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Mind the gap: gender, micro-inequities and barriers in software development

Emitzá Guzmán[1] · **Ricarda Anna-Lena Fischer**[1] · **Janey Kok**[1]

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Abstract
Gender diversity and equity are known problems in the software industry. However, relatively few studies has examined the everyday work experiences and barriers that software professionals in technical roles encounter through a gender perspective. In this work, we investigate micro-inequities (e.g., interruptions, lack of eye contact, being assigned menial tasks in a project) and barriers experienced by software professionals working in technical roles with a gender perspective. We also analyzed age as a confounding factor. In our study, we surveyed 359 software professionals (50:50, women:men ratio) from globally distributed locations. Our results show that women and respondents in certain age groups encounter micro-inequities significantly more than men and other age groups. Further, women experience and witness sexism and harassment in the workplace in significantly higher numbers. We also found that women report having significantly less support and authority to make necessary decisions in their work, are less satisfied with their pay, and feel less valued and recognized in their teams. Finally, we found that the main barriers reported by women are related to team dynamics and gender biases, while men report most on technical and project related issues. Our results can serve to create awareness in the community about the large disparity and help practitioners revise their training programs and internal policies.

Keywords Gender diversity · Software development teams · Questionnaire-based survey · Micro-inequities · Barriers

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✉ Emitzá Guzmán
e.guzmanortega@vu.nl

Ricarda Anna-Lena Fischer
r.a.l.fischer@vu.nl

Janey Kok
j.kok@student.vu.nl

[1] Faculty of Science, Vrije Universiteit Amsterdam, De Boelelaan 1111, 1081 HV Amsterdam Amsterdam, The Netherlands

1 Introduction

Diversity—with its different dimensions, such as, gender, age, abilities, roles, expertise, tenure, attitudes, beliefs, sexual orientation, language, socioeconomic status and physical appearance—contributes to better end-results in innovation and technology-focused disciplines (Earley and Mosakowski 2000). Teams that are diverse and that foster the meaningful participation of their members contribute to the creation of products that better address the needs of our diverse society and that tackle a wider range of social problems. Despite the proven knowledge (Page 2008) of the positive effects diversity brings, gender diversity and equity—the fair treatment, access, opportunity, and advancement for all people (Kapila and Searby 2016)—remains a problem in software development. For example, in 2019, in the US, 26% of the professionals in the computing sector were women, and only 18% of Chief Information Officer (CIO) positions in Top 1000 companies were held by women[1] (National Center for Women and Information Technology 2020). Similar numbers in the computing workforces for various countries such as Germany, India, Mexico and South Africa, indicate that the issue is not specific to one country (World Economic Forum 2020).

Gender diversity and equity is more than a pipeline problem (Ashcraft et al. 2016), and is bidirectionally linked to organizational culture—understanding the daily difficulties and barriers that underrepresented software professionals experience in their work organizations is vital for creating strategies that can address detected issues.

While gender diversity has been studied in the software engineering domain, most studies (e.g., Horwitz and Horwitz (2007); Vasilescu et al. (2015); Gila et al. (2014)) have focused on its impact on different outcomes, such as productivity or innovation. For example, previous research has found that gender and tenure diverse teams are more productive than uniform teams (Vasilescu et al. 2015), that gender diversity benefits team performance (Gila et al. 2014) and decreases bug fixing time (Ortu et al. 2017).

There is, to our best knowledge, few research that has examined the barriers that software professionals in technical roles experience in their everyday work through a gender perspective. James et al. (2017) found that the perceptions of women and men software professionals in technical roles on team dynamics, performance and recognition are very similar. Lee and Carver (2019) analyzed the acceptance of women in open source projects and found that while women are generally perceived in a positive light, they do encounter sexism. While there are numerous surveys studying different experiences of people working in the tech (ICT) industry with a gendered lens (e.g., Vassallo et al. (2016); Women Who Tech (2017); Simard (2008)), these surveys cover answers from participants working in a wide range of roles that are not necessarily related to software development. The results from these previous works have inspired our study, in which we aim to better understand if the previously found barriers and similarities between genders hold outside of the open source community and for a population of professionals with roles that are exclusively related to software development.

In this study we investigate some of the everyday experiences and barriers encountered by software professionals in technical roles from a gender perspective. We also analyzed age as a confounding factor. In particular, we report on a survey of 359 software professionals in which we investigate three main topics. First, we analyze the experience of *micro-inequities* among women and men[2] and different age groups. Micro-inequities are subtle, repeated

[1] We could not find a similar report with the numbers for non-binary people.

[2] Due to the low response rate of people identifying to other genders we did not include their responses in our extensive analysis which involved statistical tests. However, we report on the answers of non-binary people using their numbers.

negative messages (verbal and non-verbal), such as interruptions, lack of eye contact during discussions and being assigned menial tasks in a project (Rowe 1990); "micro" refers to their apparent subtleness and recurring frequency, not the size of their impact. When encountered, they can make the receiver feel unwelcome, incompetent or unqualified, and can impair performance in the workplace (Young 2016). Second, we examine, from a gender perspective, previously detected *barriers* in men-dominated fields related to leadership and recognition (Bryson et al. 2014), harassment and sexism (Women Who Tech 2017), as well as growth opportunities and pay (Glassdoor Team 2014; Kamamoto 2013; Kenny and Donnelly 2020). Finally, we analyze self-reported descriptions of unfair treatments and the main obstacles that women and men software professionals experience. In an effort to improve awareness of the issues faced by underrepresented groups, we present some of their reports directly in this paper. We make the anonymized, generated and analyzed datasets available.[3]

The main contributions of our work are: (1) an investigation on how women and men, and people in different age groups, working in technical roles experience micro-inequities and barriers in the software industry, (2) quantitative evidence of technical software professionals' experiences with leadership, team recognition, growth opportunities and pay that adds to previous knowledge in the field, (3) a compilation and qualitative analysis of how the participants describe the unfair treatments they have experienced and their major obstacles in the field.

2 Related Work

Much of the growing work on gender-related studies in software engineering has focused, as described by James et al. (2017), on giving an 'external view' of the impact of gender diversity. For example, previous work has analyzed how tenure and gender diversity affect team productivity and performance (Vasilescu et al. 2015; Gila et al. 2014), bug fixing time (Ortu et al. 2017) and the general health in teams (Catolino et al. 2019). Previous research has also looked into the effects of gender bias in pull-request acceptance (Imtiaz et al. 2019; Terrellet al. 2017), the effects of gender bias in technical decisions during software development (Wang and Redmiles 2019) and how gender-biased tools can affect newcomers' experiences (Padala et al. 2020). Research on mentoring and gender in open source projects, for example, found that men interviewees perceived no differences in women and men contributors, while some women mentees felt less comfortable with men than women mentors. The interviews also revealed that women mentors feel underestimated compared to their men counterparts (Balali et al. 2018). Other work analyzed the behavior of women and men in an online software engineering community and found that women tend to be more collaborative and supportive and seek to share their knowledge more than men contributors (Zolduoarrati and Licorish 2021).

James et al. (2017) analyzed the perceptions of women and men software professionals in technical roles on team dynamics, performance and recognition; and found that overall the perceptions of both genders are very similar. Another work (Canedo et al. 2020) observed that the majority of women core developers in open source projects have not experienced gender discrimination in their work on open source projects. Contrary to this finding, Lee and Carver (2019) analyzed the acceptance of women in open source projects and found that while women are generally perceived in a positive light, they do experience sexism. These set of results inspired some of the questions of our study, in which we aimed to better

[3] https://figshare.com/s/72700292e7d3af47218f.

characterize gender bias in the overall software engineering community, outside of open source; and analyze if some of the similarities in experiences related to team recognition and support reported by James et al. (2017) would hold for different populations.

Previous work showed that there is a significant pay gap between women and men working in the software industry (Kamamoto 2013; Glassdoor Team 2014). Existing studies also found that there are less women than men in the technical workforce of Silicon Valley in leadership positions (Simard 2008), and in the world overall (Nash Harvey 2014). Despite this difference one third of the people in upper leadership positions in the ICT sector do not believe that women are underrepresented in such positions (Nash Harvey 2014). Other research found that women in technical roles are less satisfied with their careers as their tenure progresses (James et al. 2017), that women working in technology startups witness and experience more harassment than men (Women Who Tech 2017); and are less satisfied with the recognition and rewards they receive compared to men in the workforce (Bryson et al. 2014). Trinkenreich et al. (2022) analyzed in a company-specific case study challenges perceived by women working in ICT and reasons for women to leave their company. They found that women often face socio-cultural challenges such as work-life issues, sexism and hitting the glass ceiling. In the scope of their analysis, they also provide suggestions on how to mitigate these challenges (Trinkenreich et al. 2022). These previous works motivated us to investigate to what degree these barriers are encountered by software professionals, directly involved in software development tasks, irrespective of their leadership positions.

Work in the software engineering domain has studied barriers encountered by software professionals from a technical perspective (Yost et al. 2016), has analyzed socio-technical barriers in open source software projects (Lee and Carver 2019; Steinmacher et al. 2015a, b), as well as barriers encountered by women when participating in technical online communities (Ford et al. 2016; Vasilescu et al. 2014). For example, they found that women tend to see the community size or stranger discomfort as a barrier to participate in technical online communities (Ford et al. 2016). Previous research (Lee and Carver 2019) in open source projects showed that social barriers are the most common barrier for women to contribute followed by entry difficulties and personal barriers. Our work is complimentary as we look beyond technical barriers and open source, and ask software professionals about the major barriers they have experienced in general, which may or not be related to online participation.

With respect to micro-inequities, the work that is most related to ours is a study (Vassallo et al. 2016) that surveyed women working in the Silicon Valley tech industry in leadership roles on their experiences with different micro-inequities such as interruptions, eye contact and assignment of menial tasks. Our work is complementary, since we focus on professionals working only on technical roles, and sample on a diverse pool in which not all participants have leadership positions. Moreover, we surveyed software professionals from two genders and different age groups to analyze possible disparities between gender experiences and had participants from a diverse number of countries.

To better understand the impact of gender on micro-inequities and barriers, we included age as a confounding factor in our analysis. Some work in the area has started to look at inter-sectional issues related to gender in the software engineering context. For example, Russo and Stol (2020) have found that different genders differ significantly in personality traits and their relationships among each other. Other work found that gender diversity in the online community participation in North America and Southeast Asia has increased over the years, while it has changed little in most other parts of the world (Prana et al. 2021). This research stream inspired us to investigate two factors (gender and age) that might have an impact on micro-inequities and barriers in software development. These two factors were analyzed in only a few previous studies. One of them (Hyrynsalmi 2019) shows that some

women in software development are more worried about potential age discrimination than gender discrimination when applying for new jobs in the sector. Work investigating age stereotypes (Schloegel et al. 2018) found that older developers are the most affected group by age stereotypes while younger developers have especially strong negative stereotypes towards older developers in agile software development. This perception is underlined by research results that showed that employers and employees estimate the productivity of older workers lower as of younger employees (Van Dalen et al. 2010). Other age stereotypes found in this latter work towards older employees are the resistance to change, the lower ability to learn and the higher costs involved. Research has shown that these age stereotypes can have an effect on workplace related decisions (Posthuma and Campion 2009). These results motivated us to include age as a confounding factor in our study.

3 Research Questions

The goal of this study is to investigate some of the everyday experiences and barriers encountered by software professionals in technical roles from a gender perspective. In particular, we analyze the experience of *micro-inequities* among different genders and age groups; as well as previously detected *barriers* in men-dominated fields.
We focus our study on two research questions:

RQ1: Micro-inequities. *To what degree do software professionals experience micro-inequities when interacting with colleagues? How do these experiences differ among genders?*

Micro-inequities are small, coverted, often unintentional, and hard to-prove events that occur wherever people are perceived to be different (Rowe 2008). These small events come in the form of subtle and sometimes subconscious messages (Hinton 2004). They can vary in the way they are delivered, for example, spoken words and sentences, looks, gestures, and voice tone (Hinton 2004). The "micro" in "micro-inequities" could suggest that they are trivial (Rowe 1990); however, their repetitive nature and cumulative effects can account for a significant burden over time. Examples of micro-inequities are being told you are bossy or aggressive when demonstrating non-stereotypical assertiveness (Alabi 2015; Chang and Milkman 2020), being assumed to not have the skills for your job role (Rowe 1990), and people not making eye-contact during in-person interactions (Butler and Geis 1990). Micro-inequities can gradually constitute a considerable barrier for performance, productivity, and career advancement (Haslett and Lipman 1997), can lead to damaged self-esteem, and eventual departure from the workplace (Hinton 2004).

RQ2: Other barriers. *Do software professionals face barriers previously detected in men-dominated fields? How do these experiences differ among genders?*

When investigating RQ2, we focus on three previously detected barriers related to: leadership and recognition (Bryson et al. 2014), harassment and sexism (Women Who Tech 2017), as well as growth opportunities and pay (Glassdoor Team 2014; Kamamoto 2013; Kenny and Donnelly 2020). We also analyze self-reported descriptions of the main obstacles that software professionals experience from a gender perspective. We investigate these aspects by answering the following sub-questions:

- **RQ2.1: Leadership and recognition.** How often are software professionals trusted into leadership positions and do they feel that their contributions are properly recognized? How do these experiences differ among genders?

- **RQ2.2: Harassment and sexism.** To what degree do software professionals experience harassment and sexism in the workplace? How do these experiences differ among genders?
- **RQ2.3: Growth opportunities and pay.** What is the perception of software professionals on growth opportunities and pay in the software industry? How do these perceptions differ among genders?
- **RQ2.4: Major barriers.** What are the largest barriers that software professionals self-report from the workplace? How do these barriers differ among genders?

To answer the research questions, we carried out the questionnaire-based survey described in this section.

3.1 Population

The target population of the survey was software professionals who are working or have worked in the software industry in a technical role (e.g., developers, testers, data scientists and product owners). By applying purposive sampling (Kemp 2000) we aimed at achieving a balance in the number of women and men respondents. To recruit participants, we advertised the survey in our personal networks, through industry contacts and by postings in online communities (Reddit, LinkedIn and Facebook). To balance the number of women respondents, which were initially lower than those of men, we also posted our survey on groups or subthreads focusing on women working in the field.

3.2 Survey Design

The survey contained a series of 30, close-ended and open-ended questions, some inspired by previous work (James et al. 2017; Lee and Carver 2019; Vassallo et al. 2016; Women Who Tech 2017). We first asked participants for general demographic information, and then proceeded to ask them questions relevant to each of the RQs. Table 1[4] shows the questions and their corresponding RQs, as well as the order in which they appeared in the survey. With one exception, our questions for micro-inequities were adapted from previous work investigating start-ups in tech (Women Who Tech 2017), and the overall tech industry (Vassallo et al. 2016). All behavioral actions described in the micro-inequities questions from our survey have been considered micro-inequities by previous research (Alabi 2015; Rowe 1990; Sue 2010). Similarly, with the exception of one question, all questions in our survey related to well known barriers were adapted from work investigating startups in tech (Women Who Tech 2017), open source projects (Lee and Carver 2019) and leadership and recognition in the software industry (James et al. 2017).

To avoid biasing participants throughout our survey, we formulated the questions in a gender-neutral language. An anthropologist with experience in gender studies reviewed the survey questions on this aspect. A pilot study was conducted with eight participants who were in the target population. The survey instrument was revised according to the received feedback. The survey was administered online via a Google form. We report on the answers received in the time period between April 9th 2020 to June 7th 2020. Except for questions Q21 and Q22, which were optional, eligible participants had to answer all questions to submit the survey. We decided to make all other questions including the demographic questions

[4] **Results with statistical significant** difference between gender and age are marked with *, only between genders are marked with *. If only age has a statistically significant influence, this is marked with an * .

Table 1 Survey questions

#	Question	Response options	Reference
RQ1: Micro-inequities and interactions with colleagues			
Q11	In meeting discussions I am interrupted by colleagues.	[Always; Very often; Sometimes; Rarely; Never]	Own
Q12	* In work meetings or discussions, I experienced colleagues making eye contact with other colleagues and not me.	[Always; Very often; Sometimes; Rarely; Never]	adopted Vassallo et al. (2016)
Q13	* A coworker has asked a colleague a question, that due to my experience, they should have asked me.	[Always; Very often; Sometimes; Rarely; Never]	adopted Women Who Tech (2017)
Q14	* A coworker has presented an idea of mine as theirs without the proper attribution.	[Always; Very often; Sometimes; Rarely; Never]	adopted Women Who Tech (2017)
Q15	* I have been asked to do menial tasks that other colleagues are not asked to do (e.g., take notes, organise meetings, order food).	[Always; Very often; Sometimes; Rarely; Never]	adopted Vassallo et al. (2016)
Q19	* I have been told that I am too aggressive or bossy at my workplace.	[Never; 1 or 2 times; 3 or 4 times; More than 4 times]	adopted Vassallo et al. (2016)
Q20	* I have felt excluded from key social/networking opportunities at work.	[Never; 1 or 2 times; 3 or 4 times; More than 4 times]	adopted Vassallo et al. (2016)
RQ2.1: Leadership and recognition			
Q16	* In my work environment I am responsible for managing or leading others.	[True; False]	Own
Q17	* I have the support and authority to make necessary decisions.	[Strongly agree; Agree; Neutral; Disagree; Strongly disagree]	adopted James et al. (2017)
Q18	I feel that my team values and acknowledges my contributions.	[Strongly agree; Agree; Neutral; Disagree; Strongly disagree]	adopted James et al. (2017)
RQ2.2: Harassment and sexism			
Q23	* Have you ever experienced or witnessed harassment when working in the software industry? For example: intimidation, offensive jokes or pictures, inappropriate touching or comments due to race, age, political beliefs, religion or gender identity.	[I have experienced this behaviour; I have witnessed this behaviour; I have experienced and witnessed this behaviour; I haven't experienced or witnessed this behaviour]	adopted Women Who Tech (2017)

Table 1 continued

#	Question	Response options	Reference
Q24	* Have you ever experienced or witnessed sexist behaviour in the software industry? For example: sexist language, misandry or misogyny, or salary inequalities due to gender identity	[I have experienced this behaviour; I have witnessed this behaviour; I have experienced and witnessed this behaviour; I haven't experienced or witnessed this behaviour]	adopted Women Who Tech (2017)
RQ2.3: Growth opportunities and pay			
Q25	* Do you think there are enough growth opportunities for you in the software industry?	[Strongly agree; Agree; Neutral; Disagree; Strongly disagree]	adopted James et al. (2017)
Q26	* Do you think you are fairly compensated for the work you are performing?	[Strongly agree; Agree; Neutral; Disagree; Strongly disagree]	James et al. (2017)
Q27	* If you had the opportunity to start all over, would you choose to be in this field?	[Strongly agree; Agree; Neutral; Disagree; Strongly disagree]	Own
RQ2.4: Self-reported Barriers			
Q21	Have you ever had the feeling that you've been treated unfairly in the software industry? Could you explain?	Open question	Own
Q22	What is the biggest obstacle you face, or have faced in the past, regarding to your work in the software industry? Could you explain?	Open question	Lee and Carver (2019)
Q28	* Do you think it is more challenging for people identifying to certain genders to be accepted in the software industry?	[Strongly agree; Agree; Neutral; Disagree; Strongly disagree]	adopted Lee and Carver (2019)
Q29	[If answered with Strongly agree or Agree in Q28] For which gender do you think it is more challenging to be accepted in the software industry?	[Women; Men; Non-binary]	Own
Other			
Q30	Is there anything else you would like to share with us?	Open question	

mandatory since we wanted to reduce the number of missing answers. Although we are aware of the possibility to estimate missing values (Little and Rubin 2019), the methods are not accurate if the amount of missing data is large (Kitchenham and Pfleeger 2003). Some of our closed-ended questions have an inverted Likert-scale frequency order. We chose this logic to ensure that respondents consciously answered the questions and to not introduce primacy effects, i.e., people choosing the earlier presented options (Krosnick 2018). We also presented answer options that were quantifiable ("Never; 1 or 2 times; 3 or 4 times; More than 4 times") for micro-inequities that we thought would appear more rarely and to which respondents might be able to distinctly remember how often they happened.

3.3 Data Analysis

We apply a mixed-methods approach for analyzing our results. Due to the low amount of responses from non-binary participants, we did not include their data in the statistical tests, but report on them using their numbers. When referring to gender differences in this work, we refer to those between women and men.

To better understand the impact of gender on micro-inequities and barriers, we include age as a confounding factor in the analysis. We did not include all collected independent variables in our analysis because we have too few answers for conducting reliable statistical tests with all involved independent variables. We chose age as the additional factor to examine, as previous studies have shown that age can often be a discriminatory factor in the workplace (Roscigno et al. 2007). For the age analysis, we use age clusters (18-25; 26-35; 36-45; 46-55; 56-65). To increase the observation points in each age cluster, we merged the age cluster 46-55 and 56-65 to one group. The reference category for the age analysis is the age cluster 18-25, meaning that the influence of the other age clusters is inferred in comparison to this age cluster. We chose this reference category because this is often the age of entry into the first job in the industry.

The application of the chosen statistical tests, follows the recommendations of McCrum-Gardner (2008) and Hoffmann (2016). We consider that there is a statistically significant difference when the p-value is less than 0.05. For the demographic questions, we examine if there is a difference between women and men responses through either a Chi-square or Mann–Whitney U-Test. For the close-ended questions of the rest of the survey, we quantitatively analyze if there is a difference between women and men and different age cluster responses through an Ordinal Logistic Regression or a Cumulative Logit Model. This has the advantage that we can measure the impact of the two independent variables (gender and age) simultaneously.

We tested if the underlying assumptions are fulfilled by transforming the answers (e.g., ranging from Never, Rarely, Sometimes, Very often, Always) to numbers (e.g., ranging from -2 to 2). Afterwards, we converted the coefficients into odds ratio to achieve a better interpretability of the results. To use the Ordinal Logistic Regression, the dependent variables need to be ordinal, which is the case for our closed-ended questions. Our analysed data does not show any multi-collinearity, which is the second assumption for using an Ordinal Logistic Regression. We used a Brant test to analyze whether the proportional odds assumption is satisfied for all of our underlying Ordinal Logistic Regressions. This is the case for almost all studied questions except for five (Question 14, 15, 24, 26, 28). For the fulfilling variables, we can use the Ordinal Logistic Regression since all assumptions of the test are met. Q16 consists of only a binary dependent variable (managing or not managing). In this case, we use a Logistic Regression. For the five questions that do not fulfill all assumptions, we apply a

Cumulative Logit Model with non-proportional odds to mitigate the problem of non-existent proportional odds.

For the qualitative data stemming from the open-ended questions, Q21 and Q22, two of the authors manually coded the answers individually. For this step, each author coded the first 50 answers from the first open question and created her own code set independently. Afterwards, we compared the code sets through discussions and solved disagreements. We did another iteration with the following 100 responses. Then, we repeated the process for the remaining responses. Finally, we thematically grouped the codes into higher-level categories. We followed the same approach for the second open question, but used the fine-grained codes and higher-level categories from the previous question as a starting point, as the content of the answers for both questions was overlapping.

We received 377 responses. Answers from respondents who reported that they were not working in the software industry in a technical role (14), were removed because they did not belong to the target population. When inspecting the data, we came across four answers that we considered noise. The answers showed that these participants had not taken the questionnaire seriously. For example, they had marked themselves as being below the age of 18 and already being retired, so we removed them from the dataset. After cleaning the data, we ended up with 359 participants, whose answers we report in the following section.

3.4 Ethics Compliance

We described the broad research goal (without mentioning its focus on gender, to avoid biasing participants) and how the data would be managed at the beginning of the survey. In this part we also provided our contact details in case participants needed additional information. To ensure that the data was not accessible outside of our research group, we restricted the permission rights of the collected data before the distribution of the survey to those within our research group and analyzed the data after its anonymization. We made sure that no personal information are contained in our provided dataset. We met with the Ethical Review Board from our university after performing the distribution and analysis steps in our study. During their check, they focused on the study methodologies and used tools. They concluded that despite not using a GDPR compliant tool for the survey distribution, the precautions taken during the analysis and sharing of the data are adequate, and that the information given to the participants about the goals of the study and how the information would be processed were also inline with their recommendations for similar studies.

4 Results

Throughout this study, we mark all **results with statistical significant** difference between women and men with an * at the beginning of its title. If both age and gender have a statistically significant effect, we mark this with an *. If only age has a statistically significant influence, we mark this with an * .

4.1 Demographics

Of the 359 valid and complete survey answers, 177 (49.3%) were responses from participants identifying as women, 176 (49%) as men and six (1.7%) as non-binary (Q4). We report on

Table 2 Respondent demographics

Demographic Type	Group	Men	Women	Non-Binary Persons
Age	18-25	18 (10%)	32 (18%)	3 (50%)
	26-35	74 (42%)	96 (54%)	1 (17%)
	36-45	54 (31%)	35 (20%)	0 (0%)
	46-65	30 (17%)	14 (8%)	2 (33%)
Region	Europe	98 (56%)	75 (42%)	3 (50%)
	North America	39 (22%)	90 (51%)	2 (33%)
	Other	39 (22%)	12 (7%)	1 (17%)
Education	Associates Degree	1 (0%)	3 (1%)	0 (0%)
	Bachelors degree	69 (39%)	86 (49%)	4 (66%)
	Doctorate	24 (14%)	16 (9%)	0 (0%)
	High school degree or equivalent	15 (9%)	7 (4%)	1 (17%)
	Masters Degree	67 (38%)	65 (37%)	1 (17%)
Employment Status	Full-time (38+ hours a week)	147 (84%)	149 (84%)	1 (17%)
	Part-time (less than 38 h a week)	13 (7%)	16 (9%)	3 (50%)
	Retired	0 (0%)	1 (1%)	0 (0%)
	Self-employed	9 (5%)	5 (3%)	0 (0%)
	Unemployed (looking for a job)	5 (3%)	5 (3%)	2 (33%)
	Unemployed (not looking for a job)	2 (1%)	1 (0%)	0 (0%)
Involvement in Software	Less than 2 years	19 (11%)	43 (24%)	2 (33%)
	2-5 years	45 (26%)	53 (30%)	2 (33%)
	6-10 years	37 (21%)	45 (25%)	0 (0%)
	11-15 years	30 (17%)	15 (9%)	0 (0%)
	16-20 years	17 (10%)	9 (5%)	0 (0%)
	21+ years	28 (16%)	12 (7%)	2 (33%)
Role	Architect	25 (14%)	10 (6%)	1 (17%)
	Analyst	0 (0%)	5 (3%)	1 (17%)
	Researcher	4 (2%)	5 (3%)	0 (0%)
	Consultant	4 (2%)	7 (4%)	0 (0%)
	Role in Data Science	12 (7%)	6 (3%)	0 (0%)
	Designer	1 (0%)	2 (1%)	0 (0%)
	Developer	84 (48%)	100 (56%)	4 (66%)
	Machine Learning Engineer	0 (0%)	1 (0%)	0 (0%)
	Product Owner	16 (9%)	16 (9%)	0 (0%)
	Project Manager	8 (5%)	7 (4%)	0 (0%)
	Management Level	8 (5%)	5 (3%)	0 (0%)
	Requirements Engineer	1 (0%)	1 (0%)	0 (0%)
	Scrum Master	0 (0%)	5 (3%)	0 (0%)
	Tester	4 (2%)	6 (3%)	0 (0%)
	Other	9 (5%)	1 (0%)	0 (0%)

the demographics of our respondents per gender in Table 2. The percentages displayed in the table show the share per gender. In the following section, we report the demographics share across the complete population.

Men respondents have more experience working in the software industry. For example 43% of men have eleven or more years of experience, compared to 20% of women. The difference of the years of working experience between both genders is statistically significant (Mann–Whitney: U=11260, $p < 0.001$). The greater part of the respondents are young or middle aged (14% are 18-25, 48% are 26-35, 25% are 36-45), fewer participants are over 45 years (8% are 46-55, 4% are 56-65). The women respondents of our dataset are in average younger than men. The age differences between men and women in our dataset are significant (Mann–Whitney: U=11992, $p < 0.001$). The majority of the non-binary respondents had only five or less years (67%) of experiences while two of them had more than 21 years of experience (33%) in the software industry.

Participants reported living in 36 different countries. Most participants live in the United States (33%) and the Netherlands (16%). Most women reside in the United States (46%), while most men live in the Netherlands and United States (20% each). 50% of the non-binary respondents live in the European Union. Other countries with a considerable number of answers are Germany, United Kingdom, Argentina and Brazil. The proportion differences between the different genders and location groups are statistically significant (Chi-square: χ^2=78.921, df=37, p-value < 0.001).

Most respondents reported having a bachelor (49% women, 39% men, 67% non-binary) or masters (37% women, 38% men, 17% non-binary) as their highest education degree. Men respondents hold more doctoral degrees (9% women, 14% men). The proportion differences between genders and their education is not significant (Chi-square: χ^2=9.065, df=6, p=0.17). One non-binary respondent holds a high-school degree or equivalent (16%).

The majority of respondents, 84%, are working full time. Most of the respondents have a developer role (52%). Other frequent roles among respondents are architects (10%), product owners (9%), project managers (4%), consultants (4%), data scientists (4%) and testers (3%). The proportion differences between the role in the company and gender is not statistically significant (Chi-square: χ^2=67.43, df=58, p=0.19).

4.2 RQ1: Micro-inequities

Figure 1 shows the main results of the questions on micro-inequities for the two genders considered in our study.

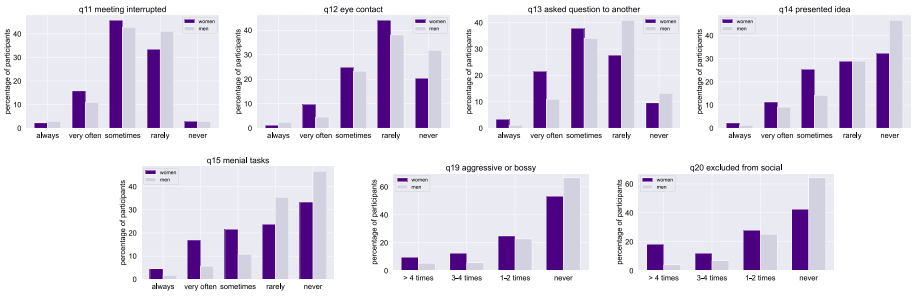

Fig. 1 Micro-inequities and interactions with colleagues (Q11-15, Q19-20)

Table 3 Ordinal logistic regression test results for eye contact (Q12)

Variable	Value	Std. Error	t-value	p-value
Age cluster 26-35	0.1070	0.2936	0.3645	0.7155
Age cluster 36-45	0.2374	0.3297	0.7202	0.4714
Age cluster 46-65	0.4762	0.3828	1.2440	0.2135
Men	−0.4785	0.2018	−2.3712	0.0177*

p-value < 0.001 '***'; p-value < 0.01 '**'; p-value < 0.05 '*'

Q11 Interruptions During Discussions: Both genders indicate that they are interrupted during meetings very often (women 16%, men 11%). A small minority of women (2%) and men (3%) stated that this happens always. However, most of the participants expressed that this happens sometimes (46% women, 43% men), rarely (33% women, 41% men) or never (both 3%). There is no statistically significant difference between the answers from both genders. Three out of six non-binary respondents (50%) reported that they are sometimes interrupted by colleagues in meetings, while two respondents answered rarely (33%) and one respondent (17%) said it happens very often. The statistical analysis shows no statistically significant influence of age on interruptions during discussions.

Q12* Eye Contact: A large proportion of women and men reported that avoiding eye contact during discussions with colleagues is rare. About one fourth of the women and men reported that this sometimes happens. Women reported frequently experiencing this behaviour more often than men. When asking about eye contact, two non-binary respondents (33%) answered that they never experienced eye contact exclusion, while three (50%) reported that it occurs rarely and one that it sometimes happens. There is a significant difference between the answers of both women and men (p-value = 0.018*). Table 3 shows the results for the ordinal logistic regression on the eye contact variable. The findings show that for women the odds of experiencing that colleagues make eye contact with other colleagues and not with them is 1.61 times more likely, holding constant all other variables.

Q13* Being Skipped on Questions: More men (41%) than women (28%) reported rarely experiencing being skipped on questions that due to their expertise should have been asked to them, about a tenth of the respondents disclosed that they are never excluded in this respect. A third of women and men reported that they sometimes experience this matter, with more women indicating that it always happens to them. Five out of six non-binary respondents (83%) said colleagues asked co-workers instead of asking them, while one respondent (17%) answered that this never occurred. There is a significant difference between the answers from women and men (p-value = 0.0010**). Table 4 shows the results for the Ordinal Logistic Regression on the being skipped on questions variable. The findings show that for women,

Table 4 Ordinal logistic regression test results for being skipped on questions (Q13)

Variable	Value	Std. Error	t-value	p-value
Age cluster 26-35	−0.3386	0.2989	−1.1328	0.2573
Age cluster 36-45	−0.3499	0.3298	−1.0612	0.2886
Age cluster 46-65	−0.4066	0.3898	−1.0429	0.2970
Men	−0.6623	0.2017	−3.2842	0.0010**

p-value < 0.001 '***'; p-value < 0.01 '**'; p-value < 0.05 '*'

the odds of experiencing that a colleague asked someone else a question that should have been asked to them is 1.94 times more likely, holding constant all other variables. There is no significant influence of age on the behavior.

Q14 * Presented Idea Without Proper Attribution: Almost half of the men participants (47%) and almost one third of the women participants (32%) reported never experiencing this issue. More women (25%) than men (14%) reported sometimes experiencing this matter. For non-binary respondents, three (50%) never faced the issue, while two (33%) experienced it very rarely and one (17%) very often. For the gender variable, the proportional odds assumption holds, and thus, there is only one p-value to report. The influence of gender is statistically significant (p-value < 0.001***). We list the p-values of each statistical significant response set in the Table 5. For women, the odds of experience this behavior is 1.99 times more likely than for men, holding all other variables constant.

The Brant test shows that the age variable violates the proportional odds assumption. Thus, we apply a Partial Proportional Odds Model, a sub-type of the Cumulative Logit Model. In the case of a violation of the proportional odds assumption, we cannot assume that each response pairing has the same ratio. Therefore, different p-values and odds ratios must be assumed for each response set. The results show that some of the response sets for the age cluster 26-35 and 46-65 are significantly different for the variable of presenting an idea without proper attribution than for the reference group (18-25). Table 5 shows an overview of all significant response sets for this variable.

Q15 * Menial Tasks: More women respondents reported being asked to do menial tasks, such as taking notes, organizing meetings and ordering food. Women indicated that this incident happens sometimes, very often or always in higher proportions than men (see Fig. 1). Four non-binary respondents (67%) reported never being asked to do menial tasks, while one (17%) reported rarely being asked and one sometimes being asked (17%). The Brant test shows that the model violates the proportional odds assumption for both variables. Thus, we apply the Cumulative Logit Model. We list the significant p-values for this question in Table 6. The results show that some of the response sets for gender and the age cluster 26-35 are significantly different for getting menial tasks assigned than for the reference group (men/18-25). Table 6 shows an overview of all significant response sets for this variable.

Q19 * Bossy or Aggressive at Workplace: Most women (53%) and men (66.5%) have never been told that they are too aggressive or bossy in the workplace. However, when experienced, women have been told with a higher frequency than men. For example, 22%

Table 5 Partial proportional odds model test results for presented idea without proper attribution (Q14)

Response set	Estimate	Std. Error	z-value	p-value
The influence of the age cluster 26-35 for the comparison "Rarely", "Sometimes", "Very often", "Always" vs. "Never"	−2.83527	0.75430	−3.759	< 0.001***
The influence of the age cluster 46-65 for the comparison "Sometimes","Very often", "Always" vs. "Never", "Rarely"	1.40885	0.71599	1.968	0.049104*
The influence of the age cluster 46-65 for the comparison "Rarely", "Sometimes", "Very often", "Always" vs. "Never"	−2.01009	1.01776	−1.975	0.048267*
Men	−0.68581	0.08517	−8.08517	< 0.001***

p-value < 0.001 '***'; p-value < 0.01 '**'; p-value < 0.05 '*'

Table 6 Cumulative logit model test results for menial tasks (Q15)

Response set	Estimate	Std. Error	z-value	p-value
The influence of the age cluster 26-35 for the comparison "Always", "Very often", "Sometimes" vs. "Rarely", "Never"	−1.01649	0.40597	−2.504	0.01228*
The influence of the age cluster 26-35 for the comparison "Always", "Very often", "Sometimes", "Rarely" vs. "Never"	−1.66372	0.68495	−2.429	0.0151*
The influence of gender for the comparison "Always" vs. the rest of the answers	−0.62360	0.22598	−2.760	0.006**
The influence of gender for the comparison "Always", "Very often" vs. the rest of the answers	−1.32500	0.25622	−5.171	< 0.001***
The influence of gender for the comparison "Always", "Very often", "Sometimes" vs. the rest of the answers	−1.29261	0.34725	−3.722	< 0.001***

p-value < 0.001 '***'; p-value < 0.01 '**'; p-value < 0.05 '*'

of the women respondents indicated that this issue has occurred three or more times, against 11% of the men. None of the non-binary respondents have been told that they are aggressive or bossy at the workplace. There is a significant influence of gender (p-value < 0.001***) and the age cluster 36-45 (p-value < 0.001***) and 46-65 (p-value < 0.001***) on whether the person has been told to be aggressive or bossy at the workplace. For women, the odds of having been told that they are too aggressive or bossy at the workplace is 2.43 times more likely than for men, holding constant all other variables. For respondents in the age groups between 36-45 and 46-65, the odds of having been told that they are too aggressive or bossy at the workplace is 4.21 and 4.52 times, respectively, more likely than for respondents of the reference category (18-25), holding constant all other variables. Table 7 shows the results for the Ordinal Logistic Regression on the bossy or aggressive variable.

Q20 * Excluded From Social or Networking Opportunities at Work: While a large proportion of respondents reported that they have never felt excluded from social or networking opportunities, the difference between genders is strong, with men (64%) reporting more often than women (42%) that they have never felt this way. Many more women (30%) than men (11%) indicated that they have felt excluded from social or networking opportunities three or more times. When asking about the exclusion for key social networking opportunities, three non-binary respondents (50%) answered that they never experienced this, one (17%) that it happened 1 or 2 times and two (33%) reported that they were 3 or 4 times excluded from key social networking opportunities. The Ordinal Logistic Regression shows

Table 7 Ordinal logistic regression test results for bossy or aggressive at workplace (Q19)

Variable	Value	Std. Error	t-value	p-value
Age cluster 26-35	0.6091	0.3582	1.7004	0.0891
Age cluster 36-45	1.4384	0.3908	3.6809	< 0.001***
Age cluster 46-65	1.5080	0.4409	3.4203	< 0.001***
Men	−0.8884	0.2269	−3.9159	< 0.001***

p-value < 0.001 '***'; p-value < 0.01 '**'; p-value < 0.05 '*'

that gender (p-value < 0.001***), the age cluster 46-65 (p-value = 0.007**) and the age cluster 36-45 (p-value = 0.0207*) have a significant effect on whether the person has felt excluded from key social/networking opportunities at work. For women, the odds that the person has felt excluded from key social/networking opportunities at work is 3.22 times more likely than for men, holding constant all other variables. For respondents in the age between 36-45/46-65, the odds that the person has felt excluded from key social/networking opportunities at work is 2.28/2.96 times more likely than for younger respondents, holding constant all other variables. Table 8 shows the results for the Ordinal Logistic Regression on the excluded from social or networking opportunities at work variable.

RQ1: Micro-inequities Software professionals frequently experience micro-inequities while working. The odds of women experiencing micro-inequities related to *eye contact avoidance* and *not being asked questions* are statistically higher than for men. Respondents' age and gender have a statistically significant influence on the frequency of *being assigned menial tasks* and *someone else presenting an idea of them without proper attribution*. Women and people from the age group 36-45/46-65 have statistically higher odds of being *called bossy or aggressive* and being *excluded from social networking opportunities at work*. However, men and women as well as different age groups experience the same amount of interruptions during meetings.

4.3 RQ2.1: Leadership and Contributions

Q16 * **Managing and leadership position:** Slightly more men reported holding a position in which they are in charge of managing or leading others (41% women, 46% men). There is no statistical significance on gender and holding managing or leadership positions. However, for the age clusters, there is a statistical significant influence on whether they have a managing or leadership position. The age cluster 26-35/36-45/46-65 has a statistical significant influence on the leadership position (p-value = 0.030*/p-value < 0.001***/p-value = 0.002**). The odds for being in a leadership position is 2.25 times higher for respondents in the age group 26-35 compared to the 18-25 group. For the age group 36-45 the odds of being in a leadership position is 5.23 higher and for age group 46-65 the odds are increased by a factor of 4.27 compared to the reference group (18-25). Table 9 shows the results for the Logistic Regression on the managing and leadership position variable.

Q17 * **Support and Authority to Make Decisions:** Most survey participants (63% women, 71% men) (strongly) agree that they obtain the support and authority to make

Table 8 Ordinal logistic regression test results for excluded from social or networking opportunities at work (Q20)

Variable	Value	Std. Error	t-value	p-value
Age cluster 26-35	0.4219	0.3214	1.3128	0.1893
Age cluster 36-45	0.8263	0.3572	2.3133	< 0.02071*
Age cluster 46-65	1.0847	0.4045	2.6817	< 0.0073**
Men	−1.1697	0.2188	−5.3454	< 0.001***

p-value < 0.001 '***'; p-value < 0.01 '**'; p-value < 0.05 '*'

Table 9 Logistic regression test results for managing and leadership position (Q16)

Variable	Value	Std. Error	t-value	p-value
Age cluster 26-35	0.81175	0.37632	2.157	0.030999*
Age cluster 36-45	1.65513	0.40791	4.058	< 0.001***
Age cluster 46-65	1.45149	0.46219	3.140	0.001687 **
Men	−0.01085	0.22719	−0.048	0.961893

p-value < 0.001 '***'; p-value < 0.01 '**'; p-value < 0.05 '*'

necessary decisions in their workplace. However, more women (strongly) disagreed on this matter (15% women, 6% men). Two out of six non-binary respondents (33%) indicated that they have the support and authority to make necessary decisions, one strongly agreed, one is neutral, and two disagreed with this statement. The findings show that the gender (p-value = 0.021*) and the age cluster 46-65 (p-value = 0.032*) have a statistically significant influence on the support and authority to make decisions. For men, the odds of having the support and authority to make necessary decisions is 1.61 times more likely than for women, holding constant all other variables. For respondents in the age between 46 and 65, the odds of having the support and authority to make necessary decisions is 2.36 times more likely than for respondents in the age cluster 18-25, holding constant all other variables. Table 10 shows the results for the Ordinal Logistic Regression on the support and authority to make decisions variable.

Q18 Team Acknowledgement: Most respondents (77%) (strongly) agree that they feel valued in their work team and that their team acknowledges their contributions. However, more men (82%) feel valued and acknowledged when compared to women (72%). When asked if they feel their team values and recognizes their contributions, four non-binary respondents (67%) answered agree and two (33%) answered strongly agree. The influence of gender or age on the team acknowledgment is not statistically significant.

RQ 2.1: Leadership and recognition. Almost half of our respondents are trusted in *positions that involve managing or leading others*, this is experienced in similar proportions by men and women. Respondents in the age clusters 26-35/36-45/46-65 have statistically higher odds of being in a position that involves managing and leading others than the age cluster 18-25. While we did not find any gender or age differences with respect to team acknowledgment on individual contributions, women and people from the age cluster 18-25 have statistically higher odds of experiencing *less support and authority to make decisions*.

Table 10 Ordinal logistic regression test results for support and authority to make decisions (Q17)

Variable	Value	Std. Error	t-value	p-value
Age cluster 26-35	0.3859	0.2993	1.2892	0.1973
Age cluster 36-45	0.5200	0.3372	1.5422	0.1230
Age cluster 46-65	0.8585	0.3995	2.1489	0.0316*
Men	0.4736	0.2055	2.3045	0.0212*

p-value < 0.001 '***'; p-value < 0.01 '**'; p-value < 0.05 '*'

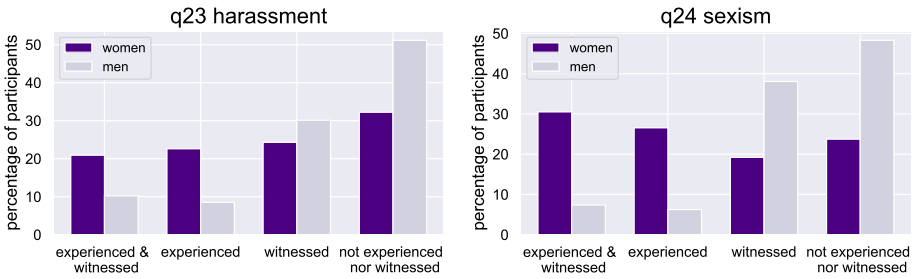

Fig. 2 Harassment and sexism (Q23 & Q24)

4.4 RQ2.2: Harassment and Sexism

Figure 2 shows the main results for harassment and sexism.

Q23* Harassment: A significant larger proportion of women have experienced or witnessed harassment while working in the software industry; 43.5% of the women reported experiencing harassment, compared to 19% of the men; 24% of the women reported witnessing harassment but not experiencing it themselves, compared to 30% of the men. Overall, 32% of the women and 51% of the men reported never experiencing or witnessing harassment in the software industry. Four out of six non-binary respondents (67%) have reported that they have not experienced or witnessed harassment at the work, one (17%) has witnessed this behavior and one (17%) has experienced and witnessed this behavior. The odds for experiencing or witnessing harassment is 2.62 times higher for women compared to the men.

The influence of gender on harassment is statistically significant, while age is not statistically significant. We list the significant p-values for this question in Table 11.

Q24* Sexism: 76% of the women respondents have experienced or witnessed sexism in the software industry. More than half, 57%, have directly experienced sexism. In stark contrast, 14% of the men have experienced sexism while working in the industry and 38% of the men have witnessed sexism, while not experiencing it directly. Two out of six non-binary respondents (33%) have experienced and witnessed sexist behaviour, one (17%) has witnessed this behavior and three (50%) haven't experienced or witnessed this behaviour.

The Brant test shows that the gender variable does not hold for the parallel assumption. Thus, we apply a Cumulative Logit Model. The influence of gender on this behaviour is significant, while age is not statistically significant. The influence of gender on this behavior is statistically significant for all answer choices in the cumulative form. We list the significant p-values for this question in Table 12.

Table 11 Ordinal logistic regression test results for harassment (Q23)

Variable	Value	Std. Error	t-value	p-value
Age cluster 26-35	0.5039	0.3043	1.6558	0.0978
Age cluster 36-45	0.5812	0.3378	1.7206	0.0853
Age cluster 46-65	0.3501	0.3935	0.8897	0.3736
Men	−0.9640	0.2065	−4.6689	< 0.001 ***

p-value < 0.001 '***'; p-value < 0.01 '**'; p-value < 0.05 '*'

Table 12 Cumulative logit model test results for sexism (Q24)

Response set	Estimate	Std. Error	z-value	p-value
The influence of gender for the comparison "I have experienced and witnessed this behaviour" vs. the rest of the answers	−1.08085	0.23761	−4.549	< 0.001***
The influence of gender for the comparison "I have experienced and witnessed this behaviour", "I have experienced this behaviour" vs. the rest of the answers	−2.24053	0.27584	−8.123	< 0.001***
The influence of gender for the comparison "I have experienced and witnessed this behaviour", "I have experienced this behaviour, "I have witnessed this behaviour" vs. I haven't experienced or witnessed this behaviour"	−1.79157	0.34029	−5.265	< 0.001***

p-value < 0.001 '***'; p-value < 0.01 '**'; p-value < 0.05 '*'

RQ2.2: Harassment and sexism. There is a large imbalance of women and men *experiencing and witnessing harassment and sexism* in our sample. While more than 60% of the women either experienced or witnessed harassment and 76% sexism, roughly half of the men respondents have not witnessed or experienced sexism or harassment. The differences are statistically significant. Respondents from different age groups experience harassment and sexism similarly.

4.5 RQ2.3: Growth Opportunities and Pay

Q25 * Growth Opportunities: Most women (70%) and men (73%) respondents are satisfied with the growth opportunities in the software industry. Slightly more women (strongly) disagree on the topic (12% women, 7% men). Four out of the six non-binary respondents (67%) reported that they agree that there are enough growth opportunities for them in the software industry, while one (17%) strongly agrees and one (17%) disagrees. Due to the relatively small number of strongly disagreeing and disagreeing responses, we merged these two categories to one response category. The Ordinal Logistic Regression shows that gender (p-value = 0.034*) and the age cluster 36-45 (p-value = 0.025*) have a significant effect on whether the person thinks that there are enough growth opportunities for them in the software industry. For men, the odds that the person thinks that there are enough growth opportunities for them in the software industry is 1.54 times more likely than for women, holding constant all other variables. For respondents who are in the age between 18-25, the odds that the person thinks there are enough growth opportunities for them in the software industry is 2.09 times more likely than for respondents in the age group of 36-45, holding constant all other variables. Table 13 shows the results for the Ordinal Logistic Regression on the growth opportunities variable.

Q26 * Fair Compensation: Over half of the respondents (strongly) agree that the compensation they obtain for their work is fair (58% women, 65% men). However, more women (strongly) disagree (25% women, 11% men). Three out of six non-binary respondents think that they are fairly compensated, two are neutral and one disagree with this statement.

The Brant test shows that the model does not hold for the parallel assumption. Thus, we apply a Cumulative Logit Model. We list the significant p-values for this question in

Table 13 Ordinal logistic regression test results for growth opportunities (Q25)

Variable	Value	Std. Error	t-value	p-value
Age cluster 26-35	−0.1918	0.2964	−0.6470	0.5176
Age cluster 36-45	−0.7390	0.3289	−2.2470	0.0246*
Age cluster 46-65	−0.5331	0.3988	−1.3369	0.1813
Men	0.4302	0.2032	2.1166	0.0343*

p-value < 0.001 '***'; p-value < 0.01 '**'; p-value < 0.05 '*'

Table 14. The results show that some of the response sets are significantly different regarding fair compensation among women and men.

Q27 * Starting all Over Again: Most participants (strongly) agree that they would choose to work in the software industry again, would they have the opportunity to start over (70% women, 81% men). However, more women (10%) than men (6%) would choose to not go in the field again. Among non-binary people, four agreed they would choose the software industry again, one remained neutral and one disagreed. The tests show that there is a statistically significant influence of gender (p-value = 0.010*) on this behavior. For men, the odds that the person would start over in the same field if they had the chance to is 1.69 times more likely than for women, holding constant all other variables. Age does not have a significant influence on this behavior. Table 15 shows the results for the Ordinal Logistic Regression on the starting all over again variable.

RQ2.3: Growth opportunities and pay. Most women and men are satisfied with the growth opportunities and pay in the software industry. However, a higher amount of women would like to have more *growth opportunities, and a fairer compensation* than men. Moreover, a higher amount of women would not choose the software industry if having the possibility to *start over again*. All three differences are statistically significant. With respect to age, respondents in the age group 36-45 would like to have statistically significant more *growth opportunities* in comparison to the age group 18-25.

4.6 RQ2.4: Major Barriers

Q28 & Q29 * More Challenging for a Particular Gender: The majority of women (76%) and almost half of men (47%) (strongly) agree that it is more challenging for certain genders to be accepted in the software industry. Men (27%) have a more neutral stance on the topic

Table 14 Cumulative logit model test results for fair compensation (Q26)

Response set	Estimate	Std. Error	z-value	p-value
The influence of gender for the comparison "Strongly Agree" vs. the rest of the answers	1.42206	0.66373	2.143	0.032152*
The influence of gender for the comparison "Strongly Agree" or "Agree" vs. the rest of the answers	1.09630	0.30147	3.637	< 0.001***

p-value < 0.001 '***'; p-value < 0.01 '**'; p-value < 0.05 '*'

Table 15 Ordinal logistic regression test results for starting all over again (Q27)

Variable	Value	Std. Error	t-value	p-value
Age cluster 26-35	−0.0363	0.3016	−0.1202	0.9043
Age cluster 36-45	−0.3178	0.3336	−0.9526	0.3408
Age cluster 46-65	−0.5564	0.3993	−1.3933	0.1635
Men	0.5248	0.2040	2.5730	0.0101*

p-value < 0.001 '***'; p-value < 0.01 '**'; p-value < 0.05 '*'

than women (15%) and (strongly) disagree more often on this issue (8.5% women, 26% men). More than half of the participants (52% women, 56% men) responded that it is harder for women and non-binary people to be accepted in the software industry. More women reported that it is only harder for women to be accepted (40% women, 23.5% men). Slightly more men pointed out that it is only harder for non-binary people (7.5% women, 12% men). None of the women reported that it is harder for men to work in the software industry while 9% of men reported that this is the case. Four non-binary respondents agreed and two strongly agreed to the statement that it is more challenging for people identifying to certain genders to be accepted in the software industry.

The Brant test shows that the proportional odds assumption does not hold. Therefore, we apply the Cumulative Logit Model. The influence of gender on this behavior is statistically significant for all answer choices in the cumulative form ("Strongly Agree" vs. the rest; "Strongly Agree", "Agree" vs. the rest, etc.). The influence of age is not statistically significant on this behaviour. We show the significant p-values for this question in Table 16.

Q21: Unfair Treatment: To understand unjust behaviours in the software industry, we asked participants to report on previous unfair treatments they have experienced in their current or previous jobs in the field. We manually analyzed and open coded 31 unfair treatments, which we grouped into six higher-level categories related to: (1) team dynamics, (2) biases, (3) reward, (4) management, (5) workload and work-life balance, and (6) technical and specific project issues. Many participants reported multiple unfair treatments, therefore, answers from a single participant could be related to several categories. Also, a single unfair treatment could belong to more than one category. For example, we coded "*as a woman I have to constantly prove myself in my team*" as belonging to the categories (1) team dynamics and (2) bias.

Table 16 Cumulative logit model test results for more challenging for a particular gender (Q28/29)

Response set	Estimate	Std. Error	z-value	p-value
The influence of gender for the comparison "Strongly Agree" vs. the rest of the answers	−2.18982	0.78281	−2.797	0.005152**
The influence of gender for the comparison "Strongly Agree" or "Agree" vs. the rest of the answers	−1.41048	0.32061	−4.399	< 0.001***
The influence of gender for the comparison "Strongly Agree" or "Agree" or "Neutral" vs. the rest of the answers	−1.19168	0.23626	−5.044	< 0.001***
The influence of gender for the comparison "Strongly Agree" or "Agree" or "Neutral" or "Disagree" vs. the rest of the answers	−1.08468	0.26040	−4.165	< 0.001***

p-value < 0.001 '***'; p-value < 0.01 '**'; p-value < 0.05 '*'

In total, 78.5% of the women and 69% of the men answered this question; of those that answered 29% of the women and 54.5% of the men reported not having experienced unfair treatment in their current or previous work in the software industry. Three of the six non-binary respondents answered this question, among which only one gave details about the experienced unfair treatments. Figure 3 shows the main sources of unfair treatment for the women and men respondents. We report on the described unfair treatments, from most occurrent to least, as follows.

Team Dynamics: Situations related to team dynamics as sources of unfair treatment were the most reported by women (64%) and second by men (13%). Women often reported on having to prove themselves—at times repeatedly—on their teams not considering their opinions, as well as being assumed to have less knowledge or non-technical skills although having a technical role. On having to repeatedly prove herself and being assumed to be less technical, one woman wrote: *"I have to prove myself over and over and over and over again. Past accomplishments mean nothing. Male colleagues see me as someone that they can teach [...]"*. When describing situations in which their opinions were not considered, women recounted events in which they were ignored and not taken seriously, as one women describes: *"[...] I do my best to be competent and civil but am often ignored at best or treated with contempt at worst."*.

Several women reported experiencing that they were assumed to be non-technical. Some shared stories in which they described not being assigned technical tasks, despite officially having a technical role: *"At my latest job, I was hired to do back-end development, and yet in 9 months I have worked there, I have only taken meeting minutes, sent emails, and 'enabled communication and transparency'. When my team got back-end work, I was the only one to not be assigned any, despite being one of the very few people with experience. This makes no financial sense. I don't think it is fair."*. Some women described being encouraged to take less technical roles in their careers. For example, one participant wrote: *"I get the feedback that I should look into management because I have great leadership qualities and because I'm allegedly a lot more emotionally intelligent than my male peers. I wonder how much of this is actually based on my qualities as a person, and how much of this is influenced by the fact that I am a woman. Moreover, I think it's curious that those who are advising/coaching/mentoring me think it's a great idea to lean towards a less-technical career path rather than moving up to a more technical role like a tech lead or a principal engineer"*.

Women also reported verbal mistreatment, not being recognized as leaders, people not trusting their decisions or quality of work, harassment and a bro culture environment as some

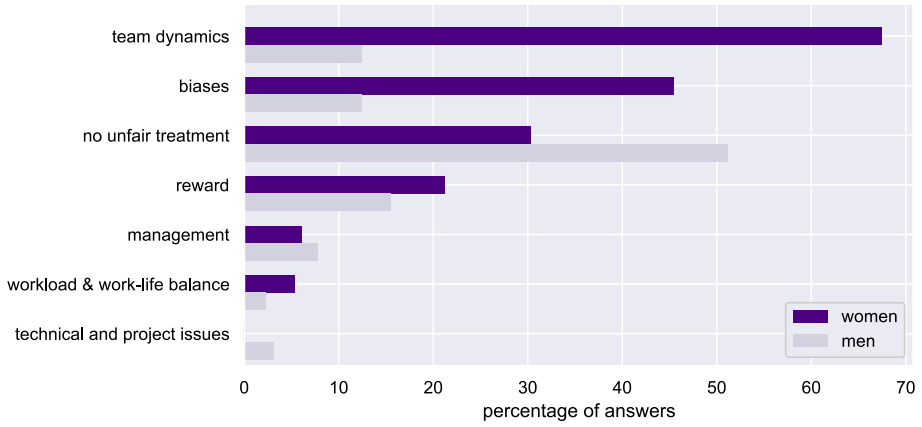

Fig. 3 Unfair treatment (Q21)

of the issues leading to unfair treatment. When recalling verbal mistreatment situations, women reported being subjected to derogatory comments, such as being labeled 'bossy' or 'aggressive', as well as being talked down to, and in some cases, not being addressed by their preferred pronouns. Regarding instances in which they were not recognized as leaders, women described situations in which other colleagues were asked to communicate to other teams or external stakeholders despite having leadership positions. On this matter, one women reported: *"[...] we had a client that had issues with women in leadership position and had to ask a male colleague to present my ideas in order for it to be accepted."* With respect to bro culture in the software industry and not feeling valued or acknowledged by her team, one woman commented: *"Yes, although not intentionally. There exists a "bro culture" so ingrained that it's the norm and I don't think my fellow developers realize what they're doing [...]. I've noticed myself and other women being interrupted during meetings and talked over [...] The guys will go to lunch together to chit chat and they never invite us women. It makes me feel excluded."* Several other women described similar experiences.

Common issues among women respondents related to recognition and team dynamics were largely unreported by men. The situations that men most described in this category were related to verbal mistreatment and not feeling valued or acknowledged by their teams; both of these issues were reported with more frequency among women.

Biases: Biases were the second most reported source of unfair treatment by women (43%) and men (13%). Sexism (32% women, 1% men) was the most reported bias by women. More behind were general favoritism and ageism. Biases based on seniority or experience were also stated, as were those on race, culture and spoken language. On sexism, one woman wrote: *"Yes, women are penalized when they are ambitious, when they challenge or contradict a man, when they speak up. Traits that get men promotions make women 'difficult,' 'not a team player,' 'aggressive,' or various sexist slurs."*. Some women reported more than one bias when narrating the unfair treatment(s) they encountered. In reports describing more than one bias, gender bias was usually one of them. On the interplay of language, gender, and global south-north biases one woman reported: *"I am the only non native english speaker in my team and I am also the only female from a developing country; so often during meetings with people outside my company, they tend to ask question to other team members that should be directed to me because they assume I either do not have the knowledge or communication skills to answer them."*. Gender was also frequently reported together with age bias. In this case women usually reported being cast out because of their young age. Cases from discrimination due to being older were not reported, possibly because most women were young. With respect to age and gender bias, and not being heard, one woman wrote: *"Most of the time I am the only woman in the room, and at the same time the youngest person, and sometimes I find it very difficult to make the other people listen to what I have to say or what I am trying to explain. [...] And this has never been the case with my male colleagues."*, other women described similar experiences.

Men reported issues with ageism, general favoritism and seniority with the same frequency, racism and language bias were also reported but in lesser degree. With regards to age bias, one man wrote: *"I feel I've been passed over for opportunities because I was seen as "not having future potential". My interpretation of this was that they were evaluating me based on my age rather than my ability to do the work and succeed."*.

Reward: Issues related to reward were the third most popular for women (20%) and first for men (16.5%). In this category, the most reported issues for both genders were related to promotion and pay. Several women described situations in which they received lower salaries than those of men colleagues with similar responsibilities and experience. For instance, one woman reported: *"My salary was significantly lower than my male colleag[u]e's salary who did exactly the same work and joined the company even later than I. Our degrees were the same. I was shocked about the salary difference."*. For men, the mismatch between the skills they brought to the job and pay, was a common factor. Gender pay inequality, was not mentioned among them, one man,

for example, commented: *"Specifically on salary terms and career opportunities. My skills have differed many times from my salary."*. In regards to promotion both women and men described situations in which they were passed over for promotions that they had been promised or thought they deserved. Women, however, sometimes mentioned being passed over in preference for men, men did not report this situation for women. On this aspect, one women wrote: *"It feels like it's harder and takes longer for me to get promoted than my make colleagues, even though I'm qualified."*.

Management: 6% of the women and 5% of men reported unfair situations stemming from poor management. On this point, one man described *"Sometimes in the distant past my manager didn't have a global view while I was helping other teams he was only concerned with his own targets."*.

Workload and Work-Life Balance: Situations related to workload and work-life balance were reported by 4% of women and 2.5% of men. Some women mentioned situations related to parenthood as a source of unfair treatment in their descriptions; only one man did the same. On this manner, and other types of unfair situations, one woman expressed: *"Too long to explain. Multiple cases of discrimination during team lead selection, best project selection, promotions and a big one after maternity leave."*. In contrast, a man reported company policies favoring families over single-households: *"Many company policies are designed for older employees with families; the policies don't support single life nearly as much."*.

Technical and Project Issues: 3% of the men mentioned specific situations related to a project, such as having to hack features last minute and deprioritized projects. None of the women reported similar unfair treatments.

No Unfair Treatment: While 54.5% of the men reported not having experienced unfair treatment in their current or previous work in the software industry, a few of these men recognized that this was due to their privilege. For example, one man answered *"No, being a well educated, reasonably confident, native English speaking, white male, this hasn't happened to me. I'm very aware how privileged I am."*. Others admitted to being on the "positive" side of the preferential treatment. For example, one man responded *"Yes, but I'm on the positive side of the unfairness. Everybody listens when I speak. They keep promoting me and giving me more money. Yes I work hard, but it probably shouldn't be this easy."*. Finally, a few women and men, wrote that unfairness was inevitable or unintentional. For example, one man answered: *"No. We all earn our way. There is no fair in life, or software."*.

Q22 Barriers: To understand the major barriers that software professionals face when working in the software industry, we asked participants to describe the largest obstacle they have experienced when working in this industry. Overall, respondents reported on 39 obstacles, which we thematically grouped into eight higher-level categories. When unfair treatment intensifies, it can develop into significant barriers for individuals. As a result, the same categories emerge as in Q21, in addition to two new ones related to professional growth and development, and personal skills.

Many participants reported multiple barriers, leading to single answers being coded as belonging to multiple categories. In total, 32% of the women and 34% of the men answered this question. Five non-binary respondents answered the question. Of those that responded, only 2% of the women and 5% of the men reported not having any barriers in their current or previous work in the software industry. Figure 4 shows the most frequently mentioned high-level barriers for the women and men respondents, Fig. 5 shows the most frequently mentioned fine-grained barriers for the women and men respondents. We discuss our findings for each higher-level category, in order of frequency appearance below.

Team Dynamics: Barriers related to team dynamics were the most reported for women (54%) and second for men (19%). As in Q21, women often reported having to prove themselves. They also reported considerably often not being acknowledged or valued and having difficult colleagues as their main obstacles. On not being acknowledged or valued one woman

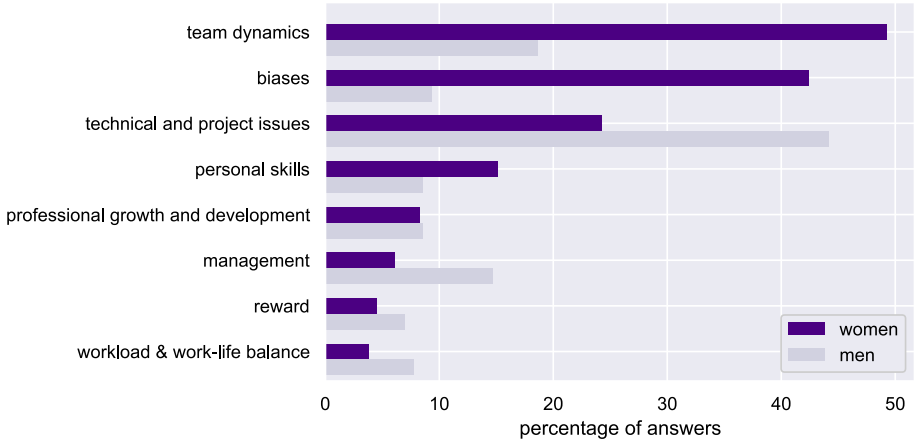

Fig. 4 Major barriers (Q22)

reported her main obstacle as: *"Not being taken seriously as a woman in tech; people not listening to my opinions/experience/expertise until/unless it is repeated by a (white) man. (And then not getting the credit.)"*. Another frequently reported main obstacle was being assumed to not have technical skills or to have less knowledge in general. Men reported matters related to team dynamics as their largest barrier with a much lesser degree. They mostly described problems with difficult colleagues, communication issues and not feeling acknowledged or valued.

Technical and Project Issues: Barriers related to technical aspects and specific project issues were the most reported type of barrier for men (44%) and third for women (24%). Many men reported on issues related to keeping up to date in terms of used technology and needed project knowledge. On keeping up to date and workload one man commented: *"It's simply hard work to get on. Most people are doing their 40 billable hours and then another 10 of study and practice just to keep up and stay relevant. If you don't love the work, you will pretty soon try to find a management gig or something else easier. By the way, I do love the work."*. On the same point one woman reported *"[...] I didn't get any training or time to learn new tools and technologies before applying them into production level codes."*. Several men described issues with the software engineering processes or used methodologies, interactions with external stakeholders, issues related to project requirements and dealing with change within the project. On used processes and methodologies as the main obstacles in their work one man commented: *"Bureaucracy and resistance to change. Many in my organization are content to maintain current processes and software development methodologies and technologies despite some significant waste and other problems. [...]"*. Other categories that were mentioned, but with lower frequency were retaining valuable members in a project and specific aspects of code.

Biases: Biases were the second source of barriers reported by women (42%) and fourth by men (9%). Gender bias was most reported by women (28% women, 0% men), followed by ageism and seniority. With regards to gender bias a shared opinion of many women was reflected in the following responses: *"Gender inequality is the biggest obstacle I face in software industry. The day to day struggle with Gender bias is too tiring."*, *"Definitely sexism and misogyny. I hope to one day find a workplace where I'm not constantly trying to advocate for my own Gender"*, *"Sexism - men's egos and patronizing/sexist behavior are the largest barriers to success."*. Similarly as in the unfair treatment question (Q21), ageism was reported in cases were the respondent was or appeared young. Several women respondents included more than one bias in their descriptions of their

main obstacles, with one of them frequently being sexism. For example, one woman, reporting on gender, age and cultural bias wrote: *"The biggest challenge is to overcome the initial prejudice some people have when they meet me in a professional setting, as I am a female immigrant who looks very young. Usually, people assume I am in an entry-level position, and it takes them time to acknowledge my capabilities."*. Similarly, gender bias was often intertwined with barriers belonging to other categories. For example, on gender bias, leadership and work-life balance one woman answered: *"That engineering leadership positions and responsibilities have been designed for men over time. In other words, alpha, workaholic breadwinners with a homemaker to take care of the rest of life's responsibilities at home. And it's so ingrained that we don't even question when being an alpha workaholic is necessary or valuable to the job. Instead we ask everyone to try to be more alpha (take up space! be assertive! make decisions quickly!) and more workaholic (inbox zero! wake up at 5am and read management books!) just to match this preconceived notion that that is the only kind of leader that is valuable. If I don't want to be that kind of leader, it's hard to find a company willing to accept a different kind of leader."*. Figure 6 shows the most frequent barriers co-occurring with gender bias as experienced by women.

Men on the other hand reported most frequently on ageism and on language issues (i.e., being perceived as not fluent enough because of not being a native speaker). Racism and general favoritism were reported as barriers by women and men, albeit in lower frequency.

Management: 23% of the men respondents reported management, the lack of good leadership and politics as their major work barriers. In comparison 6% of the women reported on the same issues as their major obstacle. Having managers without the necessary knowledge for the role was a common concern among men and women. In this respect one man respondent wrote: *"Ignorance of ignorance. In a hierarchical organisation the manager is expected to know more than his team. In reality this is pretty rare in software development but some managers are unaware of that reality. "*

Personal Skills: Personal skills were reported with a fair frequency as a major barrier among both women (15%) and men (8.5%). Imposter syndrome was commonly mentioned among women, albeit barely mentioned among the men. Other personal skills that were mentioned by women and men as barriers were own high expectations, anxiety and communication skills. On overcoming impostor syndrome as their main obstacle one man commented: *"Finding the confidence to consider myself an expert. I'm super-privileged and super passionate about software engineering. Therefor[e] I'm in the fortunate position that the biggest obstacles I face are the ones I put*

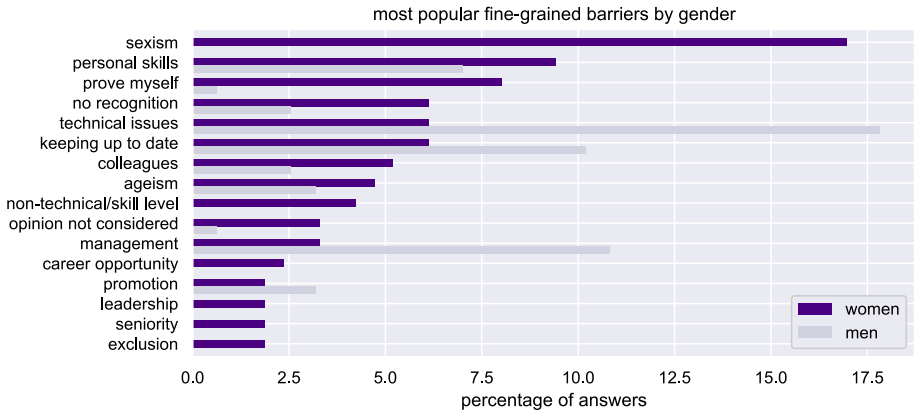

Fig. 5 Most popular fine-grained barriers (Q22)

on myself, overcoming my impostor syndrome is a continuing struggle, but peanuts when compared to what others face."

Professional Growth and Development: Issues related to professional growth and development were mentioned with the same frequency by women and men (8%) as major obstacles. Common matters in this category were problems with the lack of career opportunities, not being involved in interesting tasks at work, lack of mentors and issues related to having non-traditional educational backgrounds. With respect to the lack of formal educational background as their main obstacle one man reported: *"When applying to new jobs I faced problems because my field of study was not computer science, but liberal arts and the prospective employer feared that I would not have enough knowledge, although my previous work showed practical experience."*. On the lack of career opportunities as their main obstacle, one woman commented: *"[It is] Difficult to get positions reflecting skill and experience. "*.

Workload and Work-Life Balance: Barriers related to a high workload and the absence of a work-life balance were reported by both women (4%) and men (8%). While women reported problems related to parenthood as one of their largest barriers, no men did the same. On a work-life balance as their main obstacle one man expressed: *"work life balance: peak workload around major releases or big escalations"*.

Reward: Barriers related to reward were not commonly mentioned by either women (4%) or men (7%) as their largest obstacle. The most common issues reported in this category were related to promotion. On this latter point being a major obstacle one man said: *"True career op[p]ortunities, apart from common promises."*

Non-binary respondents reported primarily that their main barriers were due to technical and project issues (33%), personal skills (33%) and too few rewards (17%) (Fig. 5).

RQ2.4: Largest barriers The largest reported obstacles for women are related to *team dynamics* and *gender biases*, while more men described barriers that are connected to *technical and project issues*. Women in our sample experience more frequently unfair treatment in the software industry in comparison to men. These are mostly connected to *team dynamics and gender biases*, while men's were related to *reward*. There is a statistically significant difference among women and men on their perceptions of gender and challenging experiences in the software industry. We did not find any statistically significant differences for the different age groups on this point.

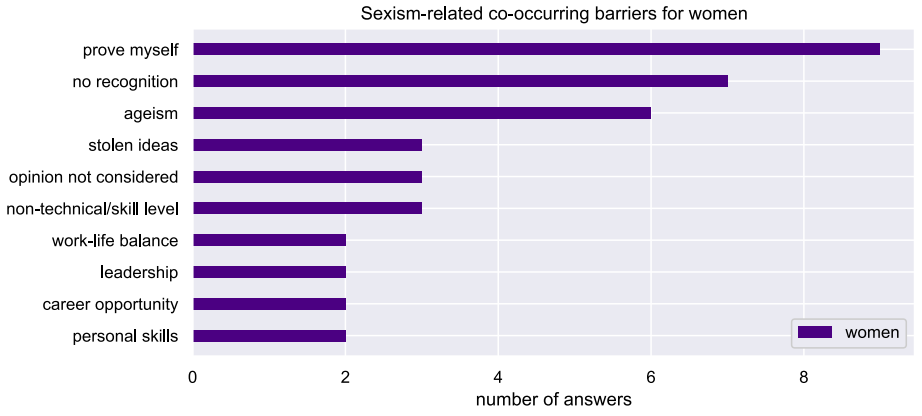

Fig. 6 Sexism-related co-occurring barriers for women

5 Discussion

Our results show several diverging experiences between women and men working in technical roles in the software industry. In 14 of the 17 closed survey questions, gender or age had a statistically significant impact on the investigated variables. In six questions gender and age had a statistically significant impact on the analysed behavior (marked with * in Sect. 4). In seven questions, only gender had a statistically significant impact on the analysed behavior (marked with * in Sect. 4). In one of the 17 questions, only the age of the respondent had a statistically significant impact on the answers (marked with * in Sect. 4).

Of the seven **micro-inequities** we investigated, women and men reported significantly different experiences on six of them. Women experienced more often than men being excluded through lack of eye contact in discussions, being skipped on questions that due to their expertise should have been asked to them, having someone else present an idea of theirs without proper attribution, being assigned menial tasks, being told they are bossy or aggressive, and being excluded from social or networking opportunities at the workplace. These results are consistent with previous work that surveyed women in high-level positions in tech and found that micro-inequities were prevalent in the field (Vassallo et al. 2016). This is also in line with other discrimination behaviors found in previous research experienced by women such as a lower acceptance rate, longer waiting time for the initial feedback or for completing code reviews (Bosu and Sultana 2019).

The only investigated micro-inequity in which women and men reported similar experiences was interruptions, a common occurrence among both genders. This result is consistent with previous work that found that neither gender interrupts or is interrupted in meetings more than the other (James and Clarke 1993). When looking at the impact of the age differences, it is noticeable that respondents in the age group 26-35 report less often experiences of being assigned menial tasks. Additionally, older respondents reported being told they are bossy or aggressive, and being excluded from social or networking opportunities at the workplace more often.

Micro-inequities can cause feelings of discouragement and impair performance in the workplace (Young 2016) and are usually caused by unconscious biases (Ashcraft and Blithe 2010). It is, therefore, vital to create more consciousness in the community about the commonality of their occurrence.

Almost as many women as men are responsible for **managing or leading others**. Although we did not investigate if these responsibilities are reflected in their job titles and pay, this is an encouraging result, especially if we consider that previous research (Lutter 2015), found that women's failure hazard increases if they operate in teams with a higher proportion of men at the managerial level. However, we also found that women perceive that they have the support and authority to make the necessary decisions in a significant lesser degree than men. **Team recognition** was the third most reported major barrier by women (Q22). This latter result is interesting—when directly asked (Q18) most women and all non-binaries reported that their contributions were valued. The contradiction between answers could be due to desirability bias or misinterpretation issues when responding to Q18, more in depth qualitative work is needed to understand the issue. Previous work also found that women report experiencing less recognition than men (Bryson et al. 2014).

Women are more frequently targets of **sexism and harassment** than men. A significant larger proportion of women have experienced or witnessed harassment while working in the software industry, 43.5%. In comparison, half of the men have never experienced or witnessed harassment. These figures resemble those found by a previous study investigating harassment

in tech startups (Women Who Tech 2017). More than half of the women respondents, 57%, have experienced sexism in the software industry, versus 14% of the men. Almost half of the men respondents have not experienced or witnessed sexism, indicating that many men software professionals might be unaware or untrained to recognize sexism at the workplace. The widespread sexism reported by women in our study confirms the results of previous studies analyzing the overall environment in ICT (Vassallo et al. 2016; Ashcraft et al. 2016) and in open source projects (Lee and Carver 2019; Nafus 2012). As found in questions Q21 and Q22 sexism is a main source of unfair treatment and a significant barrier for women pursuing a technical career in the software industry. Our numbers exceed those of another study (Trinkenreich et al. 2022) that surveyed women in a global technology company. They found that 22% of the respondents had experienced sexism in the field. This disparity could stem from the fact that they surveyed women from one specific company, possibly reflecting the experiences of a more homogeneous population.

Overall, most respondents from both genders were satisfied with the **growth opportunities and pay** in the software industry. However, men in general think that there are more growth opportunities than women in this field. This is inline with reports of women that feel that the ICT field is more challenging for them (Kenny and Donnelly 2020). Previous work that surveyed women in a global technology company found that hitting the glass ceiling was the second most reported reason for leaving (Trinkenreich et al. 2022), women especially had to deal with sparse growth opportunities and unequal salaries. These issues were not the most pressing for our respondents. Interestingly, respondents in the age group 36-45 think that there are not as many growth opportunities than the reference age group (18-25). This could be related to the fact that the software industry expects more performance from younger people and that older people are more frequently seen as not suitable for a software-related job (Comeau and Kemp 2007; Schloegel et al. 2018).

With regards to pay, women were more negative than men. However, the differences between both genders were not statistically significant. Previous studies found that there is a significant pay gap between women and men working in the software industry (Kamamoto 2013; Glassdoor Team 2014). However, in our work we did not measure the exact difference in pay (and its association with other relevant measures, i.e., seniority and company tenure), but the overall satisfaction that both genders have with their salaries. In general, women were less satisfied with their jobs in the industry than men and less women than men would choose the field if given the opportunity to start over. This result is inline with another survey that found that women working in the ICT industry in technical roles generally report lower career satisfaction than men (Glassdoor Team 2014) and that more women in the STEM field leave their job compared to other fields (Glass et al. 2013).

The large disparity between the *nature* of the **major barriers** by women and men highlights that unconscious biases are prevalent in the software industry. The largest obstacles reported by women were mostly related to team dynamics—such as, having to prove themselves and not being acknowledged or recognized—and gender bias; while men reported mostly on barriers related to technical and project issues. A significant larger proportion of women reported having experienced unfair treatment in the software industry. Similar to the identified major barriers, there is a large disparity in the nature of unfair treatments reported by both genders. For women, the most common sources of unfair treatment were related to team dynamics and gender bias, while men's were related to reward. It is not surprising that there is an overlap in the issues reported as unfair treatment and major barriers; when unmitigated unfair treatments become growth and career barriers. Issues related to pay were mentioned in similar numbers by both genders. However, while the gender pay inequality was remarked by several women, none of the men mentioned it. This example highlights the

disparity between experiences from both genders. Even when the issue is reported to be the same (pay), women perceive this as a result of gender bias, while men may blame hierarchical structure or nepotism. Women and non-binary respondents agreed to the statement that it is more challenging for people identifying to certain genders more often than men, emphasizing the results of the open questions and previous research (Kenny and Donnelly 2020).

The general consensus regarding the experienced micro-inequities and barriers among non-binary respondents is mixed, which makes it difficult to draw conclusions. Accordingly, further studies in this context are needed with a higher rate of responses from this group.

There is large interest in the software community on the topics surveyed in this study. In total 57% of our participants answered that they would like to be informed of the results of our study or are willing to be contacted for additional inquiries related to their responses.

6 Call for Action

Our results reflect that **unconscious biases** are widespread in the field and that **systemic biases** are also present. To **solve these problems**, individual and organizational actions are needed (Ashcraft and Blithe 2010).

Unconscious biases cause micro-inequities and many of the issues related to deficient team dynamics reported in our study, such as having to prove oneself, opinions not being considered, not being assigned technical tasks despite being in a technical role and not feeling valued or acknowledged. It is important that organizations foster a culture in which unconscious bias are discussed more openly, so individuals from majority and underrepresented groups can reflect, identify and take action to challenge preconceived notions.

Besides gender, respondents described biases related to age, race, cultural background, language and seniority as major barriers and sources of unfair treatment. These biases were reported in much lower numbers than gender bias. However, we believe that they unveil a much larger problem in the industry. For some biases, their relative low numbers could be a reflection of the under-representation of some groups in our sample—and in the whole field—or it could also be due to the fact that we asked participants to report on only one major barrier and not multiple. One possibility for addressing biases is by ensuring that diversity is considered throughout the hiring process. This includes engaging more diverse interview teams during the hiring process of technical teams (Ashcraft et al. 2016).

To increase awareness about the experiences of underrepresented groups, compilations of reports related to barriers or unfair treatments, such as the one presented in this study are needed. This information should not only remain in scientific publications but efforts should be made to reach software professionals from majority groups.

Several of the situations reported by women were related to being consistently assigned non-technical tasks despite officially having a technical role. Software engineering research and organizations should analyze the nature of the tasks (e.g., core technical, support technical, support & non-technical, leadership) that are assigned to underrepresented groups, to detect patterns and potential biases in their assignment. With such measures, companies could, for example, track in which roles underrepresented groups are already working to adjust their efforts for employee development (Ashcraft et al. 2016).

Finally, many of the unfair treatment situations that were narrated by our respondents took place during meetings or informal discussions. Fostering a culture in which all members can equally contribute is vital to advance the field and to allow for the individuals working in it to develop their full potential.

7 Threats to Validity

Internal Validity: One of the largest threats in our study is the self-selection bias. Gender bias in the software industry can be a controversial topic and people with strong opinions could be more likely to reply, skewing the results. We addressed this threat by using a "neutral" title ("Team Dynamics and Challenges in the Software Industry") and description during the distribution of the survey.

Another threat is the actual professional role of our participants. Although we tried to carefully select the respondents by distributing the questionnaire in development communities from Facebook, LinkedIn and Reddit, and by filtering out answers from respondents that self-reported not being software professionals, we did not validate whether the respondents are really working as software professionals. Since our respondents received no economic incentives for answering our survey, we believe there was little to no motivation to lie on this topic. However, while we assume that there are few or none of these cases in our data, this is a threat to validity in our study.

Another internal threat of our study is the order in which our questions appeared. We did not have an explicit strategy for this when designing the questionnaire. When asking participants about their largest obstacle and experienced unfair treatments, participants had already answered all questions related to micro-inequities, as well as leadership and recognition; questions about harassment and sexism, and growth opportunities and pay were still pending. While participants could go back and modify their answers after seeing all questions, the initial order of the survey could have biased some of our participants. To reduce further biases participants could face throughout our survey, we formulated the questions in a gender-neutral language. An anthropologist with a background on gender studies reviewed the survey questions on this matter.

We made all questions in our survey mandatory to increase the amount of complete answers we got. This potentially reduced the number of answers we got, which we acknowledge as a thread to validity.

Several of our questions are subject to recall-bias, as participants could remember experiences in different manner than they actually were. This is a stronger threat for questions 19 and 20 in which participants were expected to recall the number of occasions in which specific micro-inequities occurred. Our micro-inequities questions also have a limitation when analyzing its results and the effect of age, as participants could report on experiences that happened to them in the past when they were younger, and not necessarily when they were of similar age as in the present. A further threat in our study is that we could have misinterpreted the answers for the open-ended questions. To reduce this threat, two authors independently coded all answers and followed with a discrepancy reconciliation procedure.

Our sample consists of 359 responses from participants. This is a drawback in regards to the accuracy of the statistical analysis. We mitigated this by only selecting two independent variables instead of all collected variables.

Construct Validity: It is possible that additional variables also have an influence in the studied perceptions and experiences of our participants, such as country of residence, age, role or seniority. We only partly considered these variables and future work should study their influence more extensively.

Respondents might have interpreted the questions differently than intended, which could prompt misleading results. We addressed this threat by running a pilot study and discussing with pilot participants possible misunderstandings.

A limitation of our closed-ended question analysis is that not all of the dependent variables met the proportional odds assumption. This limitation makes it difficult to draw general conclusions on our findings for these variables. Therefore, future studies should validate our results.

External Validity: A drawback of our research is its exclusive focus on women and men, whereas to get a clearer picture of gender bias in the industry, it is important to include non-binary genders as well. We did not statistically analyze the answers from the non-binary respondents due to the low amount of answers we received from this group. However, we report their responses in numbers to all questions in our survey. Nevertheless, we cannot draw definite conclusions from this raw data. To further increase their response rates in further studies, the group should be considered when performing purposive sampling.

We obtained 359 responses from participants. It was not feasible to compute the response rate because we advertised the survey through social media and personal and professional networks. We also cannot claim that our participants are representative of the whole software engineering industry; further studies should analyze if the results generalize in larger and more geographically-diverse populations.

8 Conclusions

We report on the results of a survey that analyzed the experiences of 359 women and men software professionals in technical roles with respect to micro-inequities, leadership and recognition, harassment and sexism, growth opportunities and pay, as well as the main barriers they encounter when working in the field. We found that the experiences of women and men in different age groups in most of the studied topics differ with statistical significance. In particular, we found that women report experiencing micro-inequities significantly more often than men, and that they witness and experience harassment and sexism when working in the software industry significantly more often. Moreover, our results show that while they are responsible for managing and leading others in similar proportions, significantly more women perceive to have less support and authority to make the necessary decisions in their work, are less satisfied with their pay and feel less valued and recognized in their teams. We also found that the main barriers reported by women are related to team dynamics and biases, while those of men are related to technical and project issues.

In our work, we analyzed age as a confounding factor. In this respect, we found that respondents in the 26-35 age group are less likely to experience the appropriation of their ideas by colleagues and given menial tasks, when compared to their younger peers. In addition, older respondents reported being told more often that they are bossy or aggressive and being excluded from social or networking opportunities at work than the reference group (18-25).

Our results show that unconscious biases are still widespread in the field and that systemic biases are present. The results presented in this study can be used by practitioners for intake, assessment and for revising their training portfolios. Further, they can be used to create awareness in the community and to measure the distance between the current status and the goals of initiatives on gender equity.

Data Availability To encourage further analysis, we make an anonymized version of our dataset available (license CC BY 4.0), as well as the used scripts.

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Emitzá Guzmán is an assistant professor in the Software and Sustainability (S2) group at VU Amsterdam. Her research focuses on human factors in software engineering. She is especially interested in driving software engineering processes to be more inclusive. So far, she has been involved in projects on user involvement, ethics in software engineering, software design rationale and team dynamics in development teams. She uses a diverse set of quantitative and qualitative methods, and takes inspiration from different fields, e.g., software engineering, data science and sociology, for her work.

Ricarda Anna-Lena Fischer is a PhD candidate in the Software and Sustainability group at VU Amsterdam, specializing in human factors within the software process. Her research interests encompass user feedback, team dynamics towards marginalized groups in IT teams, and the impact of intersectionality on team dynamics and user feedback. Fischer has presented her work in renowned conferences. Notable publications include "Does culture matter? Impact of individualism and uncertainty avoidance on app reviews" at ICSE-SEIS (2021) and "Towards a Cross-Country Analysis of Software-Related Tweets" at REFSQ (2023). Through these publications, she investigates the various aspects of human factors in user feedback. In addition to her academic pursuits, Ricarda Anna-Lena Fischer applies her expertise as an IT specialist at the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Her multifaceted background and dedication to advancing the field of software and sustainability make her an asset in both research and practical applications.

Janey Kok graduated with a Bachelor's degree in Information Sciences from the Vrije Universiteit Amsterdam in 2020. Currently, she operates as a front-end developer and web designer, managing her own company where she undertakes diverse web design projects. In addition, Janey occasionally works as a freelancer, collaborating with other businesses to provide her expertise in front-end development and web design. With a comprehensive skill set that encompasses both design and implementation, Janey is involved in the entire process of creating exceptional websites. Her expertise lies not only in crafting visually appealing designs but also in translating them into functional and user-friendly web experiences. Janey's passion for UX design drives her to prioritize the needs and preferences of users, ensuring optimal usability. Committed to professional growth, she actively engages in continuous learning, pursuing additional courses in areas such as marketing and UX design to further enrich her knowledge and refine her skills.