-related activities. Every section of the questionnaire ended with an optional additional comments response. A diversity questionnaire covering age, disability, ethnic origin and sexual orientation was issued separately to ensure anonymity.

Figure 2. Sample of the speaker survey

All of the 570 Speakers from the period 2011-2017 were invited to take part; 46 could not be traced; 357 Speakers responded to the Speaker survey (68% response rate; 2.9% margin of error at a 95% confidence level) and provide the sample size for this study. The time between being a Speaker and taking part in the survey varied from 1 year (42%) to 7 years (2%), reflecting the substantial increase in events over time (mean time = 2.121± 1.376 years s.d.). The career stages and disciplines of respondents at the time of Soapbox participation reflect the full spectrum of the career sector (Fig. 3). The diversity survey received 235 responses (45% response rate; 4.8% margin of error at a 95% confidence level). 53% of respondents were under 34 (Fig. 3a), 13% identified as Black or Minority Ethnic (BME), 7% considered themselves as disabled and 10% of respondents identified themselves as lesbian, gay or bisexual (LGB). One speaker self-identified as gender non-binary and one as a transwoman.
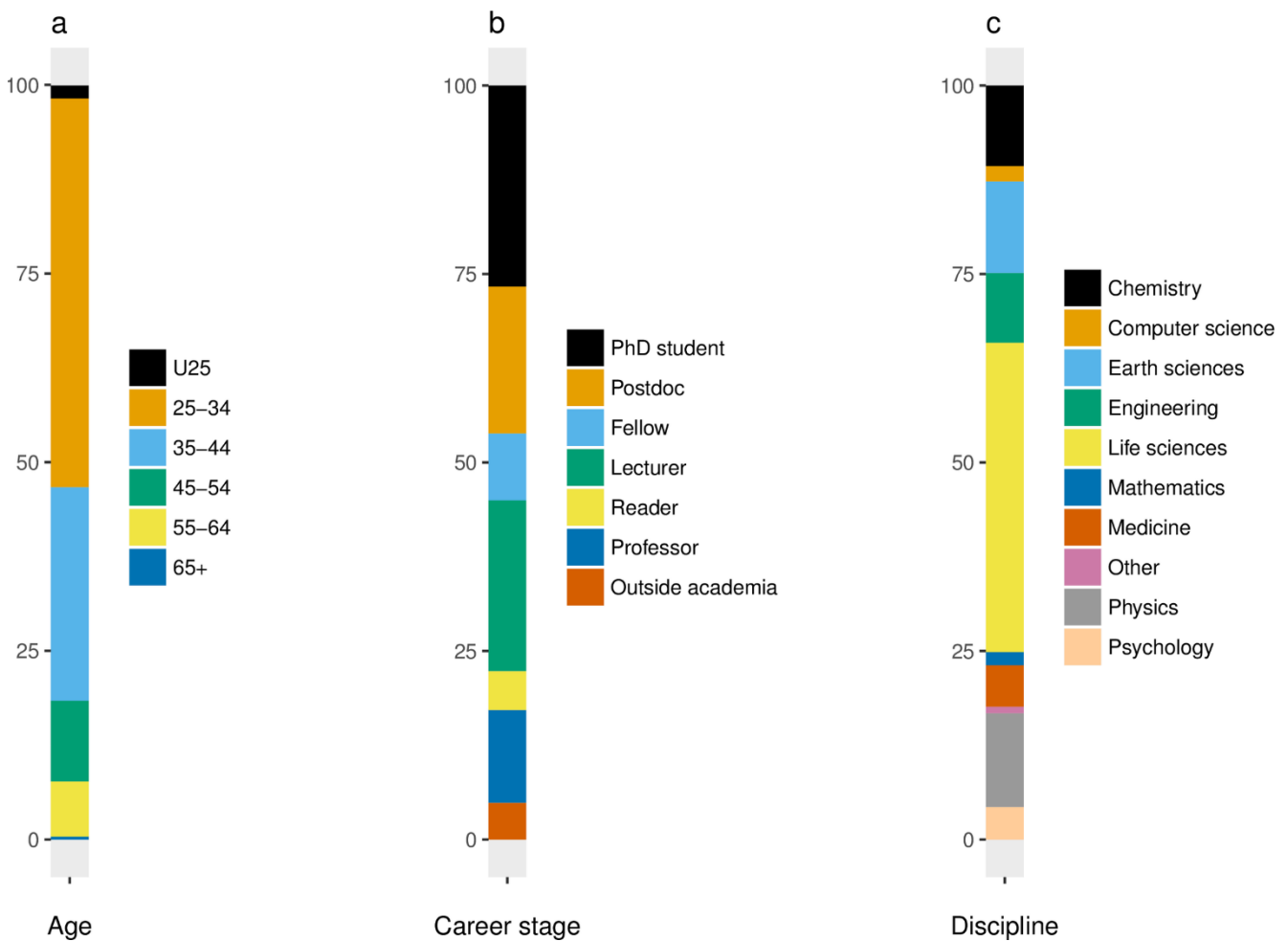

Figure 3. The distribution of Speakers' a) ages (235 responses), b) career levels (357 responses), and c) disciplines (357 responses).

Data analysis

Likert scale responses were on a five point scale. We rated scores of one to two as 'low', three as 'moderate' and four to five as 'high' confidence/support/influence. The order of questions relating to confidence before and after the Soapbox event was randomized by the survey platform used. Speakers were asked how many public talks they had given in each of the three years before and after their participation in Soapbox (0, one to two (scored as one), three to four (scored as three), five+ (scored as 5)) and the maximum 'before' and 'after' scores compared. Wilcoxon matched-pairs tests were used to analyse before and after comparisons. We used Wilcoxon signed rank tests to compare Speakers' motivations and the support of male and female colleagues.

Results

Aim 1: Public speaking significantly boosts women's confidence

Participating in Soapbox had a significant, positive impact on Speakers' self-reported confidence in public speaking, within their workplace, and in networking with their broader academic community (Fig. 4): 46% of 356 speakers rated their confidence in public speaking as low/moderate (1-2/3 on the Likert scale) before taking part in Soapbox. Confidence in public speaking increased significantly after participation (Wilcoxon matched pairs test V = 1407, p < 0.0001; Fig. 4a), from 54% to 84% of Speakers rating it as high (4-5 on the Likert scale). Secondly, participation in Soapbox shifted the proportion of women who rated their confidence at work as high from 56% to 73% (Wilcoxon matched pairs test V = 628, p < 0.0001; Fig. 4b). Finally, there was a significant shift in confidence in networking from 37% to 59% of Speakers rating it as high after Soapbox (Wilcoxon matched pairs test V = 0, p < 0.0001: Fig. 4c).
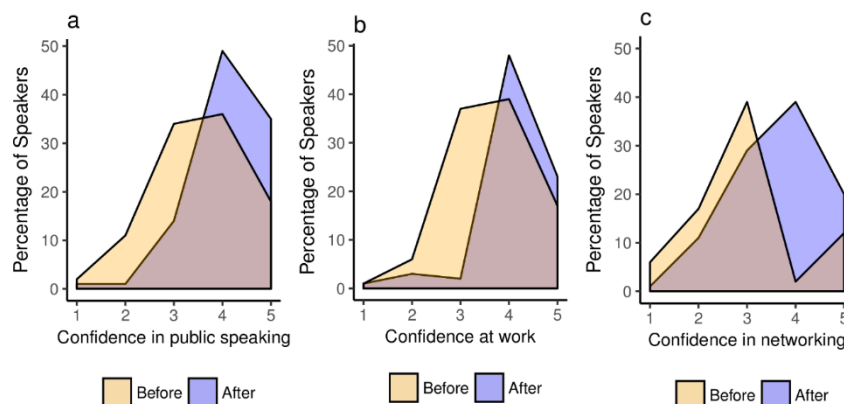

Figure 4. Following participation in Soapbox, Speakers' confidence shows a significant increase a) in public speaking, b) at work, and c) in networking. Confidence is rated on a 5-point Likert scale where 0 = no confidence and 5 = very high confidence; 356 responses.

Aim 2: Public speaking experience has a positive feedback

There was clear evidence of the perceived boost in confidence in public speaking. Almost half (44%; 307 respondents) of Speakers said that their participation in Soapbox had a high influence on their volunteering to give further public talks. The data support the Speakers' statements since there was a highly significant increase (Wilcoxon matched pairs test V = 4023, p < 0.0001) in the number of public talks given by Speakers after their participation in Soapbox.

Aim 3: Public speaking is valued by women in applying for jobs or promotions

In total, 54% of Speakers have applied either for promotion or a new position since participating in Soapbox; 97% mentioned Soapbox in their applications. Over half (57%) of these Speakers felt that Soapbox had had a moderate (37%) or strong (20%) influence on the outcome of their promotion.

In addition to these quantitative data, the following quotes offer qualitative evidence of how the Speakers valued the public speaking opportunity that was provided by Soapbox:

> *"Soapbox Science goes down well at interview panels"*
>
> *"The Tweet showing me on the soapbox was prominently featured in my job talk slides!"*

Other speakers commented that the confidence they had gained from the experience had helped them achieve promotion:

> *"I am now in a senior managerial role with my scientific institution and feel more confident"*
>
> *"Other activities I have done because of the confidence I gained from Soapbox benefitted my application significantly"*

Aim 4: Female-only public speaking platform benefits individuals and their communities.

We found two lines of evidence suggesting that female-only platforms can deliver impact to both the individual Speakers and their colleagues.

Female-only platform benefits those with low confidence in particular

Although 33% of Speakers said the female-only platform did not influence their confidence in participating, 30% said it had a high influence. There was a significant negative Spearman's correlation between Speakers' perceived security of the female-only platform and Speakers' confidence in public speaking prior to participation (p = -0.1747, p = 0.0009). This suggests the female-only platform is encouraging participation from Speakers who might not normally have the confidence to engage in public outreach.

Participation driven more by the 'gender-agenda' than scientific prestige

Increasing the visibility of women in science was a greater motivator than promoting an area of research in Speakers' decisions to apply for Soapbox (Wilcoxon signed rank test, W = 47492, p < 0.0001: Fig. 5). More generally, 88% of Speakers said that they continue to participate in activities in order to increase visibility of women in science; 60% of Speakers said that this motivation was influenced by their experience with Soapbox. Although 85% of Speakers said that they were already aware of gender inequality before participating in Soapbox Science, 45% of Speakers said that Soapbox had increased their awareness. These results suggest that gender-based initiatives like Soapbox successfully raise awareness within the workplace on inequality issues in STEM.
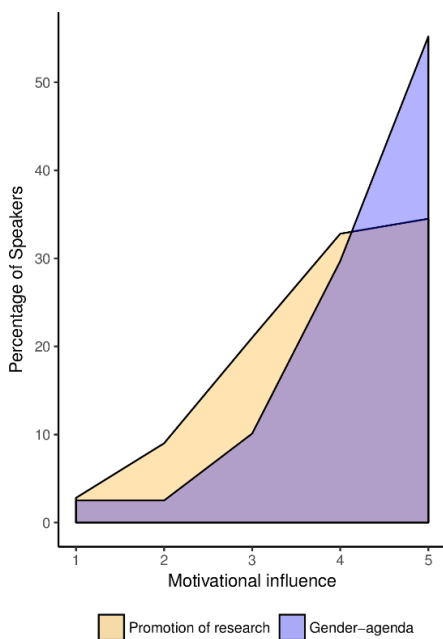

Figure 5. Speakers were motivated to participate in Soapbox more by the 'gender-agenda' than by the opportunity to promote their research. (85% of Speakers were highly influenced to participate in order to increase the visibility of women and 65% by promotion of their research area; 357 responses.)

Aim 5: Female colleagues are more sympathetic to gender-based initiatives than males

Overall, colleagues were perceived as being supportive of Speakers' participation in Soapbox and its gender-equality ethos. However, Speakers felt that their female colleagues were significantly more supportive than males (82% and 57% respectively showed high perceived support for the gender equality aspect of Soapbox Science (Fig. 6); (Wilcoxon signed rank test, W = 82170, p < 0.0001)).
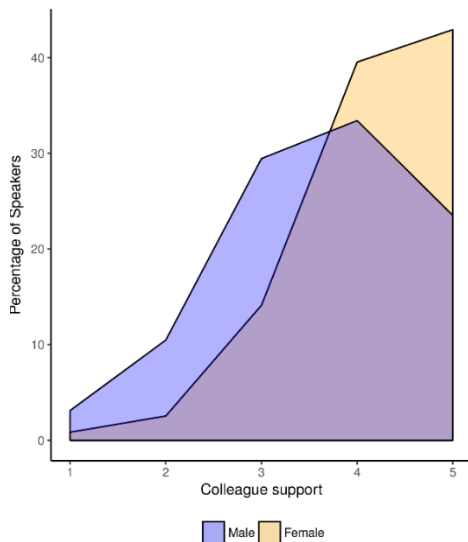

Figure 6. Female colleagues were perceived as more supportive of Soapbox's 'gender-agenda' than male colleagues. (82% of female colleagues and 57% of male colleagues were perceived by Speakers to show high support for the gender equality aspect of Soapbox Science; 354 responses.)

Qualitatively, there was the suggestion that factors other than gender per se may be at play.

"Support from male colleagues varied. Males that I work closely with (both postdocs and PIs) were very supportive but others within my department showed little interest. However, support/interest from female colleagues came from a wider base."

"Some male colleagues are very supportive of both gender equality and science communication. More senior male colleagues less so."

Several Speakers also said that male colleagues felt excluded by Soapbox or did not see the need for a female-only platform. These results therefore suggest that while a majority (57%) of male colleagues understood and supported a female-only public speaking event, a sizable minority (43%) did not. It is worth noting that several Speakers commented that their work places had a negative view of public engagement with the result that some Speakers actually kept their participation in Soapbox secret from their colleagues. For example,

"Science communication is frowned upon in my laboratory unfortunately so I did not discuss it with my colleagues."

"I try to keep the public engagement work quiet as it can be seen as 'too fluffy' for a serious scientist."

"No one cared about the participation at the time, neither male or female."

Discussion

Our study demonstrates how female-only public speaking platforms have the potential to deliver real impact in achieving gender equality in STEM. Our data suggest two overarching reasons for this impact: firstly, Speakers report that these events are boosting their confidence which may itself lead to further benefits; secondly, a female-only platform is effective in raising awareness about gender inequality in the STEM workplace, and encouraged participation from less confident Speakers (Fig. 7). We suggest that female-only public speaking platforms, like Soapbox, can help to erode the stereotypes of males as public speakers, authority figures and leaders in the STEM sector (Fig. 1).
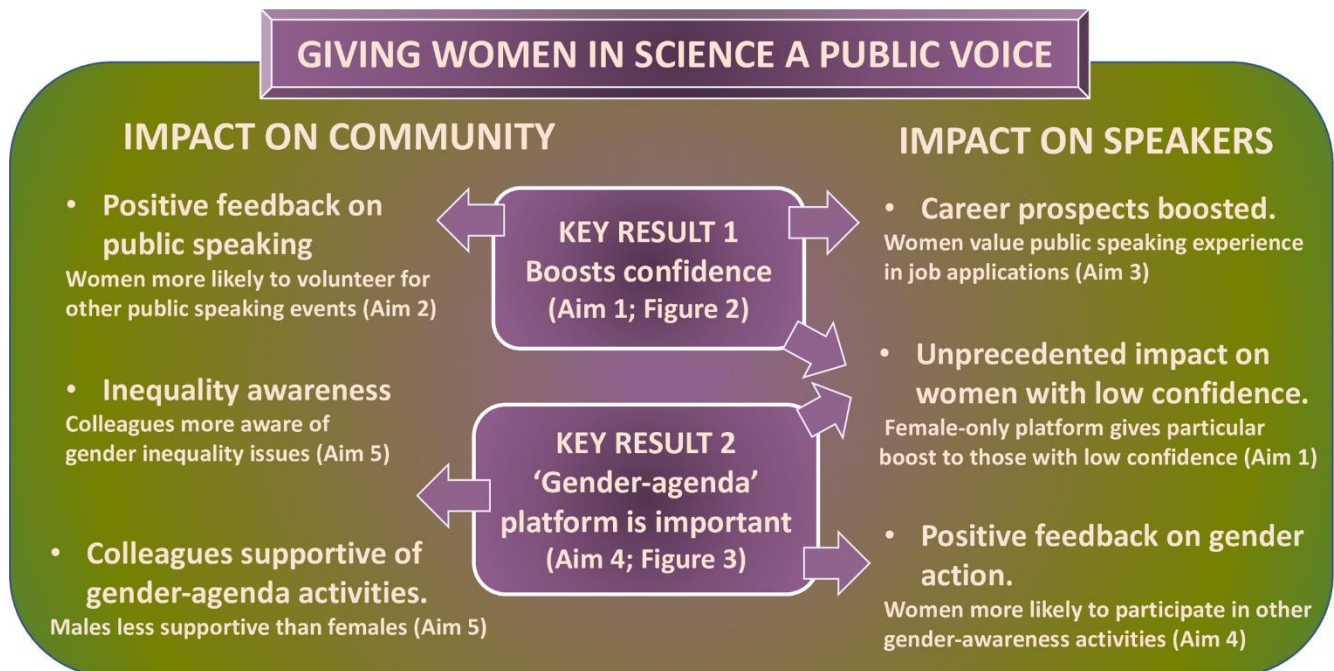

Figure 7. The female-only public-speaking platform has impact on the Speakers themselves, and their immediate workplace community. Only significant results (p<0.05) are shown.

Soapbox has had a direct, positive impact on the self-reported confidence of its Speakers in public speaking and in the workplace. This confidence boost appears to have multiple benefits on the Speakers: our study shows that Speakers are taking part in more public speaking events and gender-awareness initiatives; these factors are potentially influencing their career progression, career decisions and promotion outcomes e.g. in women's CVs, and optimizing networking opportunities (Fig. 7). Lack of confidence is commonly cited by women in STEM as an impediment to their careers [11, 38]; women underestimate their performance in STEM careers [38, 39]. Increasing women's confidence is therefore one of the critical barriers to improving progress at work and to retaining these highly skilled people. Providing women with confidence-boosting public speaking opportunities, might have real impact on one of the root causes of gender inequality in STEM.

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The Speakers' self-professed confidence boost was evidenced in several ways. Firstly, they were more likely to volunteer for other public speaking events. This is important, as it sets in motion a positive feedback for women to amplify their public voice, and help sever the link between masculinity and public speaking (Fig. 1). Positive feedback from public engagement has been previously reported [40]. However, our study highlights the importance of this for women, and more broadly for STEM as a field: it is concerning that some Speakers reported their workplaces as having negative attitudes to public engagement. Currently, STEM researchers do not partake in public engagement activities as frequently as their Arts, Humanities and Social Sciences (AHSS) counterparts and only 28% of UK researchers received training in public engagement in the period 2010-2015 [41].

To achieve an equal proportion of male and female scientists in the public arena would, with the current gender imbalance, require women to do more than their 'fair share' of outreach.
It could be argued that this is detrimental to women's careers since outreach is of lower value than other research outcomes with respect to CVs and promotion. However, initiatives such as Soapbox, which raise the public profile of more junior researchers, should help to spread the outreach load more evenly across female scientists rather than the same few high-profile scientists being consistently invited to participate in events. If, as our results suggest, outreach work increases women's self-confidence at work, the advantages to participating are well worth the time costs.

The all-female platform encouraged participation and had a highly significant effect on those women who most lacked confidence in public speaking. This may partly be due to the removal of stereotype threat, since public speaking is traditionally a male domain [22]. Excluding competition by male colleagues and creating female-only STEM environments may therefore be a quick and easy way to achieve impact on the careers of the less confident women in STEM. Same-sex groups are known to have benefits, e.g. women-only mentoring schemes; contact with same-sex experts has been found to

enhance women's self-concept in STEM and motivation to pursue STEM careers [42]. Similarly, schemes which work to improve women's self-efficacy have been shown to increase female graduation rates [43, 44].

A second impact of the female-only platform was that women reported how the 'gender-agenda' of the public speaking platform was more influential on their choice to take part than the opportunity to share (or promote) their science. These results suggest that female public outreach events should be encouraged. Public outreach in its own right is personally rewarding for scientists and a previous study has shown attitudes towards outreach to be the same, regardless of gender [24]; however, our study suggests that when there is an additional agenda (to promote women in science; provide role models) the incentive to take part is stronger, and the partaking in itself has further benefits to the individual and her community (Fig. 7).

The female-only platform helped to raise awareness about gender inequality issues among the Speakers themselves. Although almost all Speakers were already aware of gender inequality, nearly half of Speakers said that Soapbox increased their knowledge of their issue. Of those whose knowledge was not increased, many commented that they were already fully aware of the situation. Awareness was also raised in the workplace by Speakers' opening dialogue with their colleagues

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and students about inequality in STEM. Some women received a negative response from their colleagues, and our analyses suggest that male colleagues were perceived by the Speakers as more critical than female colleagues about the gender-agenda of the platform. This may be a systemic problem in STEM: a recent report revealed that men in STEM perceive fewer gender disparities than women in the same roles [45]. At one extreme, a case-study of female engineering students showed that some deliberately avoided female-specific initiatives for fear of being accused of being given 'unfair advantages' [46]. It is important that not just women, but also men, are familiar with the facts and figures of gender equity in STEM [45] and understand how gender-specific initiatives can help challenge cultural stereotypes and reset ingrained implicit bias (this study; [42]).

Gender is only one aspect of inequality that plagues the STEM community; sexual orientation, race and disability are other areas that need to be addressed [e.g. 47, 48]. Soapbox represents LGB people well (10%; European population average 6% [49]); BME Speakers (13%) were representative of the UK STEM average (13% [47]); however, disabled Speakers (7%) were under-represented (11% UK STEM average [47]). Disabled and BME groups already face additional hurdles in the workplace, [45, 47, 48] and therefore public speaking activities should work to increase accessibility and public visibility of these groups, in addition to gender. One of our respondents identifies as a 'non-binary person' and another as a 'trans woman'. We call attention to how gender inequality in STEM rarely addresses

gender non-binary or trans people and, indeed, the non-binary Speaker said they feel 'invisible' in the gender inequality dialogue.

As with any study, ours had some limitations. Perhaps most pertinently, Speakers may have recall biases regarding their pre-participation outcomes and our results must be interpreted with this in mind. Ideally we would have interviewed speakers some months before and after the event and also concurrently surveyed a control group who had not taken part in Soapbox. Soapbox was initiated on a shoe-string budget and at a small scale; its rapid expansion and popularity were unforeseen and thus, in its early years, the impact it might have had on its Speakers was not investigated. Indeed, to the best of our knowledge, although science outreach events regularly assess their impact on their audience, they do not tend to assess their impact on their Speakers. This study was the first Soapbox Speaker survey and, although in future Speakers could be interviewed both before and after the event, this is not possible for the 2011-2017 cohorts. However, if the 2011-2017 Speakers were motivated to report overly positive results this would suggest that they have positive memories of Soapbox and its impact upon them and so while such bias may have accentuated the trends we find, it is unlikely to have been their sole cause. We suggest that other outreach initiatives should follow suit in analysing their potential impact on their speakers in addition to the now standard surveys on audience impact.

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Secondly, Soapbox Speakers are selected from a much larger pool of applicants to give a diversity of career stages, backgrounds and disciplines. There may be differences in Speaker impact linked to discipline or seniority which, currently, we do not have sufficient data to explore. Thirdly, respondents are self-selected. We found significant differences between the sample of respondents and the population of Speakers with respect to year (X-sq = 15.1100, p = 0.0194) and city of event (X-sq = 52.7059, p = 0.0004). Speakers from 2015 were under-represented but this seems unlikely to affect our results. A higher proportion of London Speakers responded, perhaps because these Speakers had a particularly rewarding experience due to the high footfall and audience engagement at the London events. It is possible that Speakers who had a negative or neutral experience of Soapbox may have been less likely to fill in the survey. Nevertheless, our data represent the majority (68%) of Speakers. Fourthly, Speakers' confidence and speaking opportunities may have increased naturally over the course of their career and/or with age but given that 42% of respondents had participated in Soapbox under a year ago and 31% under 2 years ago this is unlikely to explain our

results. Lastly, although the majority of our Speaker data came from events hosted within the UK, we see no reason why results would not be similar for speakers elsewhere. The model of Soapbox is easily applicable to any university town and indeed, in 2018-2019, Soapbox Science has expanded its overseas events to Argentina, Brazil, Ghana, Nigeria, Sweden, Tanzania and the USA and to additional cities in Australia, Canada, Germany and the UK.

Conclusions

Our seven year study of over 550 women in STEM, demonstrates that giving a public voice to women can have a fast and positive impact on tackling gender inequalities in STEM. Women, given encouragement, training and a welcoming environment, are keen to provide STEM role models for society and to speak up for their science and gender, gaining career benefits in the process. We advocate support for female-specific public speaking initiatives, like Soapbox, to the STEM sector as a way to break the stereotype of males as the voice of authority, leadership and ability in STEM (Fig. 1). Giving today's generation of women in STEM a voice, paves the way for a future that embraces equality and celebrates diversity.

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