Toward Awareness Creation of Common Challenges Women are Facing in Academia: A Study from a German Perspective

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Abstract. Every day, women face plenty of challenges regarding their family, taking care of the seniors, equality, and appreciation at the workplace, etc. - usually with little outside support. While these challenges are not new, the awareness level towards these challenges is still low. This research aims to create awareness towards women's difficulties by studying the challenges women in research face at German universities. We also investigate how women in research handle their challenges and whether these challenges correlate to their place of birth. We investigate how these challenges differ between the computer science community and other STEM fields. To gain data, we conducted a survey with 200 women from technical universities in Germany. The results show that parenting and family planning are the most common challenges among women in research. Many women also describe problems dealing with men. Furthermore, women in computer science solved their problems in 34% of cases, others only in 23%. Even if help from others was the most frequently described solution (29%), strategies like a workaround (27%) or changing the workplace (11%) are common. We conclude from our study, that women in research still have many problems. These problems include finding an appropriate solution to a problem.

Keywords: Inequality gap· Experiences of women in research· Women in research· Women in computer science research· Survey.

1 Introduction

Women have been in science since ancient times [13]. However, the access to knowledge has been made more difficult for them over time. In the 17th century, women were increasingly excluded from higher education and science [8].

A higher education and university degree was only possible for women of higher status and only at certain locations. With the beginning of the women's movement in the 19th century, first colleges and universities began to open their doors and positions for women. Some institutions even began to allow women to study and get doctoral degrees [3]. However, it took more than 50 years, until the first woman became an associate professor of mathematics [12]. From the beginning of the 20th century, increasingly more universities and colleges allowed women to study. Since then, the proportion of women at universities has risen enormously: The number of women with scientific degrees increases and in 2019 45% of doctoral degrees at German universities were given to women [6]. In the academic year 2021/22 about 1.5 million women studied at German universities and colleges – expected more than men [17].

However, women are globally still underrepresented in scientific careers. In India, only 27.3% of professorial positions in 2018–2019 were filled by women [2]. The statistics look the same in other countries – for example Canada with 28% women professors [2], USA with 34.3% [2], and Germany with 24.7% [18]. While these numbers already do not reflect the proportion of women of the whole population, for math and natural sciences (20.7%) as well as engineering (14.3%), the amount was even less [5].

Therefore, nowadays not the access to higher education and scientific degrees seems to hinder women, but socio-cultural aspects. Silim and Crosse [16] complain that only 7% of professional engineers in the UK are women. They state that many girls miss the opportunity of an engineering career because of its image. They explain that with the stereotype-view of Science, Technology, Engineering, and Mathematics (STEM), a poor understanding of engineering pathways and careers, and missing prerequisites of many girls in school (e.g. A-level in physics/mathematics). Falkner et al. [7], for example, describe in their work the perceptions of computer science from the outside and how these perceptions influenced the choice of women for a career in computer science research. Moreover, for both, industrial and academic careers, there are many publications concerning environmental factors preventing women from choosing them [10, 19] and recruitment and retention strategies for students [15].

Underrepresentation and gender (in-)equality in academia is still an open issue that is constantly reported and investigated [11]. Especially, for STEM fields (science, technology, engineering, and mathematics), there is a lot of work focusing on investigating these issues. This underrepresentation is often explained with prejudices, inequality, and discrimination [9]. Beside of perception and discriminations, the underrepresentation of women in academia is often described as an effect of intertwined factors [1]. Factors can have individual, biological, social, educational, or other sources.

In this paper, we focus on problems women encounter during an academic career in a holistic view regarding personal challenges as well as challenges at work. Therefore, we restrict ourselves on STEM fields and computer science. Although the challenges and inequalities are not new, their public awareness is still insufficient. We collect solutions women found for their different problems to

provide not only awareness for problems but also for their solvability. Moreover, we are interested in differences between computer science research area and other STEM fields. Therefore, we compare these groups regarding their problems and solutions.

Furthermore, we report the current situation of women in scientific careers in Germany. We study the difficulties they face at German universities and how they address their challenges (cf. RQ1 – RQ2 in section 2). Further, we investigate whether these problems are the same within the computer science (CS) community. Avolio et al. [1] conclude from their literature study that socio-cultural parameters influence women in academia in different stages of their lives. Therefore, we are also interested in cultural aspects: We study if cultural problems correlate with the country of birth (cf. RQ3 in section 2). For this purpose, we conducted an online survey with 200 women in research working at technical German universities.

Our results show that most problems are issues in the person's environment (e.g., life planning and responsibilities) and at the workplace (e.g., equality and support). Problems referring explicitly to research, such as issues with publications and appreciation, followed. Cultural circumstances (e.g., religion) make up only 14% of the problems on average. We found no correlations between cultural problems and the country of birth. However, our results provide insights into the problems and solutions of the participants based on their free-text descriptions. In the following section, we discuss our method design and data analysis of our survey in a more detailed way.

2 Survey Design

The survey's objective is to collect problems and challenges women typically face in research and how they deal with them. Since it is common to have intercultural exchanges in science, we expect different problems for people with other cultural backgrounds. Thereby, we are interested in whether cultural problems are related to the cultural background (in our case restricted to the birth country) of women.

On this basis, we derive the following research questions:

RQ1 What problems do women face in research?
RQ2 What solutions do women find for their problems?
RQ3 Do cultural problems correlate with the country of birth?

To create a suitable survey, we needed to identify problem areas and topics we wanted to cover explicitly. Therefore, we created a mind map out of different problems and sub-problems that we knew. Based on this, we clustered the problems and identified problem areas: Cultural, personal, workplace, and research. Furthermore, we refined the areas into more specific topics. The results are provided by Table 1. More detailed information about the taxonomy can be found in our repository [4]. Based on this taxonomy, the survey is structured by the four subject areas as main question groups, each containing questions corresponding to the different topics.

	Topics per area	Description/ Example
Cultural	Religion	Anything concerning religion
	Clothing	E.g., wearing a hijab
	Name Changing	E.g., when getting married
	Cultural Infrastructure	E.g., prayer rooms that are only for men
Personal	Hormones/Period	E.g., sick days caused by PMS have to be justified
	Life plan	E.g., the time to decide to have children
	Responsibilities	Additional responsibilities e.g., parenting or housekeeping
	Pregnancy	Problems that occur during pregnancy
Workplace	Equality	Equality issues in general
	Support	Insufficient support regarding equality
	Collaboration	Collaboration with men (e.g., not getting involved into discussions)
	Workplace Infrastructure	E.g., no toilets for women
Research	Idea Sharing	Limited opportunities to share ideas (e.g., not allowed to publish)
	Appreciation	Feelings of disadvantage and discrimination
	Publications	Priority of men in author sequence of publications
	Priority	Male priority over women in research

Table 1. List of subject areas with corresponding topics

For each topic, we asked sub-questions according to the following pattern: (1) Has the participant experienced the problem addressed by the topic during her research career? If the question was answered positively, we asked for an optional detailed description (2), the stage or possibly stages of her career (studying, doctoral student, after doctoral degree) at which the problem occurred (3), whether they solved it (4), and for an optional description of the solution (5). Additionally, we provided free text fields in every subject area to collect problems that we did not identify in our working session, called *others*.

Before sending out the survey, we asked an external experienced survey designer for feedback. We used the *Think Aloud* method [14], asking her to report what comes to her mind when seeing the questions. After that, we conducted a pretest [14] with four women. On account of the feedback, we restructured the question design. We also had some minor findings from the pretest, e.g., a technical issue. A replica of our questionnaire is available in our repository [4].

The survey is targeted towards women in different research positions and age groups. Since we restrict the survey to women who study, studied, or work in STEM fields in Germany, we decided to send out the survey to all 16 technical universities in Germany. We contacted the gender equality office of the university and asked them to forward our survey to appropriate mailing lists. We provide a list of our contacts in our repository [4]. Two of them were not able to share the survey in time; we did not receive any feedback from the other contacted

universities. We decided to survey by using the online survey tool *LimeSurvey*[4] and made the survey available for two weeks (from 05/21/2021 8 am until 06/04/2021 12 pm). For validity reasons, we as authors did not participate in the study.

3 Data Analysis

Our survey got answers from 220 women. We remove 79 partially answered surveys from our evaluation. In our evaluation, we want to consider only women who study, studied, or work in Germany and are currently in research. Thereby, we remove 9 data entries from our results. Finally, our validated data consists of 132 responses. The responses originate from 5 students, 61 doctoral students, 20 postdocs, 22 professors, and 46 scientific researchers. Since the question for the current position was a multiple-choice question, the sum does not correspond to the number of participants. Thereby, our study provides a good distribution across the different stages in research careers. Regarding the age, we also reached a good distribution: 51 participants were 20-30 years, 50 women were 30-40 years, while the remaining 31 women were older than 40 years. Moreover, we want to capture the differences between women in computer science and other scientific fields. Therefore, we annotated data that belongs to persons from computer science accordingly (e.g., machine learning). Thereby, we have the following basic sets: 52 women in computer science (CS) and the counter group of 80 women from other scientific fields (no computer scientists) (NCS). To answer our research questions, we divide our first and second question (RQ1, RQ2) in three sub-questions:

RQ1a & RQ2a In which area did most problems/ solutions occur?
RQ1b & RQ2b Which topics have most problems/ solutions?
RQ1c & RQ2c What are the most frequently described problems/ solutions?

3.1 RQ1a & RQ2a: Areas of Problems and Solutions

To answer the first two refined research questions, we use the mandatory responses of the questionnaire. Therefore, the raw data is based on marks, whether the subject had a problem in the area/ topic, and whether the subject solved it.

Figure 1 provides an overview of the problem frequency in the areas (RQ1a, RQ2a). Most women in computer science research (CS) located their problems in the personal area (32.3%) and regarding their workplace (30.9%). Research problems have a share of 23.3% of the problems. Cultural issues are only the case in 13.5%. Regarding the counter group (NCS), the proportion of problems in the personal area are 35.1% and thus higher compared to the CS group. However, the work area occurred 6 percentage points less than for women in computer science. Research (25.2%) and cultural issues (14.8%) were similarly frequent compared to the CS group.

[4] https://www.limesurvey.org/

In total, women in computer science solved about 34% of their problems, while the counter group only solved about 23%. Both groups have most of their solved problems located in the personal area. However, the CS group solved more cultural, work, and personal problems, while the amount of solved research problems is almost equal.

Figure 1 shows that women have too many unsolved problems in several areas. However, problems concerning research are only at the second last rank.

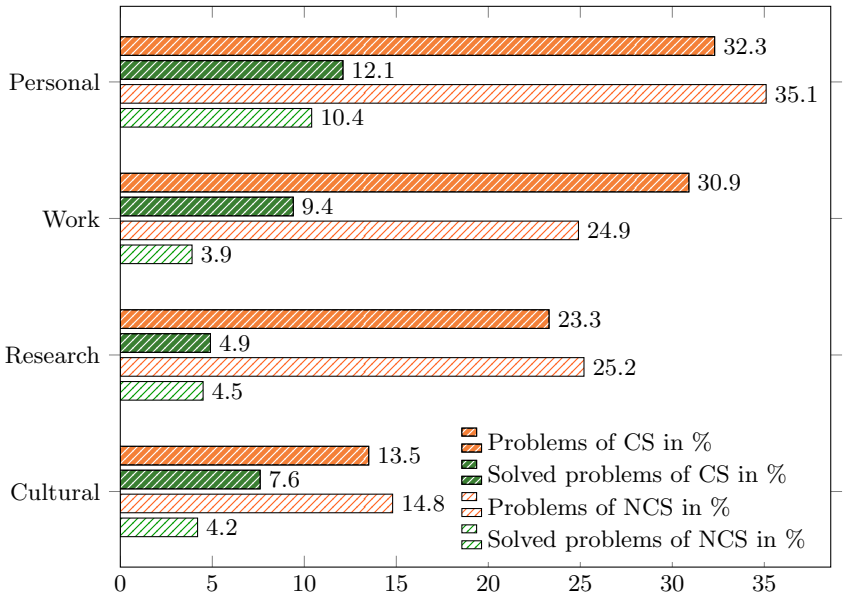

Fig. 1. The most occurred problem topics in % for the answers of both groups: women in computer science research (CS) (n = 223) and women from other scientific fields (no computer scientists) (NCS) (n = 345). Moreover, the distribution of solved problems over the topics is presented.

3.2 RQ1b & RQ1c: Topics of Problems and Solutions

Figure 2 presents a more detailed look and enables the analysis of the problem and solution frequencies between topics (RQ1b, RQ2b). The most problems of computer scientists are in the topics life plan and equality. Life planning seems to be a general problem, while equality problems are more common for computer scientists. While they also have more problems in collaborations, support, and the cultural others section, they have fewer problems in responsibilities, appreciation, and publications.

The amount of solutions for specific topics also differs greatly for some topics. In the case of collaborations, the CS group has 3.1 percentage points more solu-

tions than the NCS group, while they only have 2.3 percentage points difference regarding the problems.

The results presented in the graph seem to indicate that there are already some good solutions for some topics (e.g., for collaborations in the CS group). However, there are overall much more open problems than solved ones.

3.3 RQ1c & RQ2c: Labeling Process

To answer RQ1c and RQ2c, we need to quantify the optionally described problems and solutions. Therefore, we labeled them. Since the descriptions were arbitrary, we had to do the labeling in an exploratory way. We decided to do the labeling per area in pairs to ensure high objectivity and consistency in each area. The pairs read the descriptions and gave them labels. We concurrently tracked the labels and their explanations in a joint table. If in any case, no existing label was fitting, they could introduce new labels. Finally, a third person reviewed the classification and discussed disagreements with the pair. It was possible to assign multiple labels to one description.

In nine cases, descriptions referred to previously given answers. In these cases, we inserted the label from the last suitable description. In total, the 193 described problems lead to 37 different problem labels. We ended up with 268 labels as each description can have multiple labels. Only 81 descriptions for solutions were submitted. We derived 8 labels from these. Finally, we assigned 100 labels to solutions. 27 of these were labeled as no real solutions. For example: "Took more painkillers than before and continued going to work with cramps and migraines". Others were described or labeled too unspecific. Moreover, we have one label (giving up) that occurs only one time. Finally, our base set contains 63 labels. The complete list of labels is found in our repository [4].

3.4 RQ1c & RQ2c: Described Problems and Solutions

Finally, we focus on the specific problems that women face in research (RQ1c, RQ2c). At the beginning of Section 3 we described that we assigned 268 labels to the described problems. This set includes labels referring to problems that are not exclusively related to women. Examples are equipment that is difficult to use for short people or missing children during travels. Thus, after filtering them, we derive a basic set for the following analysis containing 235 labels. The labels of the ten most often described problems are listed and explained in Table 2, the most often described solutions are labeled as in Table 3.

The most described problems are parenting and family planning (see Figure 3). Regarding family planning, short-time contracts, and the resulting job insecurity are criticized the most. The participants write: "Family planning is complicated as there is so little job security. Taking parental leave might also be not that good for one's scientific career."; "I could not easily plan for my life because of the short contracts. It is really hard to balance work, studying[.] I search for longer contracts to support my family financially". Even during parental leave or the children's aging, the pressure in science does not seem to

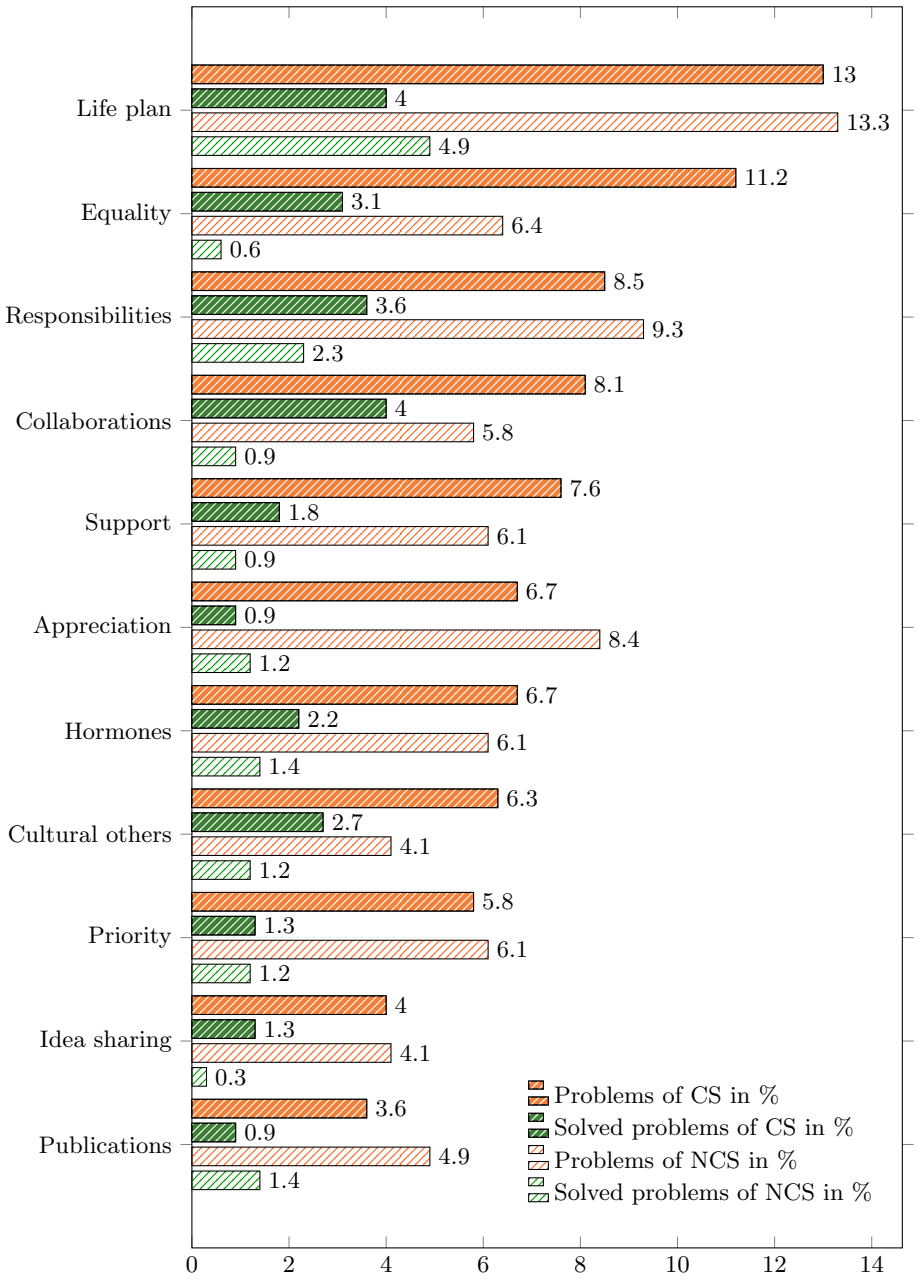

Fig. 2. The most occurred problem topics and the proportion of solved problems in it in % for the answers of both groups: women in computer science research (CS) (n = 223) and women from other scientific fields (no computer scientists) (NCS) (n = 345).

Problem label	Description
Parenting	Parenting issues (e.g., having less time because of children, not easy to move with children (as required as a researcher), doing housekeeping)
Family planning	Issues related to family planning
Male communication	Men communicate different than women: disrespectful comments and offensive behavior; language that is men-oriented; offensive behavior, insults, sexist comments and behavior, physical, or verbal harassment
Undermining	An intentional process where men move themselves in the foreground (e.g., women are not accepted as first author or the wishes of women are intentionally ignored or being talked over)
Men promote men	Men promote men and ignore women, male networks
PMS	Physical problems during or before period
Equipment	Equipment is not suitable for women (e.g., too high) or they do not get appropriate equipment (e.g., only computer with small disk space).
Self confidence	Women have problems to be confident like men, problems during discussions or sharing their ideas etc.; afraid to discuss some topics
Expertise perception	The external perception of the person's expertise/competence
Visibility	Unintentional not seeing of women in research. Examples for visibility: Men are talking to men on conferences, or are more probably invited to talks/ debates. Since people often cite more familiar authors women become invisible.

Table 2. Labels of the ten most described problems

Solution label	Description
No solution	Ignoring the problem
Help by others	Use help from others e.g., mentors/ initiatives (esp.) for women/ women networks/ ask someone for help/ ...
Workaround	Creation of a workaround for the problem (e.g., schedule separate meetings)
Strengthen self-esteem	Focus on yourself, Strengthen your self-confidence, be confident of your own results and abilities, being straight forward, communicate directly
Change workplace	Change of position or workplace
Sit out	Waiting for the end of the problematic (time) period, or try to ignore it for a periodic time
Good daycare	Have a well-organized daycare
Help others	Help others with the same problem
Be role model	Be a role model for other women and/ or demonstrate equality

Table 3. Labels of the most described solutions

decrease: “As a single mother, my colleagues considered my time with my child equivalent to their hobbies. [...] They expected me to ”organize away” my child, but I wanted to have some hours per day with my child”. These expectations seem to have a great impact on the future of young scientists: “due to familiy [sic] reasons, I gave up a professorship within the trial period, and thus could not keep the title”. In general, both problems are described as time constraints that are often incompatible with work in research. This matches the results of our topics, where the life plan and responsibilities topics occurred most frequently and are therefore the most common problems of women in research.

In third and fourth place, male communication, undermining, and promotion problems are described. Male communication is sometimes related to sexist wordings or a very dominant behavior of men in discussions, talks, and lectures. For example, a participant writes: “With some men, esp. in my own lab, I find it sometimes hard to collaborate since their style of communication appears to be rather egocentric than collaborative” - another: “Then because men always speak more in public events and are less inclusive than women”. However, this kind of communication does not seem to be the only obstacle. Regarding her fertility treatment, relief from stress, and traveling, a woman writes: “We are always afraid of speaking about this things [sic]. More flexibility and support will help. On the other hand, the topic is never spoken directly”. Therefore, the problem seems to be not only the dominance of men in discussions but also the openness and trust.

The latter seems to be disproved regarding the comments of the undermining issues. In contrast to male communication, undermining was labeled, if women had the impression that men performed intentionally against them. An example is: “Responsibilities were taken away during/after maternity leave without discussion or warning. After making the choice to reduce working hours (to 80%!!!) my own project was taken away”. Frighteningly, such impressions are not that rare as we would wish.

Promotion issues occurred in 5.96% of the labels. Here, women noted that relations between different sexes are less used in networking (e.g., for an invitation to talks or conferences): “Wheras [sic] men are supportet [sic] and invited, for example to publish with the boss and getting great recommendation letters for applying to professorships my female colleagues and I are doing the ground work, teaching for example but that doesn’ [sic] count it is expected of women that they pick up the slack that some men don’t like to do. The old buddy network is well alive and younger cohorts of male scientists are socialized into the old paradigm.”

Other often mentioned problems (over 3.5%) are regarding PMS, the equipment at the workplace, self-confidence, the perception of the expertise, and the visibility of women. PMS is often described as a problem regarding concentration, pressure, and well-being. Regarding equipment, a woman describes that she uses the toilet for disabled people because the women toilets are not equipped well enough. In general, some women have issues regarding communication. For example: “Some male researchers [...] are just more confident in ‘selling’ their

work and thus get more appreciation, whereas [...] we are more critical about our own work". However, the perception of the expertise does not seem to be a confidence issue only: "I am not even seen as part of the project, although I was the key initiator. [...] I was just that one woman on the team". These topics are similar to the general visibility of women in science. A woman describes her view: "Men know men, they cite men, the propose men for awards, they chose men for their team, the mentor men, they write better letters of recommendations for men."

Other labels applied to less than 3% of the described problems.

Since the amount of described problems and solutions is too small to conclude how problems were solved, we decided to provide such an overview just for the three most frequent problems: Parenting, family planning, and male communication. Regarding parenting, 75% of the described solutions were classified as no real solution. For example: "I did not solve the problem, [...] found a permanent position after 12 years". The remaining 25% suggest a good daycare. Family planning solutions were also classified as no solutions by 66%, for example by hoping for a better moment to get children. The remaining solutions are split over workarounds, good daycares, and workplace changes. Only 50% of the solutions for the communication with men were classified as valid solutions. To strengthen the self-esteem for conversations takes 10% of the suggested solutions.

However, to get an overview of the most frequent solutions in general, we rank them by their frequency. Figure 4 shows that the described solutions depend in 28.57% on the help of others. Some women received help by talking privately to their boss, while others rely on initiatives: "Initiative of university to prefer hiring females/members of underrepresented or minority groups in case of equal qualification". Since communication and trust in men were often criticized, we also want to highlight a positive example for a solution: "In the years as professor [sic] it was more difficult as I was now competing [...]. But there were also two male mentors who helped". Frighteningly, workarounds are in the second place (26.98%) since they often lead to more effort and thus stress and time issues. For example, a woman describes that she schedules extra meetings with only some partners to avoid communication issues. The fourth place, the change of the workplace, is mostly not described since it is self-explaining. 6.35% of the described solutions are women who sit the problem out. One had problems regarding her publications and described her solution as: "I had to wait 4 years to publish my work. - but i [sic] did in the end, because i [sic] did not give up". The least labeled solutions were to find good daycare, to help others (for example when establishing rules), and to be a role model.

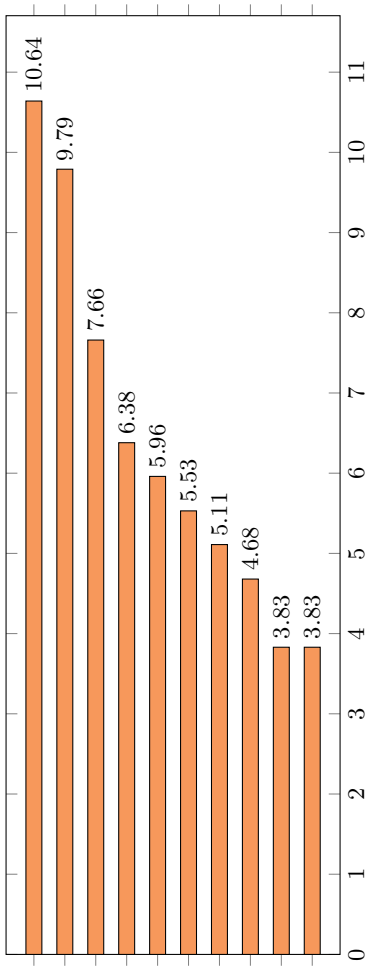

Fig. 3. Labels of described problems for both groups in % (n=235).

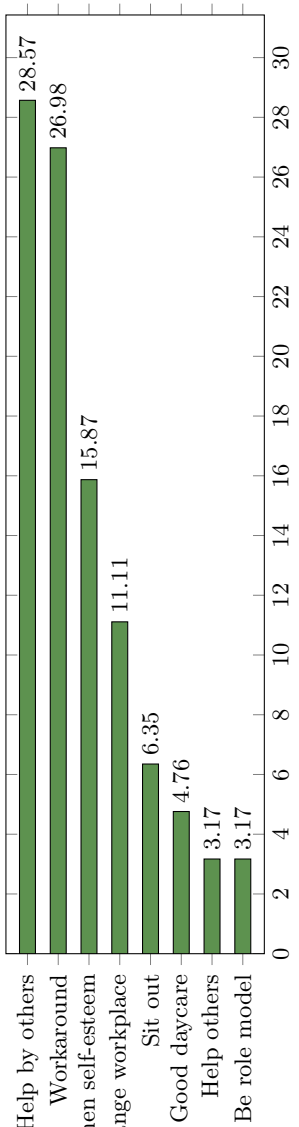

Fig. 4. Labels of described solutions for both groups in % (n=63).

3.5 RQ3: Cultural Influences

RQ3 faces the intercultural problems of women. To find a correlation between cultural problems and the country of birth, we use a chi-square test with a significance level of 0.05. Again, we divide the third research question into several hypotheses:

$H3_{0a}$ The occurrence of cultural problems is independent of the country of birth.
$H3_{0b}$ Cultural problems do not depend on whether a woman was born in Germany.
$H3_{0c}$ Cultural problems do not depend on the difference of the place of study or work and the country the participants were born in.

Both groups are not significant for $H3_{0a}$ (CS p=0.31, NCS p=0.18) and $H3_{0b}$ (CS p=0.27, NCS p=0.23). Thus, we cannot falsify the null hypothesis, but it can be seen as an indicator: Women in computer science research tend to face less cultural problems than in other scientific fields/disciplines. The results for the last hypothesis $H3_{0c}$ (CS p=0.73, NCS p=0.72) are also not significant.

4 Threats to Validity

Threats to internal validity: Threats to internal validity are threats regarding the collected data. In our questionnaire, we tried to cover all problematic areas for women in research. Nevertheless, to miss some of them is a threat to our internal validity. Therefore, we established our taxonomy of areas and topics in a group meeting with seven women in total. However, some topics are not fully disjoint (e.g., pregnancy and hormones) and could have brought some bias in our data. The next problem concerning internal validity is that the association of a problem to a topic or area depends on the subject. Thereby, it could have happened that problems were not described because the participants forgot it or did not find a suitable topic. We counteracted these problems with the "others" topic in each area.

Threats to external validity: Threats to external validity are threats regarding the generalization of the results. An issue regarding the external validity could be, that we conducted only technical universities. Moreover, we have 15 participants from social sciences and one who did not mention her scientific field included in the NCS group. Thereby, the NCS group may not be comparable to women in STEM fields. Moreover, our groups are not the same size. Furthermore, the problem and solution descriptions were optional. Thus, the generalization of our results based on the descriptions and labels can only be used as indicators. The reproducibility is mostly affected by the labeling process. To get a result as objective as possible, we conducted the labeling of each subject area in groups. If in any case, no existing label was fitting, groups could introduce new labels. These new labels were collected in a shared document including the name and description of the label. In this process, new labels could only be used after they were introduced, a relabeling was not done. The impact of this should be small: New labels were only introduced when existing ones did not fit, therefore, the previous labeling should not be affected as there already were fitting labels.

Reproducibility To enable replication of the study, we are making all of our data available. The questionnaire as well as our scripts and evaluation files can be found in our repository [4].

5 Conclusion

In this work, we report the current situation in Germany for women in research. We implemented a questionnaire and passed it to women at German universities. Our results contain data of 132 participants that we divide into two groups: Computer scientists (52) and others (80).

The average number of problems per person is almost equal between both groups. The distribution of problems across the given areas is alike. However, CS researchers solved 34% of their problems, while NCS only solved about 23%. Moreover, we found that the most important topics for problems are mostly identical for both groups. However, there are slight differences between both groups: 11.2% of problems of CS regard equality issues while this is the case for only 6.4% of problems of NCS. For collaborations as well as regarding support in research computer scientists have more problems, too. Nevertheless, they have fewer problems regarding their appreciation or publications. The most described problems in all areas are focused on parenting and family plans. These are followed by social aspects like communication with men or problems in networking. The most common solutions are to accept help from others, to make a workaround, or to strengthen self-esteem.

We could not find any evidence that cultural problems correlate with the birth country or the study/ workplace history of women in research in both groups.

Future work should investigate whether the described problems and solutions can be applied in general. Additionally, it could be interesting to collect solution ideas from women in research and provide an overview about possible solutions that could be an improvement to the current state. To find out why women chose a solution could help to provide support to women in research.

Acknowledgment

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