Breaking one barrier at a time: how women developers cope in a men-dominated industry

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ABSTRACT

Context: Participation of women in software development teams is surrounded by several challenges — including gender bias, the difficulty of engagement, and general acceptance of the teams. **Objective:** We investigated the women perception in relation to interactions, contributions, gender bias, barriers and challenges that they may face in their work. **Method:** To achieve this goal, we conducted semi-structured interviews with 17 Brazilian women. We analyzed the data using the principles of Grounded Theory and identified three categories: Challenges, Barriers and Gender Issues. **Results:** Our findings reveal that tasks considered more complex are allocated to men on the team. Our respondents also commonly observe gender bias from men on the team. **Conclusions:** The findings indicate that most of the interviewed women observe a sexist behavior amongst the software development team members. Moreover, most of the participants stated that few women perform a leadership role in their team. We close by presenting suggestions to more inclusive work environments.

CCS CONCEPTS

• **Software and its engineering** → **Collaboration in software development**; Open source model; • **Social and professional topics** → **User characteristics**; *Gender*; Women.

KEYWORDS

women developers, gender bias, barriers, challenges

1 INTRODUCTION

The software development market is rather unbalanced in terms of the presence of women workers. The motivation of women workers are not enough to guarantee their position in the industry; women in an organization depends on the characteristics of that organization, such as: size, prestige, relations with public and private organizations, opportunities for career growth, among others[30].

Women that face less attractive positions in the market might feel less motivated and more likely to quit their job [30], contributing to further reducing the representation of women in labor market. Although there are many barriers that prevent women to achieve high performing positions in the industry, several studies have been conducted to investigate the positive factors that diversity, provided by women workers, bring in the labor market [3, 6, 8, 9, 14, 19, 39, 41].

The success of gender-balanced teams is influenced by how members feel and cooperate in work environments [30]. Tech companies, indicating awareness on this concern, publish their annual reports indicating efforts towards a more diverse workforce [7, 15], investing in programs to increase the representation of women through recruitment and inclusion programs. The goal is to minimize the unconscious bias of men culture in software development teams.

The success of teams with gender diversity is influenced by the way members feel in the workplace, which may explain the conflicting findings about the effects of gender diversity. Research suggests that simply creating diverse teams does not inherently raise positive results [19]. Gender-diverse teams have higher levels of innovation, problem-solving skills and a healthier work environment [12, 34]. On the other hand, there is evidence that gender diversity interferes with the team's innovation capacity and can cause greater interpersonal friction, such as increased misunderstandings and conflicts of power and responsibilities [19].

The creation of an inclusive work environment has been shown to mediate the relationship between diversity and conflict in the teams. A climate of inclusion is stimulated by providing equal opportunities in the workplace, the ability to make decisions and opportunities to know and be accepted by yourself [19].

Catolino et al. [9] state that women are essential to reduce community smells in software development teams. Community smells represent sub-optimal conditions appearing within software development communities (for instance, non-communicating sub-teams,

deviant contributors, etc.) that may lead to the emergence of social debt and increase the overall project's cost. Although the positive aspects related to the gender diversity on software development teams, there are still many barriers and challenges faced by women during their daily activities [20, 42]. Thus, it is necessary to understand these barriers and challenges, which is exactly the aim of this research. Furthermore, it is important to understand not only whether gender bias occurs in software development teams, but also the implications of gender bias into software development teams.

The goal of this work is to understand the barriers and challenges that women face in the Brazilian tech industry. We seek to understand not only whether gender bias occurs in software development teams, but also the implications of gender bias into software development teams. To achieve this goal, we conducted semi-structured interviews with 17 Brazilian women.

Our findings reveal that tasks considered more complex are allocated to men on the team. Our respondents also commonly observe gender bias from men on the team. These concerns are also exacerbated by the sense of loneliness; there are few or just one women in the team.

2 BACKGROUND AND RELATED WORK

There is a recent flow of works studying women in technical work environments. Women are less likely to progress or remain in senior management than men, if the organization does not have women present in senior management [22].

Johnson et al. [22] investigated the factors that may impact the ability of women in the area of Information and Communications Technology (ICT) to assume leadership positions in organizations. The authors analyzed the organizational characteristics that impact the advancement of women in leadership positions. The authors concluded that there are several opportunities for women in IT and that the percentage of women in leadership positions is increasing in several sectors, such as consumer goods, education, financial services, and not-for-profit industries. However, there is evidence to suggest that the gender composition in the industry, as well as the size of the organization, can impact the gender of the IT leader.

Several researches investigated how to achieve gender diversity in areas related to Information Technology, since few women choose a career in this area. Razavian and Lago [36] investigated which skills or characteristics are attributed to the women role that bring concrete advantages to software teams. The authors conducted a series of interviews with software architects, men and women, at four major IT companies in the Netherlands. The authors asked the architects what knowledge they attributed to women roles and how this knowledge contributed to any of the three architecting activities (architecting, i.e., architectural design, prototyping, evaluating, and documenting; internal communication; and external communication). As a result, they identified seven feminine expertise flavors (Elicit the Real Needs, Communication, Intuition, Explore problem and solution space, Cherish relationships, Questioning, Embracing ambiguities), that is, traits and skills that are linked to the role of women in health teams. software architecture. These findings are related to the skills needed to successfully deal with the human aspects of software architecture.

Wolff et al. [45] investigated the problems that some women face in getting a role in software engineering. The authors interviewed 252 women who were interested in playing the programming role at companies in Finland that have a program to increase equality and gender diversity in the software industry. The authors sought to understand which early experiences can influence later career choices and the feeling of effectiveness and confidence needed to pursue careers related to technology. The authors found that women's feelings about self-efficacy in computing and attitudes towards software engineering are built on early experiences. In addition, the authors also concluded that negative experiences decrease the likelihood of women working in software engineering roles in the future, despite expressing interest in the area.

According to Trinkenreich [38], women represent less than 24% of employees in the software development industry and experience various types of prejudice and bias. The author interviewed 12 participants to identify career paths, how they joined, which roles and activities they perform, and how they arrived at their current position in software development projects.

Russo and Stol [37] studied gender differences in personality traits of software engineers. The authors collected personality data, using the HEXACO model, from 483 software engineers. The authors concluded that women score significantly higher than men in Openness to Experience, Honesty-Humility, and Emotionality. In addition, men showed higher psychopathic traits than women.

Except rare exceptions (e.g., [35]), most gender research in software engineering considers only two genders: women and men. Women working in men-dominated areas, such as software engineering, face more gender bias [18].

Catolino et al. [9] examined the relationships between gender imbalance and the occurrence of community smells (organizational silo effects (overly disconnected sub-groups) or lone wolves (defiant community members)). The authors concluded that the presence of women in teams generally reduces the amount of community smells and that women are instrumental in reducing community smells in software development teams.

Chang et al. [11] investigated the characteristics of personnel hiring and selection decisions that can influence the gender diversity of groups and teams. The authors carried out six controlled experiments and concluded that people are less likely to choose candidates whose gender would increase the diversity of the group when making staff selections alone (that is, when they are responsible for selecting a single group member) than when doing collections of choices (that is, when they are responsible for selecting multiple group members). Therefore, people build groups with greater gender diversity when selecting multiple team members.

Organized and effective communication within a software development team can influence the quality of the software development process and the software produced, since communication is a crucial factor for the success of the project. Catolino et al. [10] interviewed 60 software practitioners from the software development teams to investigate whether gender diversity was a useful tool in mitigating undesirable communication patterns. Several research participants did not find gender diversity useful to mitigate the presence of community smells. However, the authors found that most participants take communication skills into account when hiring and managing teams.

Paganini and Gama [33] researched gender-related issues regarding women's participation in hackathons and concluded that low self-esteem and toxic masculinity (misogyny, rudeness, sexism and inappropriate behavior) and underestimation, verbal harassment and inappropriate comments are problems faced by women in hackathons. In addition, women are uncomfortable participating in an environment in which they are considered a minority.

Wang and Zhang [43] did a field experiment and proved the effectiveness of the theory of inter-group contact in implicit reduction of gender bias and that the number of women in a team influences the effectiveness of this theory, in which if the number of women is greater than or equal to men, the theory can achieve maximum effectiveness.

Chang et al. [11] presented six experiments and showed that women are more likely to be hired in group hires, because in isolated situations a gender bias was evidenced. Meanwhile, Leavy et al. [24] focused their studies on the evidence of gender bias in the algorithms, and suggested in their research a way to provide a gender-proof structure as a mitigation of the algorithmic gender bias.

Unlike previous studies, in this research we interviewed some women to investigate the perceptions of women in software development teams in relation to the barriers, challenges and gender bias that they face with the men who make up the development teams that they participate in the organizations in which they work. In addition, we present what was their perception regarding their career progression and their performance in their daily activities in the software development team. The following section presents the data collection procedures.

3 DATA COLLECTION

We collected data through semi-structured interviews, which includes a list of topics designed to extract more predictable and expected information. During the interviews, we discussed their perceptions about the barriers and challenges that women may face during their work activities. We also investigated if there is any action conducted by the organizations that aims to improve the women participation on the software development process. Finally, we seek their suggestions on how to improve their organizational environment to become more inclusive.

Table 1 shows the list of topics used to guide the interviews.

We employed non-probabilistic convenience sample with snowballing, divided into two phases. First, we sent a private message to some women in our acquaintances list inviting them to participate in the research on a voluntary basis. We also asked these contacted women to indicate others who may be interested in participating in the research. In the second phase, we published on LinkedIn a wide invitation for all women in our network who would be interested in participating in our research. We ended up confirming 23 women interested in participating in our research. Six of them were unable to participate, and we ended up with 17 participants.

The first two interviews were conducted in a pilot format, and it aimed to assess the quality and length of the interview script. After these two pilot-interviews, we reviewed the list of topics to be discussed during the interview by removing some and inserting others. The main update in the interview script was the addition

Table 1: Topics discussed during the interviews

Demographic Information
1. Name
2. Email address
3. Company where she works
4. Age
5. Educational degree
6. Experience
7. Performed roles in the software development team
8. Programming languages that she works or have worked
9. Team size

Women Perception
1. Interactions between member of the team
(a) Differently with women
(b) Same way independent of the person gender
(c) Differently depending on the other person gender
2. Sexist behavioral in your team
3. Importance of the project that she works to the organization
4. Reception of her contributions by men team mates?
5. Reception of her pull requests, comments, improvement suggestions, error corrections or updated
6. Jokes with the women in her team
7. Perception of the career path?
8. Satisfaction level of her own performance on the activities she performs

Challenges, Barriers and Suggestions
1. Barriers or bias related to the fact that she is a woman
2. Barriers that she faces or have faced in her development team
3. Challenges that she faces or have faced in her development team
4. Reasons behind the women's low interest in activities related to coding and programming on software development
5. Reasons why women usually choose documentation, test, requirement, leadership related roles over coding and programming
6. Women on leadership position on her development team (team leader, project management among others)?
7. Project characteristics in which there are women executing roles (complexity, duration, team size, programming language)
8. Activity she fells more motivated to perform in a software development project
9. Actions she is executing to increase her own participation on the software development projects
10. Suggestions for the organization get a more inclusive environment to women

of one new topic about the reasons why we have more women performing non-programming roles (e.g., management roles). Given the minor change in the interview transcript, we decided not to remove the pilot interviews from our data. Thus, the pilot interviews were maintained in the data analysis.

The interviews were conducted using Skype. During the interview, we first informed that the participation in the interview was

in a voluntary basis, and that the participant could interrupt the participation whenever she feels like. We also asked the permission to record the interview. The duration of each interview was between 45 to 60 minutes, and it was guided by the list of topics presented in Table 1.

We conducted the interview analysis in pairs followed by conflict resolution meetings. One author conducted and recorded the interview. The other author watched the interview and verified if all the important information was noted and if the understanding of them was correct. A third author heard all 17 interviews and subsequently read the transcribed results to validate the notes made by the two authors who analyzed the data. During this process, some inconsistencies were detected and the respective interview was heard again by all three authors and the data was updated. The following section presents how the collected data was analyzed.

4 DATA ANALYSIS

We employed Grounded Theory (GT) to analyze the data obtained during the interview (Table 1. According to Coleman and O'Connor [13], GT has different characteristics: (1) the absence of clear research hypotheses and (2) limited exposure to literature at the beginning of the research. Grounded Theory is an approach to develop hypothesis through a set of procedures for analyzing qualitative, which contrast to more traditional theory testing approaches [13], such as those that use statistical methods to confirm or disprove pre-established hypotheses.

Grounded Theory is more suitable approach to answer research questions that aim to characterize scenarios from a personal perspective of whom is engaged in a subject or activity [26]. It is exactly the scenario presented in this research since we aim to investigate the perception of women in relation to the barriers and challenges that they might face in the labor market and what are their suggestions for a more inclusive environment in their organizations.

In addition, the GT allows researchers to build an independent and original understanding, suitable for collecting empirical evidence directly from industry practice, without the bias of previous research. The evidence is only reintegrated into the existing literature after the construction phase of the theory [27].

We performed the data analysis using the guideline on how to conduct a GT survey [1]. The guideline organizes a GT investigation in three stages: 1) Open coding data collection; 2) Selective coding data analysis; and 3) Theoretical coding. We discuss them next:

- In the first step, we first interviewed 17 women working in software industry to understand their perception of some issues. Next, we analyzed the women's responses to the topics that were discussed in the interviews. During the raw data's analysis, we sought for incident patterns that indicate concepts and then we grouped them into categories. Open coding lasted until the researchers reached an agreement.
- In the second step, we evolved the initial set of categories by comparing new incidents with those identified in step 1 in order to identify a main category. We have identified three categories: challenges, barriers, and gender issues. The main category represents the end of open coding and the beginning of selective coding. Gender issues category was identified as the main category. The selective coding ended

when we reach theoretical saturation, in other words, when the last participants provided more evidence and examples, but no new concepts or categories were identified [17].
- In the third step, we started the theoretical coding, with the objective of building a theory that explains how concepts, categories and relationships fall into a conceptual unit. Thus, we identified the subcategories for all three categories that were identified. Figure 1 shows the categories and subcategories that were identified after analyzing the data using Grounded Theory. The following section presents the results including the detailing of each category and subcategory in Figure 1.
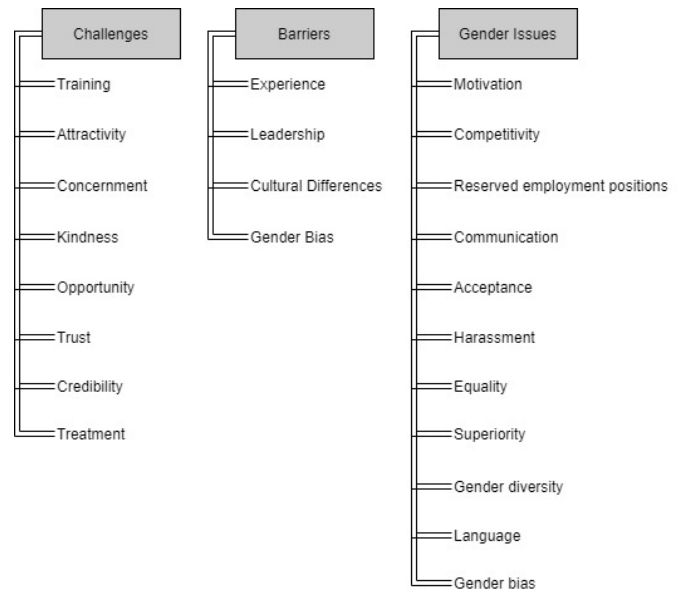

Figure 1: Categories and subcategories from interview coding

5 RESULTS

This section presents the results of our this research, considering the three groups of topics presented on Table 1 as following: demographic information, women perception, challenges, barriers and suggestions to increase women's participation on the software development process.

5.1 Demographic Information

Table 2 shows the demographics of the participants. Among the interviewees, 35.3% of them have between 21 and 25 years old, 29.4% have between 26 and 30, 17.6% between 31 and 40, 11.7% between 41 and 50, and 6% are between 51 and 60 years old. Most of them are bachelors and have more than 3 years of experience in software development related activities.

Another interesting point is that our sample is composed by young women: more than 64% of them have less than 30 years old. One third of them have less than three years of experience. This result is similar to that found in the Stack Overflow survey [32],

Table 2: Demographics Information of the Participants

ID	Age group (in years old)	Highest Degree	Experience (in years)	Current occupation	Programming Languages Experience	Team Size (number of people)
P1	21-25	Bachelor	1-2	Software Developer	Java, Scala, C, C++, Haskell, SQL and Ruby	<= 10
P2	26-30	Bachelor	6-8	Software Developer	JavaScript and Java	<= 10
P3	21-25	Bachelor	1-2	Software Developer	JavaScript, CSS, C and Python	<= 10
P4	41-50	Bachelor	6-8	Requirement Analyst	PHP	<= 10
P5	21-25	Bachelor	1-2	Software Developer	JavaScript	<= 10
P6	31-40	Bachelor	> 15	Project Manager	PHP	<= 10
P7	41-50	Bachelor	< 1	Software Developer	JavaScript	<= 10
P8	51-60	Bachelor	> 15	Requirement Analyst	JavaScript and Java	<= 10
P9	31-40	PhD	3-5	Requirement Analyst	JavaScript, Java, C and CSS	<= 10
P10	21-25	Bachelor	3-5	Software Developer	Phyton, Java, PHP, C#, TypeScript and CSS	<= 10
P11	26-30	Bachelor	3-5	Requirement Analyst	Phyton and C	<= 10
P12	21-25	Bachelor	1-2	Software Developer	JavaScript, Java, C, Swift and CSS	<= 10
P13	31-40	PhD	9-11	Project Manager	JavaScript and C	<= 10
P14	26-30	Bachelor	1-2	Software Developer	Java, Phyton, C, Swift and CSS	11-15
P15	26-30	Bachelor	3-5	Test Analyst	JavaScript, Java, PHP, C++, Ruby, Phyton, C# and CSS	11-15
P16	21-25	Bachelor	3-5	Software Developer	JavaScript, Java, PHP, Phyton, C# and CSS	<= 10
P17	26-30	Bachelor	6-8	Product Owner	C, Ruby and CSS	21-30

in which 32.2% of women said they had less than five years of experience. The most common role performed by them is software developer.

JavaScript and Java are the most reported programming languages, which contrast with the results got by Stack Overflow [32] who identified that women usually program on JavaScript and HTML/CSS. Also, our interviewees work on small teams, with no more than ten colleagues. The next sections detail each category showed in Figure 1.

5.2 Challenges Category

Eight sub-categories were identified under the challenges category, as shown in Table 3.

Table 3: Challenges subcategories

Subcategory	Detailing	# Cited
Training	Lack of training opportunity	1
	Lack of code affinity	1
	Lack of knowledgement	1
Attractivity	Lack of attractivity	1
Concernment	Lack of concernment	1
Kindness	Lack of kindness	1
Opportunity	Lack of opportunities	5
Trust	Lack of trust	7
Credibility	Lack of credibility	4
Treatment	Lack of women in the organization demotivate other women	1
	Lack of equal treatment	1
	Lack of incentive	2

The most common challenges are related to: 1) Training in which several women stated that there is a lack of training opportunity,

lack of code affinity and lack of knowledge; 2) Attractivity, there is a lack of attractiveness on the part of organizations; 3) Concernment in which there is a lack of concernment; 4) Kindness, there is a lack of welcome on the part of the development team in relation to the women who work in these teams; 5) Opportunity, there is a lack of opportunities for women in organizations; 6) Trust in which there is a lack of trust; 7) Credibility in which there is a lack of credibility; and 8) Treatment in which women stated that the lack of women in the organization demotivate other women, that there is a lack of equal treatment and lack of incentive on the part of the organizations in which they operate.

This result allows us to conclude that most of the challenges reported by the women interviewed are related to the lack of gender diversity in the organizations and to the behavior of the men of the software development teams in which they work.

Participant P5 mentioned:

> "the challenge of being recognized as a member of the software development team, sometimes I was seen as fragile and I had to demonstrate that I was able to carry out the demands that were attributed to me".

Other participants stated that it was necessary to keep up to date with the techniques and tools to be able to talk to the men on the team and have an equal treatment. In addition, the lack of confidence in carrying out software development activities was mentioned by more than half of the participants.

The participants mentioned reasons why women might not be interested in coding activities, such as: a) lack of representation; b) lack of encouragement from family members; c) the perception of "super difficult" tasks; d) the mystification that development is a men activity; e) fear of not being able to meet the team's expectations; f) lack of affinity with programming; and g) discouragement

(from colleagues and instructors) during the undergraduate studies. Due to these challenges, some women prefer to focus on other software development areas, such as documentation, manual testing, modeling, or project management.

There is also a lack of trust that women could accomplish some tasks. For instance, P4 mentioned that:

> "the most boring activities are always assigned to women, because usually the men team-mates do not want to execute them".

The lack of other women in the software development teams was also perceived as a challenge.

> "I believe this is directly related to women's lack of trust and fear of being judged by the men of the software development teams. In general, women do not consider themselves able and confident to work with coding and apply for other software development activities".

> "Typically, leaders of software development teams assign these [non-coding] activities to women. In all the teams that I participated, the team leaders always wanted to assign documentation-related tasks to me".

> "I believe that the area of programming is an area where men feel more comfortable, they feel more "Men", as if the genre defines who programs best. This ends up alienating women for promoting uncomfortable situations. Another reason is that women are engaged in other activities, such as: domestic activities and taking care of children, and of course, software development is an exhausting and stressful activity, which can be a factor".

The following section discuss the findings related to the category "Barriers".

5.3 Barriers Category

In order to understand the barriers, we asked the participants to report the barriers they face on a daily basis. Our analysis of the respondents' responses resulted in four sub-categories, as shown in Table 4.

The barriers identified arose from interpersonal relationships between members of the software development teams and include responses such as "Problem with leaders and difficulty to be accepted by the team", "Difficulty to lead the team", "Leadership profile", "Communication problem" and "Cultural differences" and experience barriers that arise due to the lack of experience on the part of the participant and include responses such as "Lack of experience", and "Gender bias in task allocation", and so on. These results demonstrate that technical barriers do not seem to be a challenge for the group of women interviewed.

Table 4 shows the barriers faced by the interviewees within their software development team. Although we noted some traditional challenges in software development projects (e.g., cultural

Table 4: Barriers subcategories

Subcategory	Detailing	# Cited
Experience	Lack of experience	1
Leadership	Problem with leaders and difficulty to be accepted by the team	1
	Difficulty to lead the team	2
	Leadership profile	2
Cultural Differences	Cultural differences	1
Gender Bias	Bias attitudes	1
	Sexist language	1
	Be useful and create something important	1
	Appropriation of ideas	1
	Communication problem	2
	Women treating other women differently	1
	Gender bias in task allocation	4

differences). The most recurring barrier is related to the lack of gender-equal communication, that is, some men do not talk equally to their women-mate. In order to express an opinion, women need to interrupt a man speech, this happens even if the person who wants to talk is a women project manager. One interviewee also reported that:

> "I had to adapt myself to the way the men talked, e.g., the slang and the bad words. When I arrived on the team, it was common for me to hear jokes from teammates that I was stupid, because I am a woman."

Our findings are similar to others found in the literature, Lee and Carver [25] reported that the main barriers were the difficulty of being accepted and the sexist games of their teammates. Ford et al. [16] also concluded that women are more likely to participate in a software project when they meet other women in the project. The lack of confidence in carrying out software development activities was also mentioned by Balali et al. [2].

Kohl and Prikladnicki [23] interviewed three white women to understand the challenges faced by women in leadership and management roles. They also sought if gender problem could limit the women participation in ICT career. The respondents work in different companies and have different experiences. They mentioned that the main barrier on women participation are related to the perception that women´s contributions and skills are less important than the male one. Furthermore, they fell that they need to put more effort to get the same results that male colleagues get. The interview women also reported that they are judged based on the clothes they wear and their own behavior. For example, when they share concern about a healthy and safe environment, they are called crazy. In addition, they reported a protectionism network among men that can prevent them to perform a more strategic role in organizations.

On relation to leadership, we asked the interviewed women to tell about their perception of women in leadership positions. Seven respondents stated that there is only one woman in a leadership position; two stated there are between two and four women in leadership position; one stated there are between five and seven women in leadership position. Finally, one stated there are between 8 and 10 women in leadership position, as shown in Table 5. The result indicates a low percentage of women in leadership positions, which is confirmed by the research conducted by Izquierdo et al. [21].

Table 5: Women in leadership positions

Number of women leadership position	Number of answers in this category
1	7
2 to 4	2
5 to 7	1
8 to 10	1

The following section discuss the findings related to the category "Gender Issues".

5.4 Gender Issues Category

Table 6 show the eleven subcategories identified under "Gender issues" category.

The gender issues are related to:

(1) Motivation - The participants stated that it is necessary to encourage and motivate women to study computer sciences and create benefits to attract more women for this area of activity;

(2) Competitivity - Competitivity among women;

(3) Reserved employment positions - organizations could reserve some employment positions to women;

(4) Communication - it is necessary to disclose what women are doing and how they do it;

(5) Acceptance - There is an acceptance difficulty of women by the software development teams;

(6) Harassment - unfortunately it is very common to identify situations of sexual and moral harassment among members of the software development teams;

(7) Equality - there must be gender equality and treatment equality between teams;

(8) Superiority - there is a superiority feeling on the part of the men of the development teams;

(9) Gender diversity - organizations must have programs to promote gender diversity among their employees, for example, conducting campaigns and/or lectures on the importance of having gender diversity, sharing experiences, hiring women, carrying out processes programs and giving more opportunities to women, promoting policies against harassment in organizations, offering vacancies for women in which a profile is defined for women who will participate exclusively in these vacancies, curbing sexist attitudes, defining policies for inclusion of women and increase women's representation in organizations;

(10) Language - define strategies to decrease gender language, mean jokes and sexist jokes in the team;

(11) Gender Bias - there is a sexist behavioral among team members, women feel more comfortable with interrelationships, it is very common to find situations in which women report that there is gender-related jokes.

Most women said that men on the software development team interact differently with women. One of the participants mentioned that:

> *"Some men have harmful attitudes, for example, stealing my ideas or reducing my participation in meetings and product deliveries".*

This statement corroborates the finding of Nafus [31] "men monopolize code authorship and simultaneously de-legitimize the kinds of social ties necessary to build mechanisms for women's inclusion".

Another participant mentioned that:

> *"when a woman joins a men's team, men do not trust immediately and their trust has to be earned".*

Gender diversity can improve team productivity, although tenure (experience accumulated by each team member) diversity can increase friction between the team [39]. The interviewees stated that:

> *"when the team is assembled by a woman, the team behaves differently. Also, one woman in leadership position sometimes still causes strangeness in other teams".*

This statement corroborates the findings of Wang and Redmiles [42], who found that technical leadership roles are associated with men. More than half of the women stated that men on the software development team that they work with do not interact in the same way for both genders, one participant mentioned:

> *"some men are very polite, sometimes it seems that they are flirting with us, because they are so much thoughtful and grateful".*

More than half of the women stated that men on the software development team that they work with do not interact in the same way for both genders. One interviewee mentioned:

> *"some men are very polite, sometimes it seems that they are flirting with us, because they are so much thoughtful and grateful".*

Most of the participants have already observed some sexist behavior in their team. We highlight some situations mentioned by our interviewees:

> *"One of my teammates often uses the idea that I said before when we were speaking each other as being his idea in a meeting with the bosses. He also cut my speech at these meetings".*

Table 6: Gender issues subcategories

Subcategory	Detailing	# Cited
Motivation	To encourage/motivate women to study computer sciences	1
	Create benefits to attract more women	1
Competitivity	Competitivity among women	1
Reserved employment positions	Reserve some employment positions to women	1
Communication	Publicize what women do and how they do	1
Acceptance	Acceptance difficulty	3
Harassment	Sexual harassment	2
	Moral harassment	5
Equality	Gender equality	1
	Treatment equality	1
Superiority	Superiority feeling	3
Gender diversity	Campaigns and/or lectures on the importance of having gender diversity	1
	Share experiences	1
	Hiring women	1
	Priority in selection processes	1
	Giving more opportunities to women	1
	Promoting policies against harassment in organizations	1
	Offering vacancies for women	1
	Woman profile	1
	Sexist attitudes	1
	Policies for inclusion of women	1
	Women representation	6
Language	Gender language	6
	Mean jokes	2
	Sexistas jokes in the team	1
Gender Bias	Sexist behavioral	1
	Women feel more comfortable with interrelationships	1
	Gender-related jokes	1
	Gender bias	12

"Yes, in the most complex demands of the project, the team leader passes the demand to the men of the team. Whenever possible, I ask to execute the demands so that everyone see that I am also capable of accomplishing it".

This finding corroborates that mentioned by Wang and Redmiles [42], who found that men and women have implicit gender biases, and these biases influenced their decisions. The authors found that men and women associated the profession of software engineer with men. In addition, women were associated with the home and family. The authors also stated that people cannot resist their implicit gender biases and do not make decisions in a gender-neutral way.

This paradox happens even though some of our respondents work on complex projects. For instance, one interviewee said that she "works on a static analysis project. The complexity comes from the interpretation of each analysis case and the tools that need to be integrated into the system." Another interviewee said that she "works on an online currency exchange project, which sells various types of cash and sends money out of Brazil. It is a large project divided into three subprojects, all on a web platform."

Most participants stated that coding activities is the activity they feel most motivated to undertake. Still, 90% of the interviewees

mentioned that they are taking training courses, with the goal of improving their technical skills. The interviewees believe that these courses will ease their acceptance and gain respect by the men of the team.

All interviewees stated that their contributions (e.g., pull requests, comments, suggestions for improvements, corrections of defects or updates) are well received by the men on the team. This result differs from the findings by Bosu and Sultana [4], who found technical biases against women developers, in which code acceptance rates were lower and feedback during code reviews was delayed by the men on the team.

The interviewees also stated that men do not make jokes to women on the software development team. This finding differs from the finding by Babali et al. [2], which noted that: "Some communication styles that are used are occasionally more awkward, and men can come off as creepy". However, although most of the interviewees are satisfied in relation to their performance in the activities developed in the team, we also noted a shared concern about career progression, as stated:

"It is noticeable that I will not have the progress that I expect, because I am a woman and do not have the technical profile that the company values. The team leader always states to the women of the team that men's promotion is easier and faster, because the stakeholders prefer men in the most important positions and they don't believe that women could return to the organization the benefit they get".

"I will need to work and strive more to be recognized and have progress in my career".

There are similar findings in the literature, Nafus [31] observed that "men monopolize code authorship and simultaneously delegitimize the kinds of social ties necessary to build mechanisms for women's inclusion". Wang and Redmiles [42] found that technical leadership roles are associated with men. Wang and Redmiles also found that men and women have implicit gender biases, which influence their decisions. Yet, the authors found that men and women associated the profession of software engineer with men; women were associated with home and family. The authors also stated that people cannot resist their implicit gender biases and do not make decisions in a gender-neutral way.

Bosu and Sultana [4] found some technical biases against women developers, for instance, code acceptance rates were lower and feedback during code reviews was delayed. Izquierdo et al. [21] also noted that the participation of women has been increasing in coding activities.

6 THREATS TO VALIDITY

There are some limitations related to this research's results. The first one is relate to the small sample size. Because women are underrepresented in the fields of Science, Technology, Engineering, and Math (STEM) [5, 28, 29, 44], it is difficult to find women working in the tech area. Among them, there are many who were not willing to participate in interviews or surveys.

The difficulty for some women to talk about the problems they face in the workplace can also be related to the fear that they have to expose themselves and suffer shreds on the part of their colleagues, due to the gender prejudice that they suffer in their teams. As a way of mitigating this threat, we contacted the professionals we knew and asked for help in finding other women to participate in the interviews. Although our sample is small, in the literature there are several other works that also interviewed a small number of women, in most of them, smaller than our sample. [19, 23, 36, 38, 40].

Another limitation of our sample is the focus on the perception of Brazilian women; therefore, the findings presented herein has some restrictions about its generalization. Moreover, perhaps due to the small sample, we observed that most of the interviewees do not occupy leadership positions; therefore, some of the problems reported may not be exactly due to issues of gender bias, but rather people who do not have a leadership profile or they are people who already have some kind of resistance towards the Information Technology area, due to having gone through some situation during the course or at the beginning of their professional career.

7 CONCLUSIONS

In this work we interviewed 17 women from different organizations to understand their perceptions regarding gender bias, challenges and barriers that they face with the members of the software development teams that they work with.

Our findings reveal that women are underrepresented, work in teams of less than 10 people and that there are few women in leadership positions in software development teams. Furthermore, it is quite common for them to face gender bias on the part of the men of the teams in which they work. Women face many barriers, including a lack of trust, credibility, confidence, and recognition. Based on these barriers and challenges, we also propose a set of suggestion to improve inclusiveness in software producing organizations.

As future work, we intend to conduct interviews with women from other countries in order to verify whether our findings also occur in larger organizations and with a different culture. In addition, we also intend to interview women working in other areas of technology, such as women working in education (higher education teachers) and engineering, to identify whether gender bias also occurs in other teams.

To solve the threat regarding the profile of the interviewees, as a future work we intend to carry out the same survey with men who do not occupy leadership positions, in order to conclude whether the problem reported in this research concerns gender bias, or the position in which they occupy.

ACKNOWLEDGMENTS

REFERENCES

[1] Steve Adolph, Wendy Hall, and Philippe Kruchten. 2011. Using grounded theory to study the experience of software development. *Empir. Softw. Eng.* 16, 4 (2011), 487–513.

[2] Sogol Balali, Igor Steinmacher, Umayal Annamalai, Anita Sarma, and Marco Aurélio Gerosa. 2018. Newcomers' Barriers. . . Is That All? An Analysis of Mentors' and Newcomers' Barriers in OSS Projects. *Comput. Support. Cooperative Work.* 27, 3-6 (2018), 679–714.

[3] Shubhasheesh Bhattacharya, Sonali Bhattacharya, and Sweta Mohapatra. 2018. Enablers for Advancement of Women into Leadership Position: A Study Based on IT/ITES Sector in India. *IJHCITP* 9, 4 (2018), 1–22.

[4] Amiangshu Bosu and Kazi Zakia Sultana. 2019. Diversity and Inclusion in Open Source Software (OSS) Projects: Where Do We Stand?. In *ESEM*. IEEE, 10.1109/ESEM.2019.8870179, 1–11.

[5] Carmen Botella, Silvia Rueda, Emilia López-Iñesta, and Paula Marzal. 2019. Gender Diversity in STEM Disciplines: A Multiple Factor Problem. *Entropy* 21, 1 (2019), 30.

[6] Paula Casagrande Bristot, Eliane Pozzebon, Felipe Zago Canal, Julio Augusto Da Rosa Carraro, and Luciana Bolan Frigo. 2020. Women Representativity in Games. *CLEI Electron. J.* 22, 2 (2020), 1–12.

[7] Danielle Brown and Melonie Parker. 2019. Google diversity annual report 2019. https://diversity.google/ (Date last accessed 16-April-2019).

[8] Edna Dias Canedo, Heloise Acco Tives Leão, Madianita Bogo Marioti, Fabiano Fagundes, and José Antonio Siqueira de Cerqueira. 2019. Barriers Faced by Women in Software Development Projects. *Inf.* 10, 10 (2019), 309.

[9] Gemma Catolino, Fabio Palomba, Damian A. Tamburri, Alexander Serebrenik, and Filomena Ferrucci. 2019. Gender diversity and women in software teams: how do they affect community smells?. In *ICSE-SEIS*. ACM, 10.1109/ICSE-SEIS.2019.00010, 11–20.

[10] G. Catolino, F. Palomba, D. A. Tamburri, A. Serebrenik, and F. Ferrucci. 2020. Gender Diversity and Community Smells: Insights From the Trenches. *IEEE Software* 37, 1 (2020), 10–16. https://doi.org/10.1109/MS.2019.2944594

[11] Edward H. Chang, Erika L. Kirgios, Aneesh Rai, and Katherine L. Milkman. 2020. The Isolated Choice Effect and Its Implications for Gender Diversity in Organizations. *Manag. Sci.* 66, 6 (2020), 2752–2761.

[12] Vinh Sum Chau and Chanell Quire. 2018. Back to the future of women in technology: insights from understanding the shortage of women in innovation sectors for managing corporate foresight. *Technol. Anal. Strateg. Manag.* 30, 6 (2018), 747–764.

[13] Gerry Coleman and Rory O'Connor. 2007. Using grounded theory to understand software process improvement: A study of Irish software product companies. *Inf. Softw. Technol.* 49, 6 (2007), 654–667.

[14] Hélène de Ribaupierre, Kathryn Jones, Fernando Loizides, and Yulia Cherdantseva. 2018. Towards Gender Equality in Software Engineering: The NSA Approach. In *GE@ICSE*. ACM, https://ieeexplore.ieee.org/document/8452743, 10–13.

[15] Rosanna Durruthy. 2018. 2018 LinkedIn Workforce Diversity Report. https://careers.linkedin.com/diversity-and-inclusion/workforce-diversity-report (Date last accessed 16-April-2019).

[16] Denae Ford, Alisse Harkins, and Chris Parnin. 2017. Someone like me: How does peer parity influence participation of women on stack overflow?. In *VL/HCC*. IEEE Computer Society, 10.1109/VLHCC.2017.8103473, 239–243.

[17] Barney G Glaser and Anselm L Strauss. 2017. *Discovery of grounded theory: Strategies for qualitative research.* Routledge, 10.4324/9780203793206.

[18] Madeline E Heilman. 2012. Gender stereotypes and workplace bias. *Research in organizational Behavior* 32 (2012), 113–135.

[19] Julie S. Hui and Shelly Diane Farnham. 2016. Designing for Inclusion: Supporting Gender Diversity in Independent Innovation Teams. In *GROUP*. ACM, ACM, 71–85.

[20] Nasif Imtiaz, Justin Middleton, Joymallya Chakraborty, Neill Robson, Gina Bai, and Emerson R. Murphy-Hill. 2019. Investigating the effects of gender bias on GitHub. In *ICSE*. IEEE / ACM, 10.1109/ICSE.2019.00079, 700–711.

[21] Daniel Izquierdo, Nicole Huesman, Alexander Serebrenik, and Gregorio Robles. 2019. OpenStack Gender Diversity Report. *IEEE Softw.* 36, 1 (2019), 28–33.

[22] Vess Johnson, Angelina I. T. Kiser, and Leon A. Kappelman. 2020. Women in IT Management: Significant Gains and Continuing Challenges. *J. Comput. Inf. Syst.* 60, 3 (2020), 244–255.

[23] Karina Kohl and Rafael Prikladnicki. 2021. Challenges Women in Software Engineering Leadership Roles Face: A Qualitative Study. *CoRR* abs/2104.13982 (2021), 1–9.

[24] Susan Leavy, Gerardine Meaney, Karen Wade, and Derek Greene. 2020. Mitigating Gender Bias in Machine Learning Data Sets. In *Bias and Social Aspects in Search and Recommendation - First International Workshop, BIAS 2020, Lisbon, Portugal, April 14, 2020, Proceedings (Communications in Computer and Information Science, Vol. 1245)*, Ludovico Boratto, Stefano Faralli, Mirko Marras, and Giovanni Stilo (Eds.). Springer, https://doi.org/10.1007/978-3-030-52485-2_2, 12–26. https://doi.org/10.1007/978-3-030-52485-2_2

[25] Amanda Lee and Jeffrey C. Carver. 2019. FLOSS participants' perceptions about gender and inclusiveness: a survey. In *ICSE*. IEEE / ACM, 10.1109/ICSE.2019.00077, 677–687.

[26] Welder Pinheiro Luz, Gustavo Pinto, and Rodrigo Bonifácio. 2018. Building a collaborative culture: a grounded theory of well succeeded devops adoption in practice. In *ESEM*. ACM, https://doi.org/10.1145/3239235.3240299, 6:1–6:10.

[27] Welder Pinheiro Luz, Gustavo Pinto, and Rodrigo Bonifácio. 2019. Adopting DevOps in the real world: A theory, a model, and a case study. *J. Syst. Softw.* 157 (2019), 1–16.

[28] Luciana Andréia Fondazzi Martimiano and Valéria Delisandra Feltrim. 2020. An Analysis of the participation of women in Information and Communication Technology courses at State University of Maringá (UEM). *CLEI Electron. J.* 22, 2 (2020), 1–12.

[29] Claudia Bauzer Medeiros. 2020. Engaging Women in Computer Science - Past, Present and Future. *CLEI Electron. J.* 22, 2 (2020), 1–12.

[30] Danièle Meulders, Robert Plasman, Audrey Rigo, and Síle O'Dorchai. 2010. Topic Report: Horizontal and Vertical Segregation. *Meta-Analysis of Gender and Science Research. European Union* 1 (2010), 1–53.

[31] Dawn Nafus. 2012. 'Patches don't have gender': What is not open in open source software. *New Media & Society* 14, 4 (2012), 669–683.

[32] Stack Overflow. 2020. Developer Survey Results 2020. https://insights.stackoverflow.com/survey/2020 (Date last accessed 08-July-2020).

[33] Lavinia Paganini and Kiev Gama. 2020. A preliminary study about the low engagement of female participation in hackathons. In *ICSE '20: 42nd International Conference on Software Engineering, Workshops, Seoul, Republic of Korea, 27 June - 19 July, 2020*. ACM, https://doi.org/10.1145/3387940.3392163, 193–194. https://doi.org/10.1145/3387940.3392163

[34] Erica L. Plambeck and Kamalini Ramdas. 2020. Alleviating Poverty by Empowering Women Through Business Model Innovation: *Manufacturing & Service Operations Management* Insights and Opportunities. *Manuf. Serv. Oper. Manag.* 22, 1 (2020), 123–134.

[35] Rafa Prado, Wendy Mendes, Kiev Santos da Gama, and Gustavo Pinto. 2021. How Trans-Inclusive Are Hackathons? *IEEE Softw.* 38, 2 (2021), 26–31.

[36] Maryam Razavian and Patricia Lago. 2016. Feminine Expertise in Architecting Teams. *IEEE Softw.* 33, 4 (2016), 64–71.

[37] D. Russo and K. Stol. 2020. Gender Differences in Personality Traits of Software Engineers. *IEEE Transactions on Software Engineering* 1, 1 (2020), 1–18. https://doi.org/10.1109/TSE.2020.3003413

[38] Bianca Trinkenreich. 2021. Please Don't Go - A Comprehensive Approach to Increase Women's Participation in Open Source Software. *CoRR* abs/2103.08763 (2021), 1–6.

[39] Bogdan Vasilescu, Daryl Posnett, Baishakhi Ray, Mark G. J. van den Brand, Alexander Serebrenik, Premkumar T. Devanbu, and Vladimir Filkov. 2015. Gender and Tenure Diversity in GitHub Teams. In *CHI*. ACM, https://doi.org/10.1145/2702123.2702549, 3789–3798.

[40] Mihaela Vorvoreanu, Lingyi Zhang, Yun-Han Huang, Claudia Hilderbrand, Zoe Steine-Hanson, and Margaret Burnett. 2019. From Gender Biases to Gender-Inclusive Design: An Empirical Investigation. In *CHI*. ACM, https://doi.org/10.1145/3290605.3300283, 53.

[41] Yi Wang and David Redmiles. 2019. Implicit Gender Biases in Professional Software Development: An Empirical Study. In *ICSE - Software Engineering in Society*. ACM, https://bit.ly/2Hu42MJ, 1–10.

[42] Yi Wang and David F. Redmiles. 2019. Implicit gender biases in professional software development: an empirical study. In *ICSE-SEIS*. ACM, 10.1109/ICSE-SEIS.2019.00009, 1–10.

[43] Yi Wang and Min Zhang. 2020. Reducing implicit gender biases in software development: does intergroup contact theory work?. In *ESEC/FSE '20: 28th ACM Joint European Software Engineering Conference and Symposium on the Foundations of Software Engineering, Virtual Event, USA, November 8-13, 2020*, Prem Devanbu, Myra B. Cohen, and Thomas Zimmermann (Eds.). ACM, https://doi.org/10.1145/3368089.3409762, 580–592. https://doi.org/10.1145/3368089.3409762

[44] Timothy J. Weston, Wendy M. DuBow, and Alexis Kaminsky. 2020. Predicting Women's Persistence in Computer Science- and Technology-Related Majors from High School to College. *ACM Trans. Comput. Educ.* 20, 1 (2020), 1:1–1:16.

[45] Annika Wolff, Antti Knutas, and Paula Savolainen. 2020. What prevents finnish women from applying to software engineering roles?: a preliminary analysis of survey data. In *ICSE (SEET)*. ACM, https://doi.org/10.1145/3377814.3381708, 93–102.