Investigating the Barriers that Women Face in Software Development Teams Focusing on the Context of Proprietary Software Ecosystems

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Abstract. Despite the growing discussion and concern about the topic, gender diversity in the Exact Sciences and Technology still requires attention. It has been observed by several authors that gender diversity is not present in a significant way in development teams, despite the potential positive effects. Moreover, with the growing demand for software that meet complex business needs, the concept of Software Ecosystems (SECO) has emerged and opens opportunities for external developers and strategies for fostering gender diversity. A Proprietary Software Ecosystem (PSECO) is a type of SECO that comprises a common technological platform with contributions protected by intellectual property. This work aims to investigate which barriers women face in software development teams focusing on the context of PSECO and what strategies can be used to increase inclusion based on a multivocal literature review. To do so, 29 studies were selected and 13 gender barriers were identified, with the 3 most cited barriers being: sexism, lack of peer parity, and imposter syndrome. Furthermore, it was observed that external PSECO actors can significantly interfere in the occurrences of gender barriers, in addition to the internal actors of the central organization (keystone).

Keywords: Diversity · Human Factors · Proprietary Software Ecosystems

1 Introduction

A significant gender disparity, with women being underrepresented, can be observed in the software industry [7]. Research has also shown that gender diversity in corporate boardrooms positively influences market value and profitability [1]. This underrepresentation of women in the software industry and development teams is attributed to persistent barriers that hinder diversity.

The Information and Communication Technology sector has been growing at a fast pace in recent years [3]. This sector traditionally demands a large number of

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professionals in the areas of Science, Technology, Engineering and Mathematics (STEM) who are mostly male professionals. In recent years, the development of new, modern, and innovative systems that meet the ever-expanding business needs has become a challenging task for companies. From this need, software ecosystems (SECO) emerge as a solution to deal with such scenario [2]. The type of SECO in which the value creation is based on proprietary contributions, protected by intellectual property management processes, is called Proprietary SECO (PSECO). In PSECO, where actors and their relationships are key roles, investigating gender diversity is also important for the environment.

In this context, the present study aims to identify the barriers that women face in software development teams in a PSECO context. Thus, a Multivocal Literature Review (MLR) was conducted to identify gender barriers and strategies to deal with such barriers, from the point of view of academia and industry.

2 Research Method

MLR emerged in the early 1990s, combining Systematic Literature Reviews (SLR) and Systematic Mapping Studies (SMS) that encompass both academic and gray literature [9]. This approach was chosen because many software professionals do not publish in academic forums, making the inclusion of gray literature essential to capture their insights. Gender diversity is a prominent industry topic, offering valuable perspectives. We followed the MLR model by Garousi et al. [6], which is rooted in Kitchenham and Charters' guidelines for SLR and SMS [8]. Protocol development and application took place between November 2022 and September 2023.

To address the purpose of the study, the following main research question (RQ) was defined: **What are the barriers to gender diversity in software development teams and what are the strategies to deal with such barriers focusing on the proprietary software ecosystem context?** To answer the RQ, the following sub-questions (SQ) were elaborated: **(SQ1) What are the barriers that women face in software development teams?**; and **(SQ2) What are the strategies to foster gender diversity in software development teams?**. After some refinements, the following search string bellow was used and Fig. 1 illustrates an overview of the process: **(women OR "gender diversity" OR "gender inclusion" OR "gender equity" OR "gender equality" OR "gender bias") AND ("software engineering" OR "software ecosystem" OR "software development" OR "open source" OR "software industry") AND (barrier* OR challenge* OR issue*)**

Unlike the scientific literature, determining when to conclude an MLR is complex due to the number of substantial results. In this study, we adopted the limited effort criterion based on Garousi et al.'s guidelines [6]. We assessed the first 100 search results for each database (200 studies in total), continuing the search only if the last page showed potential relevant findings. After examining the next page following the initial 100 records, no additional studies were deemed suitable for inclusion in the MLR.

3 Results

After executing the MLR process described in Sect. 2, information was extracted from 29 selected studies, which were numbered from S01 to S29. Further details about the selected studies are available via Zenodo[1]. To respond the main RQ, the both SQ were answered, as described next. It is noteworthy that encodings were performed based on the qualitative analysis from Grounded Theory procedures [10].

SQ1 - What are the Barriers that Women Face in Software Development Teams? Applying code procedures, 13 gender barriers were identified from the selected studies. Details on the identified barriers and the number of studies for each barrier is described bellow. It is noteworthy that a study may have described one or several barriers. To assist in their understanding, the definition of each barrier is described below:

1. **Sexism (identified in 16 studies):** Sexism can be hostile or benevolent. Hostile sexism is prejudice itself (microaggressions), such as not being heard in technical discussions and receiving derogatory comments that women perform inferiorly to men. In turn, benevolent sexism represents subjectively positive feelings towards a gender that often brings some sexist antipathy, reinforcing the idea that women need to be cared for by men;
2. **Lack of peer parity (identified in 15 studies):** Peer parity is the concept that an individual can identify herselft/himselft with at least one other peer when interacting in a community;
3. **Imposter syndrome (identified in 14 studies):** Individuals who experience intense feelings that their achievements are undeserved and fear that they may be exposed as frauds;
4. **Technical difficulties (identified in 10 studies):** This barrier refers to technical problems, such as lack of knowledge, lack of experience, and unfamiliarity with the technology or programming language used;

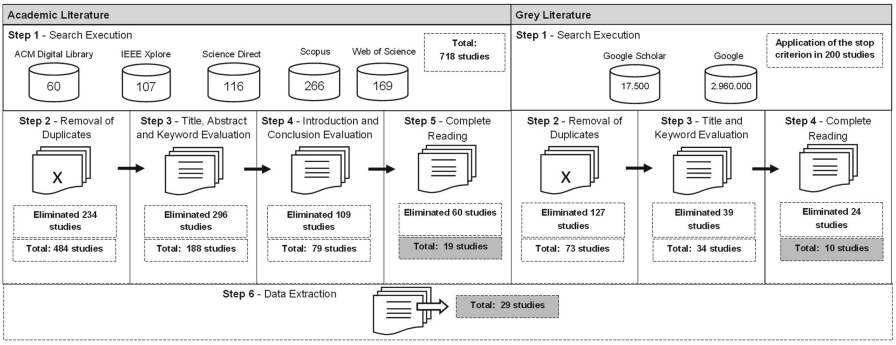

Fig. 1. Process applied in MLR.

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5. **Non-inclusive communication (identified in 8 studies):** This barrier refers to the use of exclusionary communication, such as the use of profanity and terms generally associated with men (for example, "guys");
6. **Imbalance between personal and professional life (identified in 8 studies):** This barrier refers to the lack of support for well-being, causing an imbalance in the personal lives of professionals. It is usually caused by too much overtime or pressure to deliver activities;
7. **Stereotypes (identified in 8 studies):** Stereotypes are beliefs about characteristics, attributes and behaviors of certain members of a group;
8. **Prove it again (identified in 7 studies):** It refer to the bias effect that occurs when a member of a group does not align with the stereotypes is measured to a higher standard and has to provide more evidence to demonstrate competence;
9. **Harassment (identified in 6 studies):** Harassment is abusive conduct demonstrated by means of words, behaviors, acts, gestures, or writings that may harm a person's personality, dignity or physical, or mental integrity, endangering their employment, or degrade the work environment;
10. **Glass ceiling (identified in 5 studies):** This is a transparent barrier that prevents women from rising above a certain level in corporations;
11. **Lack of recognition (identified in 4 studies):** Not feeling valued and not being recognized when good work is done;
12. **Toxic culture (identified in 4 studies):** It is characterized by work environments where there is room for favoritism, rumors, and people trying to harm each other;
13. **Maternal and family issues (identified in 4 studies):** Describes the experience of women who have children or someone in their family who requires care and suffer prejudice due to this situation, being excluded from certain opportunities.

SQ2 - What are the Strategies to Foster Gender Diversity in Software Development Teams? Based on the selected studies, it was possible to identify some strategies to foster gender diversity in software development teams. Most of the items listed below were identified in S13, which brought a detailed analysis of how to address each of the challenges mapped in its study. Below is a breakdown of the 7 identified high-level strategies and 26 actions to address each of them:

1. Embrace equality: give training to all managers regarding soft skills to be more empathetic and avoid burnout (Ac.01); respect and give voice to women (Ac.02); ensure equal pay (Ac.03); provide opportunities and challenges (Ac.04); not allocate women only to operational tasks (Ac.05); and give career choices to women in the same rate as men (Ac.06);
2. Supporting women's career growth: encouraging women to advance in their careers (Ac.07); have more women in (technical) leadership (Ac.08); and mentor other women who are role models (Ac.09);
3. Support work-life balance: implement well-being policies (Ac.10); discourage overtime (Ac.11); improve location and time flexibility (Ac.12); and support parenthood (Ac.13);

4. Empower Women: publicize women's successes on social media and at external events (Ac.14); and recognize and reward women's achievements (Ac.15);
5. Hire more women: make job opportunities attractive to women's needs (Ac.16); change the recruitment and marketing processes (Ac.17); have more women recruiting for open positions (Ac.18); create IT vacancies aimed exclusively at women (Ac.19); and invest in programs to attract girls to STEM (Ac.20);
6. Promote women's groups and events: organize supporting groups for women (Ac.21); promote interaction between women (Ac.22); and organize campaigns and/or lectures on the importance of gender diversity (Ac.23);
7. Create and reiterate policies: create, disseminate, and raise awareness of the code of conduct (Ac.24); promote anti-harassment policies (Ac.25); and make explicit statements that there is zero tolerance for anti-gender inclusive behavior (Ac.26).

4 Discussion

In the bibliometric analysis, recent studies, primarily from the United States, were selected, with 2022 and 2018 having the most publications. Notably, the most frequently cited barriers in the selected studies were sexism, lack of peer parity, and imposter syndrome. Trinkenreich et al.'s study [11] on women in open-source software communities also highlighted imposter syndrome and lack of peer parity as key barriers. This study additionally identified seven other barriers, including harassment, technical difficulties, glass ceiling, lack of recognition, and maternal and family issues.

Analyzing these results in the context of PSECO, the barriers were categorized into internal and external barriers. Internal barriers included imposter syndrome and maternal and family issues, while external barriers encompassed sexism, lack of peer parity, glass ceiling, lack of recognition, non-inclusive communication, prove it again, imbalance between personal and professional life, technical difficulties, stereotypes, harassment, and toxic culture.

Despite PSECO having its own characteristics, developers interact with other actors through ecosystem relationships. External barriers apply to PSECO, addressing interactions with keystones or other ecosystem actors. However, internal barriers should not be overlooked and require proper evaluation for inclusive environments.

An SLR performed by Canedo et al. [5] highlighted strategies to increase women's participation in open source projects, similar to those found in the present study, such as exclusive vacancies for women, training, code of conduct, and inclusive policies. Continuous monitoring of female participation for metrics generation was also suggested. Van Breukelen [4] emphasized the intersection between multiple minority groups, such as veteran women or black women, who face unique barriers, requiring targeted strategies for meaningful change.

5 Final Remarks

We conducted an MLR to explore gender barriers in software development teams within the PSECO context, revealing 13 gender barriers in total, but 11 distinct barriers that are beyond the organizational boundaries, involving external actors such as clients and suppliers. We also identified strategies to address these gender barriers and promote women's inclusion in this environment.

Regarding threats to validity, our study covered specific databases and some grey literature was not evaluated, but we followed recommended stopping criteria. We acknowledge that our search was limited to English-language studies, but this aligns with the prevalent language in global academic research.

To mitigate potential bias, we discussed inclusion criteria with other researchers and conducted a thorough review process. In future work, a field study could validate the identified barriers among women in real PSECO settings. Additionally, similar MLR studies could be conducted to map barriers and strategies for other types of diversity beyond gender with a focus on women.

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