



# Women in Open Source: We Need to Talk About It

Bianca Trinkenreich, Marco Aurelio Gerosa , and Igor Steinmacher ,  
Northern Arizona University

*Women are underrepresented in open source projects, causing them to lose career and skill-development opportunities. This article highlights the challenges that women face being a part of open source projects and lists a set of strategies that communities can implement to mitigate these issues.*

**W**omen are underrepresented in open source software (OSS) communities. Despite the efforts taken by OSS organizations to increase gender diversity and place more women in leadership positions, the numbers are still low. Women represent approximately 10% of the contributors and are underrepresented in central OSS roles, although they are better represented earlier in the joining process (for example, in mentoring programs).

Digital Object Identifier 10.1109/MC.2022.3200860  
Date of current version: 15 November 2022

Women's participation has increased in recent times, but those who contribute report having only a few hours per week to devote to OSS.<sup>1</sup> Although OSS projects idealize a meritocracy wherein quality speaks for itself, several biases undermine women, who feel that their quality is not able to speak for itself and report experiencing "impostor syndrome." Gender biases can represent a "glass floor" and a persistent barrier to entry.

Women are one of the gender minorities, and gender is one of the aspects of diversity. Diverse software teams are more likely to understand user needs, contributing to a better alignment between the delivered software and its customers. Diversity further positively affects productivity by bringing together different perspectives, and fosters innovation and problem-solving capacity, leading to a healthier work environment. Reducing the gender gap in OSS projects requires not only attracting but also retaining women.

Women could decide to leave a project if diversity is not a priority.<sup>2</sup> Note that in this article, we use the term

**FROM THE EDITOR**

The open source community at large likes to bill itself as meritocratic, sometimes even democratic, where everyone gets their say and is heard. As it turns out, like in much of society, some voices are louder and more successful than others, and as this article shows, open source is no different. Mindbogglingly enough, women, constituting half of the world’s population, are not only a minority in open source in numbers, but face additional challenges of discrimination. This article illustrates the problem and the various challenges that make life extra hard for women in open source. For once, not just happy hacking, but also happy changing for a better world!—*Dirk Riehle*

gender as a socially constructed concept, where gender identification, display, and performance might or might not align with a person’s sex assigned at birth. To reflect this social concept of gender, we use the terms *women* and *men* as shorthands for people who self-identify as such. In many cases, women drop out because their jobs are not aligned with their motivations. Understanding the reasons behind the decision to step out of a project or role can help create strategies to increase retention. In this article, we

summarize what is known about the challenges faced by women, strategies that are in place, and what else can be done to change this landscape.

**WHAT DO WOMEN FACE?**

A recent study that mapped the literature<sup>1</sup> has shown that women face a variety of challenges in OSS, as discussed in the following and illustrated in Figure 1.

**Lack of peer parity**

Feeling outnumbered and alienated, women can feel more comfortable and

accepted by other women, and frustrated when they are “the only woman in the room.” Women reported feeling invisible in larger male-dominated groups.

**Noninclusive communication**

In a recent survey,<sup>3</sup> roughly one-third of women reported that they experienced written or spoken language that made them feel unwelcome in OSS interactions. Discriminatory expletives, swear words, and negative critiques often used in code reviews and mailing lists may be especially insulting to women. Awkward communication styles and terms usually associated with men (for example, “guys”) can also impact women.

**Toxic culture**

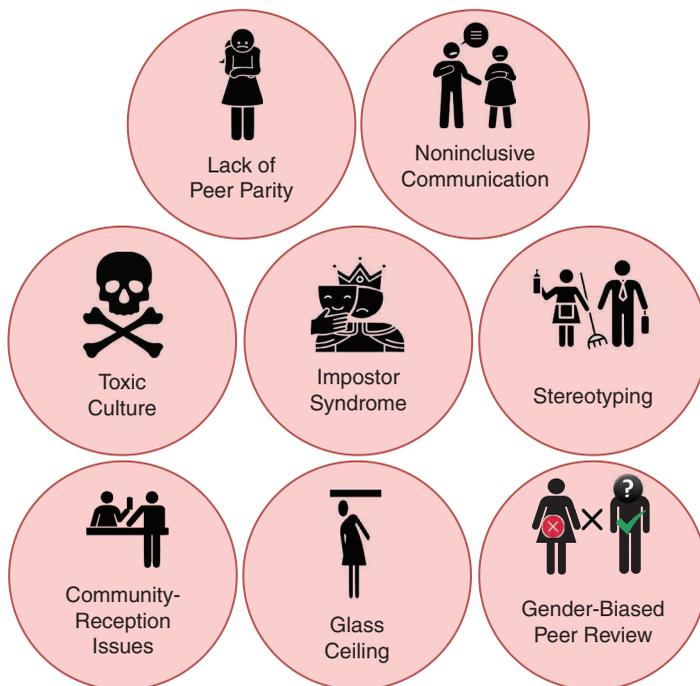
In a survey from 2022,<sup>3</sup> women reported twice as many threats of violence than men in the context of OSS. Incidents of symbolic violence and harassment against women can hinder their access to the community, such as when men decide to “hire that one because she is hot.”<sup>4</sup> Women also need to prove themselves (prove it again) constantly, and face judgment, abuse and discrimination, offensive talk, and feel obliged to remind men not to “stare and point” at them.

**Impostor syndrome**

Women often report experiencing impostor syndrome, a psychological concept about a pattern of behavior wherein people doubt their abilities and experience a persistent fear of being exposed as a fraud. Impostor syndrome in OSS can be amplified by the hostile and toxic culture that pervades communities. Despite being knowledgeable and professionally well settled, women may be more reluctant to publicly display their work.

**Community-reception issues**

Women generally feel restrained when communities nullify them when they do not have enough skills to provide contributions on their first day. When trying to find a mentor, upon discovering their mentee’s gender, male mentors



**FIGURE 1.** Challenges faced by women when contributing to OSS.<sup>1</sup>

can treat the relationship as a dating opportunity. As a result, many women use fake accounts and hide their gender “so that people would assume [they] were male.”<sup>2</sup>

### Stereotyping

Women, more often than men, encounter language or content that makes them feel stereotyped, boxing them into caretaker and parental roles. Both descriptive (how women are) and prescriptive (how women should be), gender stereotypes and the expectations they produce can compromise women’s career progress. Academic literature has shown that implicit stereotypes about gender and science, technology, engineering, and mathematics (STEM) have profound effects on girls’ and women’s interest, confidence, and persistence in STEM education and careers.<sup>5</sup> Similarly, gender roles and “macho” attitudes can cause gender inequalities in OSS communities.<sup>4</sup>

### Glass ceiling

According to a Linux Foundation survey from 2021,<sup>3</sup> women still perceive they have fewer opportunities than men to be a part of the decision-making process in OSS. Although women are increasingly present in community-centric roles,<sup>6</sup> they still represent less than 10% of the leaders.<sup>7</sup> Several studies found women’s participation ranges from 4.3% as core developers to 14.2% as participants of Google Summer of Code, showing that they are better represented earlier in the joining process (for example, in mentoring programs) than in core roles. When looking at participation rates, only a few women join OSS to increase their job opportunities. However, if they join, after becoming contributors, this motivation increases. This represents the “shifting belief” that women have in OSS toward building a career, which increases only after overcoming the barriers to joining and becoming contributors.<sup>1</sup>

### Gender-biased peer review

Although women can have merge-acceptance rates nearly equivalent to or

slightly higher than men, there is a bias against women’s contributions when the gender is identified, and women perceive this bias. Still, the code submitted by women often have lower churn per comment, women have to wait longer to receive initial feedback for their code changes, and their review

intervals can last longer than men’s.<sup>1</sup> As a consequence of the challenging environment, women often decide to hide their gender when contributing to OSS.

### HOW ARE WE DEALING WITH THAT?

There are several strategies that OSS communities employ to increase women’s participation, as discussed in the following and illustrated in Figure 2. OSS communities can promote awareness of the presence of peers and recognize women’s achievements (visibility) by publishing success stories of women, having the potential to attract more women, and retaining women who are already contributors. Considering that this media exposure can include women’s posts and pictures, this action also helps to destereotype the OSS contributor, which has usually been associated with images of men.

Promoting women-specific groups and events is an easy first step for communities, and it can be done, for example, by creating a women-only forum. This strategy can be a part of greater efforts to encourage and welcome women, which can include mentoring or inviting women to contribute to specific activities. Another action that can help is creating and enforcing a code of conduct by providing online training and transparency about the punishments for those who violate it.

Still, training can be offered (preparing mentors to guide women) for allies who advocate for women. Content of the training can include practical examples of acceptable and non-acceptable behaviors to avoid toxicity. One place where toxicity can manifest is in communications via comments

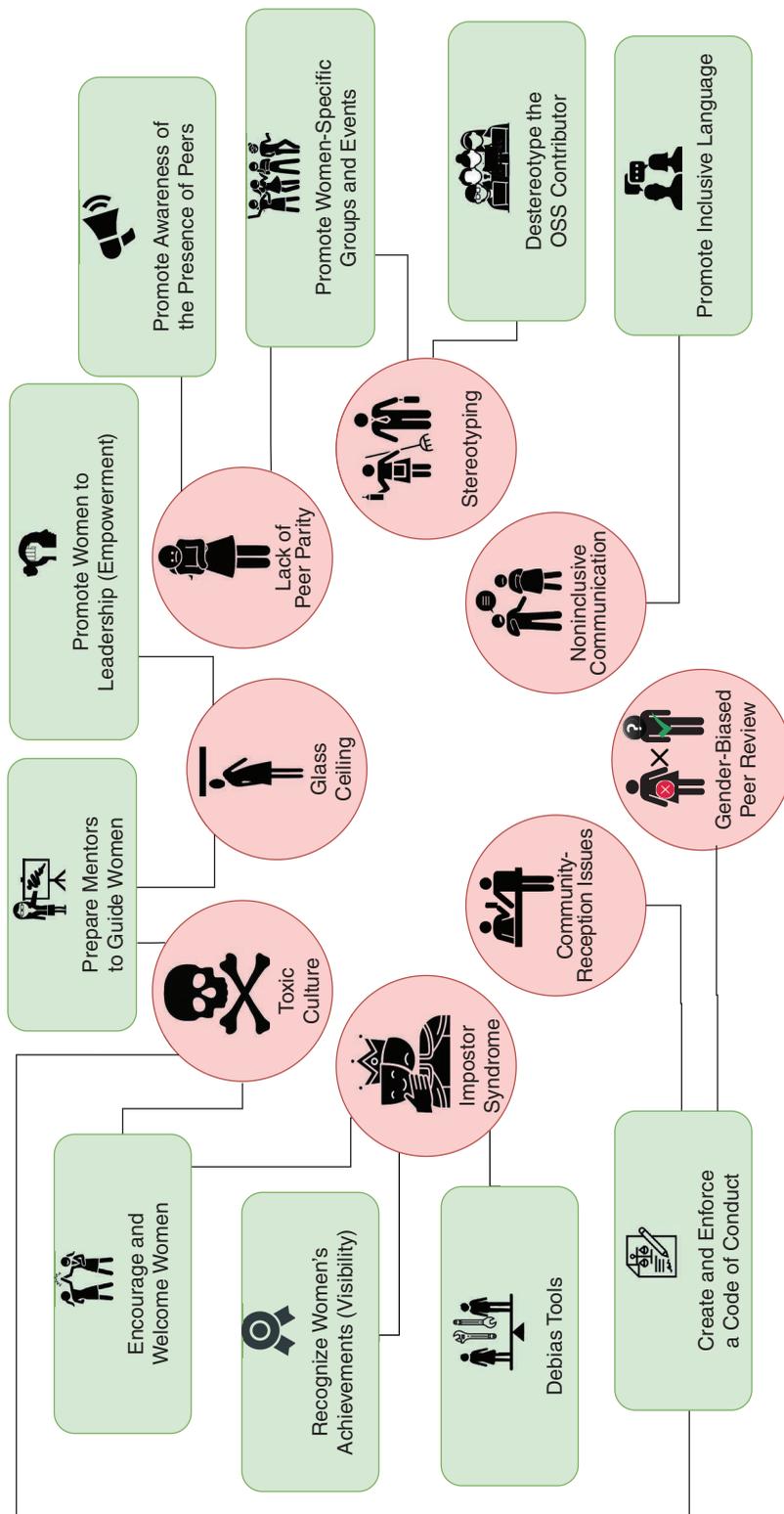
Diverse software teams are more likely to understand user needs, contributing to a better alignment between the delivered software and its customers.

in code reviews and in mailing lists and forums. Code reviewers may need education support to articulate their review comments in a way that builds relationships. One strategy could be providing review templates that help developers use inclusive words and employing empathy to help promote inclusive language.

### HOW FAR ARE WE?

The rates of women in OSS have increased over time but at a slow pace. Many organizations now have business goals that increase the rates of women in their teams and in leadership positions. However, women want to have opportunities, but not due to benevolent sexism—that is, only because they are women—that often brings sexist antipathy. They want equal conditions, treatment, and opportunities for realizing their full potential.

It is clear that there is still a large gender disparity in OSS contributors. However, the gender disparity is less pronounced in the initial stages (for example, as students of Google Summer of Code). There is attrition of women contributors as they move through their pathways, making them underrepresented in core and leadership roles—the leaky pipe phenomenon. This attrition can be a consequence of the several sociocultural challenges faced by women during the process. Women face gender bias



**FIGURE 2.** The strategies used to mitigate challenges faced by women in OSS (circles represent challenges and rectangles represent strategies).<sup>1</sup>

in communication, acceptance in the community, and lower contribution-acceptance rates when they explicitly identify themselves as women. Although mentorship events enhance (women) participants' sense of competence and increase the chances of future contributions' values, these programs alone are insufficient as women do not stay long enough to become project leaders. The majority of the challenges that women face or the reasons for women leaving OSS are sociocultural in nature and not related to technical skills. The existing research<sup>1</sup> suggests that women are as productive as their male colleagues in an inclusive OSS project, sometimes more so. Therefore, strategies that help create an inclusive environment geared toward retaining and mentoring women are needed to fix the leaky pipeline.

Recognition and empowerment are strong strategies to fight impostor syndrome, but although attaining promotion to leadership is not easy, serving in a high position can be even more challenging. Women often lack the support or authority to accomplish their strategic goals. Empowering women is not only about promoting them to leadership but preparing them for the position and also giving them the proper authority. Moreover, as women often have social motivations (for example, kinship), and the reported challenges are also social, there is a conflict between their expectations and reality, which can explain why women are not joining or staying in OSS projects. When women join an OSS project expecting to find other women around and friendly colleagues, but instead find lack of peer parity and face a toxic culture, this directly conflicts with their motivations. The lack of peer parity can be alleviated by attracting more women, which can be accomplished by understanding that they

may have different motivations and career goals to achieve their “pots of gold,” thereby also recognizing different types of contributions.<sup>6</sup>

We observed a recent growth in the creation of codes of conduct in OSS projects. But is unclear how these are enforced and, for them to work, enforcement is key. Although having a code of conduct will not prevent sexism, it indicates to everyone who engages in sexist behaviors that such actions will not be tolerated in the project. Communities should put mechanisms in place to implement the code and show that violations have consequences.

**T**here is still much work ahead for OSS, the software industry, and us as a society to create a more diverse and inclusive environment. We hope to enlighten actions toward reducing the perceived challenges and (more importantly) increasing awareness about the structural and cultural hurdles imposed on women that negatively influence diversity in OSS. 

#### ACKNOWLEDGMENT

This work is partially supported by the National Science Foundation under grant number 1900903.

#### REFERENCES

1. B. Trinkenreich, I. Wiese, A. Sarma, M. Gerosa, and I. Steinmacher, “Women’s participation in open source software: A survey of the literature,” *ACM Trans. Softw. Eng. Methodol.*, vol. 31, no. 4, pp. 1–37, May 2021, doi: 10.1145/3510460.
2. B. Vasilescu, V. Filkov, and A. Serebrenik, “Perceptions of diversity on Git Hub: A user survey,” in *Proc. 2015 IEEE/ACM 8th Int. Workshop Cooperative Hum. Aspects Softw. Eng.*, pp. 50–56, doi: 10.1109/CHASE.2015.14.
3. H. Carter and J. Groopman. “The Linux foundation report on diversity, equity, and inclusion in open source.” The Linux Foundation. Accessed: Jul. 20, 2022. [Online]. Available: <https://bit.ly/3PmbKu5>
4. D. Calvo, “The (in)visible barriers to free software: Inequalities in online communities in Spain,” *Stud. Commun. Sci.*, vol. 21, no. 1, pp. 163–178, Jun. 2021, doi: 10.24434/j.scoms.2021.01.011.
5. N. Dasgupta and J. G. Stout, “Girls and women in science, technology, engineering, and mathematics: STEMing the tide and broadening participation in STEM careers,” *Policy Insights Behav. Brain Sci.*, vol. 1, no. 1, pp. 21–29, Oct. 2014, doi: 10.1177/2372732214549471.
6. B. Trinkenreich, M. Guizani, I. Wiese, A. Sarma, and I. Steinmacher, “Hidden figures: Roles and pathways of successful OSS contributors,” in *Proc. ACM Hum.-Comput. Interact.*, 2020, vol. 4, no. CSCW2, p. 22, doi: 10.1145/3415251.
7. D. Izquierdo, N. Huesman, A. Serebrenik, and G. Robles, “OpenStack gender diversity report,” *IEEE Softw.*, vol. 36, no. 1, pp. 28–33, Jan./Feb. 2019, doi: 10.1109/MS.2018.2874322.

**BIANCA TRINKENREICH** is a Ph.D. candidate at Northern Arizona University, Flagstaff, AZ 86011 USA. Contact her at [bianca.trinkenreich@nau.edu](mailto:bianca.trinkenreich@nau.edu).

**MARCO AURELIO GEROSA** is a full professor at Northern Arizona University, Flagstaff, AZ 86011 USA. Contact him at [marco.gerosa@nau.edu](mailto:marco.gerosa@nau.edu).

**IGOR STEINMACHER** is an assistant professor at Northern Arizona University, Flagstaff, AZ 86011 USA. Contact him at [igor.steinmacher@nau.edu](mailto:igor.steinmacher@nau.edu).