NO INDUSTRY ENTRY FOR GIRLS – IS COMPUTER SCIENCE A BOY'S CLUB?

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ABSTRACT

The Computer Science (CS) industry stands out as male-dominated. On top of that, many companies struggle to retain women that dedicated themselves to enter careers in CS as they manage to do so. While initiatives to achieve gender parity within CS might be considered utopian, any form of discrimination against any gender in the industry is highly pernicious. Therefore, organizations employ official and unofficial measures to counter bias. The paper introduces a multi-country survey among scholars and IT/CS professionals. The survey explores how common and impactful are the issues revealed by the pilot study as well as highlights what has been done so far to encourage women and girls to join and/or stay in STEM. Based on that, change agents and organizational best practices are elaborated. The current paper covers and discusses the results of the first stage of the study.

KEYWORDS: Computer Science; Gender Inequality; Job Retention; Organizational Practices.

1. INTRODUCTION

There is a wide consensus that skills directly related to Computer Science (CS) – such as problem solving, design and evaluation of complex systems as well as human behaviour understanding – enable constructing meaningful artefacts using computers and are of critical importance in 21st century (Giannakos et al., 2017). Even though women actively took part in information technology evolution, still relatively few of them are pursuing their professional careers in Engineering industry. The lack of consistence in terminology used by research teams investigating the phenomena (IT-related contributions often address similar research settings as Computer Science, Computing or Systems) results in a number of studies with data that slightly vary. Similar variances have been observed among developed economies – data coming from Northern America sources are to some extent different than those coming from the European ones. For instance, according to Graf, Fry & Frunk (2018), only 14% of Engineering workers are women, and CS industry is underrepresented (25%) as well; at the same time, there was only 2% increase in Engineering jobs within the 27 years timespan (between 1990 and 2017) – whereas 7% drop in numbers in Computing. To provide a basis for comparison, throughout the same period the share of women in other fields (such as health-related, life sciences and even the other STEM areas – such as physics and maths) has increased. Homogenous data, also coming from the Northern America market, is provided by Ehrlinger et al. (2018). On top of that,

Gorbacheva et al. (2019) make an observation that women constitute only 16.7% of employed IT specialists, even though overall 47% of them are active on the job market. Those claims are based, among others, on data provided by the Eurostat.

Moreover, diverse research also reveals that there is (1) a difference in the retention of women and men in the field of their study upon successfully completing their major in Computing/Engineering fields; (2) gender salary gap remains in place – just to mention research by Craigie & Dasgupta (2017) as well as Stephan & Levin (2005). The mechanics behind women effectively disappearing from some fields that can be considered 'geekier' is still an open issue, and one of a vital importance for business organizations and faculty. Therefore, the authors followed the research goal of identifying the hindrances leading to women underrepresentation within Computer Science industry and elaborating a set of best practices how to overcome some of the common problems and work together on evening up the numbers in computing to make it more diverse and inclusive.

After the introduction, we address a number of related studies and contributions that scrutinize the overall mechanics as well as the succeeding escalation phases of female underrepresentation within CS in section 2. Research questions are motivated and introduced in section 3, whereas the research approach adopted is recapitulated in section 4. Then, preliminary results of the study are presented and discussed in section 5, followed by a brief summary of on-going work and conclusions.

2. LITERATURE REVIEW

2.1. Faint flow into the pipeline

The reasons behind gender disparity within CS were approached in previous research from several angles. To visualize the phenomenon, the notion of STEM pipeline that experiences severe leaks throughout women education, up to their graduation, was forged. Indeed, it is pointless to dispute some of the indicators. Gordon (2016) maintains that CS in fact has no issues with potential suitors – yet males dominate individual cohorts at later stages of education with shares that exceed 80%. The phenomenon spreads worldwide. As reported by Galpin (2002), participation of women in Computing courses at undergraduate level highly varies throughout countries, with a bulk of results between 10% and 40%. That being said, unless one is keen on extending the beginning of the pipeline to as early stages of individual's education that a potential future graduate in practice has no actual say regarding educational choices – and many analyses do just that – flow into the pipeline itself is a major factor. This flow is faint at best. Cheryan, Master & Meltzoff (2015) argue that even should the most abstract scenario of retaining each and every woman who committed to majoring in CS or Engineering upon entering college came into fruition, sheer number of men who travelled the same path would cover their own leaks with a surplus.

Among the factors that contribute to this faint ingress flow, stereotypes regarding professional careers in CS combined with perception of absolute/relative gender strengths certainly deserve further exploration. Cheryan et al. (2009) offer a reasonable analogy in that regard: just as people who are not outdoor enthusiasts may find a city full of outdoor gear stores and cars with ski racks attached unappealing, women may find masculine stereotype-lined path counterproductive. Both solutions and inspirations for further research resulted from previous studies regarding CS stereotypes issue:

- in contrast to men, women are sensitive to artefacts in their environments that affect perception of such environments in terms of masculinity and femininity (Cheryan et al., 2009);
- females were keener on enrolling in an introductory CS course upon steering the classroom environment away from stereotypes regarding CS that high school students had at a time (Master, Cheryan & Meltzoff, 2016);
- stereotype factor remains in place even after changing the environment into a professional one, retaining gender proportion and providing homogenous salaries (Cheryan et al., 2009);
- broadcasting the image of CS and Engineering as highly-specialized fields makes more harm than good since potential candidates lose their sense of belonging; therefore, bringing down barriers at the entry of the pipeline requires broadening the mental picture of what it means to be a CS professional or an engineer (Cheryan, Master & Meltzoff, 2015).

While both academia and business can take advantage of stereotype-centred studies whilst designing their facilities and attracting students and employees, several core issues can be backtracked to early education and parenting practices. As this paper is focused more towards the end of the pipeline, we shall highlight the effects of non-belonging that might potentially directly translate to professional career stages. As reported by Garcia et al. (2018), even high-achieving CS female students still consider themselves less recognized than their male counterparts. Awareness of this fact is likely to affect decision processes of younger female generations and their tendency to feed the pipeline. Stoet & Geary (2018) note an interesting paradox – countries renowned for their gender equality policies tend to report larger sex differences as women feel free to pursue their comparative advantages and personal preferences, whereas in less gender-equal countries the cost of forgoing a well-paying STEM career encourages more moment to enter the pipeline.

2.2. Leaky academic pipeline

Gordon (2016) associates academic retention with the share of students who go along their selected course of study at a single institution instead of switching to another course/discipline or discontinuing their study; retention in CS was revealed to be the worst among all disciplines. Giannakos et al. (2017) dive into CS retention issue using Structural Equation Modelling and reveal that (1) CS students find their discipline lacking interactive and social aspects; (2) whereas high-quality teaching is a must across all disciplines, it does not ensure keeping CS students engaged in their studies and sticking to their selected majors. Peters et al. (2014) associate weak retention numbers with limited past experiences with programming and derivative struggles to envision future participation in CS activities and negotiation of meaning. Since most Engineering and CS curricula introduce programming subjects and focus on programming skills early on, students interested in broader perspective on technology and its social impact may find themselves discouraged (Peters & Pears, 2013). Misunderstanding of CS may also be linked to the lack of discipline-specific entry qualifications (Gordon, 2016).

As far as leaks from the pipeline given academic context are concerned, Virnoche & Eschenbach (2010) report that gender is not among the factors that affect retention significantly. Miller & Wai (2015), based on their analysis of a 30-year-long interval, point out that males and females currently persist at roughly equal rates in STEM fields between the bachelor's and Ph.D. degree. So, whereas the loss of CS students as they progress their education is severe, it is not discriminatory in nature. Early academic careers within CS also seem to be immune to gender bias. Ceci et al. (2014) do not hesitate to highlight a paradox: women tend to achieve the most success at being hired, promoted and remunerated as professors in the very fields they are underrepresented the most; thus, the academy itself is not to be overly blamed for disrupting gender neutrality. On top of that, Miller (2015) criticises the notion of STEM pipeline altogether, pointing out that many 'leaks' that are unfairly stigmatized carry on using technical skills gained to make significant societal contributions throughout other fields.

2.3. Leaky professional pipeline

IT industry, at first glance, is strongly open to gender neutrality. Since CS and IT reported shortage of qualified staff for years and such deficit only increases the exposure of whole nations to competitive risks, women and minorities are often considered untapped resources (Vitores & Gil-Juárez, 2016). Whereas studies conducted by the end of 20th century often revealed gender-related discrimination practices while hiring, more recent studies paint a definitely more balanced picture. For instance, Carlsson (2011) upon investigation of hiring practices in two largest Swedish job markets reports that no evidence was found to support a bias exists regarding the probability of being invited to an interview in male-dominated occupations, while in female-dominated occupations women had a higher call-back rate compared to men. Similar conclusions were reached by Charness et al. (2020) after experimentally investigating anticipated discrimination across gender, hiring patterns, and performance in tasks with different stereotypes in a labour-market setting: math-related discrimination against females in hiring did not take place at all.

Recruiting practices within CS evolve towards being more female-friendly. On one hand, it is many a time motivated by good publicity. On the other, women are reported to be more inclined to apply for a job given certain information points are in place. Sullivan (2018) lists 25 influence areas for attracting female applicants, which include revealing the proportion of women in this particular job, offering side-by-side company comparisons in terms of women-friendly features, providing project approval rates, or demonstrating the extent to which the job can be customized. It is the algorithmic hiring that ought to be highlighted when considering recruitment-specific risks to equality challenge. Such algorithms not only may follow data patterns that are obsolete given relatively recent shifts in policies. On top of that, women are more likely to raise red flags due to potential gaps in employment related to giving birth and children care (Parker, 2015).

We would argue that the real problem that contributes to females leaking from the pipeline upon graduation lies elsewhere. Majeed (2019) points out that hiring personnel to entry-level IT positions without any sign of bias might be easy, but at one point of any woman career she aspires to have more responsibility. Should that responsibility be unfairly denied, a potential leak would form. Obstacles in gaining access to high-power leadership positions in certain situations were confirmed by Hoover et al. (2019), who revealed that while high-ranking males rated male and female applicants for managerial position in line with their qualifications, lower-

ranking ones reacted with discrimination to alleviate the threat of being subordinated to a woman.

One also cannot ignore the gap in salaries that refuses to go away. Although Budig (2014) reports that the tendency is clear, and between 1979 and 2012 the American market was very successful towards closing it, fatherhood is revealed to come with a salary bonus – while motherhood with a penalty. Rayome (2016) provides a number of technology market-focused indicators, concluding that (1) young female tech professionals (i.e. aged between 18 and 25) are particularly impacted by the difference in median salary that peaks at 29% and decreases over time; (2) one of the main reasons the salary gap persists is that women are more reluctant to negotiate the first offer compared to men; (3) scrutinizing salary-based data against gender disparities and coming up with objective criteria for evaluations that decide on promotions is a best practice for companies to implement. Ultimately, 56% of women in technology (twice as many as men) quit at the mid-level point, just when the loss of their talent is most costly to companies (Hewlett, 2008). Stephan & Levin (2005) point out that the lower retention rate of female IT professionals may not necessarily be tracked back to the comparative advantage of other industries – women are simply more likely than men to leave the labour force altogether.

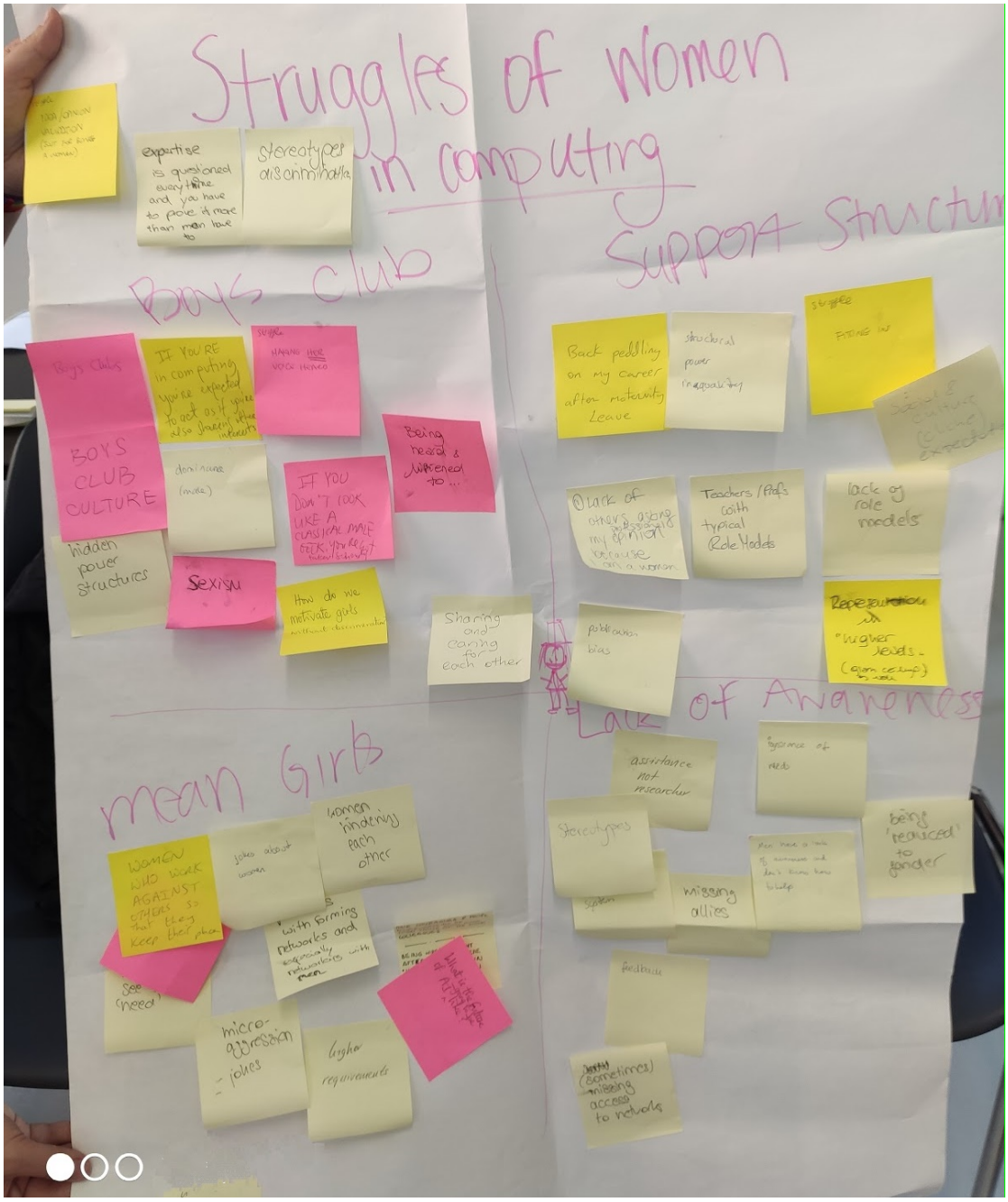
3. RESEARCH QUESTIONS DEVELOPMENT

Literature review shows that significant underrepresentation of women among CS professionals is the picture that is not going to change in the foreseeable future. Not so many females worldwide seriously consider undertaking this particular path early on, and a significant share opts out along the way. A number of myths, stereotypes and misconceptions contribute to such tendencies (Kindsiko & Türk, 2017) – and many researchers came up with best practices to counter them. That being said, given even more extremes present among the countries that might be classified as gender bias-free and hardly discriminatory academic practices, we find some of the more radical efforts to re-shape the phenomenon counterproductive. In our opinion, governments, companies and individuals should be actively committed to removing hindrances. The very hindrances that might pile up in front of these women, who actually decided to go against the tide and dedicated themselves to a career in CS as they enter the labour force.

To pave the way for exploring this topic, a pilot study was conducted: a focus group that involved nearly 20 women from around the world. The members of the group were asked about what they consider the main reasons for them behind struggling to decide to start their professional careers and stay in IT (Figure 1). The feedback helped to identify four areas of problems:

- it is a boy's club indeed – if you do not look or act like one, you cannot belong to it;
- there is a lack of support structure or role models;
- different standards for different genders and women hindering each other;
- lack of awareness or exposure.

Figure 1. Struggles if women in computing – focus group.



Still, there is a huge difference between an individual sense of being out-of-place – and the working environment neglecting, or even encouraging practices that make somebody feel out-of-place. Between the natural process of familiarizing oneself and fitting in a new setting that is full of challenges – and having an unofficial policy of the entire company in place that discriminates based on gander, ethnic group or any other attribute. Between field-testing, even unsuccessfully, anti-bias measures – and having no answers at all. Therefore, we posed a few research questions addressing diversity and inclusivity of CS working environments. In the current paper, we attempt to answer three of those:

RQ1: Do companies establish official anti-discrimination practices that cover gender or is it just a matter of organizational culture?

RQ2: What sort of measures (both formally anti-discriminatory and of general nature) are used to reconcile professional careers of employees and parenthood?

RQ3: What is the level of labour force support for introducing formal parities and programs addressed exclusively to female employees?

4. RESEARCH APPROACH

In order to collect empirical data, we launched a survey targeted at members of the global community that were professionally involved in IT/CS or represented academia in the aforementioned fields. Nigel, Fox & Hunn (2009) bring up a number of advantages of using survey approach: (1) it can cover samples that are geographically spread; (2) in most research settings it can provide results that may be efficiently used to draw conclusions and generalize those to wider population; (3) it can be thrown in the mix with other methods to deliver richer data; (4) since its participants are only exposed to events that would take place anyway, it does not introduce ethical concerns. We employed online Google forms service as an instrument for collecting data. The questionnaire featured both open-ended and closed questions, with the latter being primarily based on a 5-point Likert scale. The first stage of analysis, the results of which are covered in this paper, was initiated upon exceeding the threshold of 100 respondents providing their feedback.

The questionnaire form was divided into three sections of 5, 6 and 9 questions respectively (Table 1). Whereas the first section was put in place to capture particulars of each respondent and enable moderation of results, the second addressed audience's judgements regarding possible hindrances for women in CS, and the last one – ways of handling them.

Table 1. Questionnaire form

<table>
<tr><th colspan="4">Respondent's particulars</th></tr>
<tr><td colspan="2">1. Respondent's year of birth</td><td colspan="2">2. Respondent's country of residence</td></tr>
<tr><td>3. Line of work</td><td>o Business
o Academia</td><td rowspan="2">4. Size of the employing company</td><td>o Micro (1-9 people)
o Small (10-49 people)
o Medium-sized (50-249 people)
o Large (250 people or more)</td></tr>
<tr><td>5. Gender</td><td>o Male
o Female
o Neutral/undisclosed</td></tr>
<tr><th colspan="4">Hindrances</th></tr>
<tr><td colspan="4">6. IT has traditionally been a boy's club – and I consider entry barriers to be high</td></tr>
<tr><td colspan="4">7. Female role models that appeal to me are very rare in Computer Science</td></tr>
<tr><td colspan="4">8. Women do not get enough exposure and are being assigned secondary roles more often</td></tr>
<tr><td colspan="4">9. Should you be in favour of the previous statement – what reasons for such lack of women exposure are there?</td></tr>
<tr><td colspan="4">10. Women within the industry tend to hinder each other significantly more often than men</td></tr>
<tr><td colspan="4">11. Please provide any additional hindrance(s) you can think of that applies to making careers by women within Computer Science field</td></tr>
<tr><th colspan="4">How to deal with those problems?</th></tr>
<tr><td colspan="4">12. My company is taking official measures to deal with inequality</td></tr>
</table>

13. If so, what policies were implemented?	☐ *Corporate policy in place that prohibits any form of discrimination* ☐ *Official anti-discrimination education sessions* ☐ *Balanced schemes for professional training funding* ☐ *Implementing formal parity while recruiting* ☐ *Implementing formal parity while promoting* ☐ *Support for work-life balance (nursery/infant schools at the workplace, paid maternity leave beyond the one enforced by law etc.)* ☐ *Mechanisms to deal with complaints confidentially* ☐ *Other: (short answer field)*
14. And which of those would you recommend?	☐ *Corporate policy in place that prohibits any form of discrimination* ☐ *Official anti-discrimination education sessions* ☐ *Balanced schemes for professional training funding* ☐ *Implementing formal parity while recruiting* ☐ *Implementing formal parity while promoting* ☐ *Support for work-life balance (nursery/infant schools at the workplace, paid maternity leave beyond the one enforced by law etc.)* ☐ *Mechanisms to deal with complaints confidentially* ☐ *None*
15. I consider unofficial mentoring from experienced and recognized specialists to be a viable solution	
16. Managers need to be made to react immediately to any form of non-inclusion	
17. Company should enable/fund networking opportunities exclusively for female employees within Computer Science	
18. Please provide any additional ways to increase inclusion of women within CS field	
19. Any other feedback or suggestions?	
20. If you want us to be able to reach you in the future regarding the feedback, please leave your e-mail address here (*data processing statement included*)	

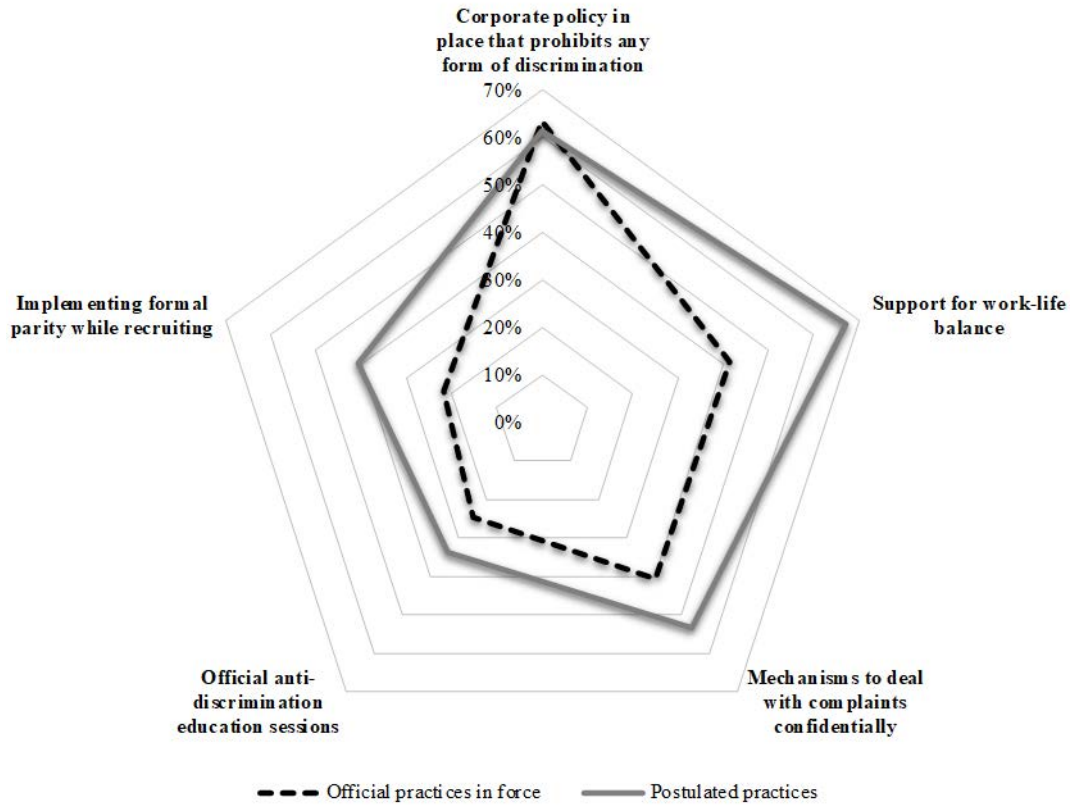
5. PRELIMINARY RESULTS OF THE STUDY

During this stage, we focused we focused on exploring the attitude of the community as a whole to the issues raised in RQ1-3. Questionnaire forms filled to date turned out to be close to gender parity (men constituted a marginal majority), while by far the largest share was attributable to the staff of companies that employed 250 people or more. Residents of as many as 25 countries shared their opinions, with the largest group being British.

As regards to whether companies that employ our respondents established official anti-discrimination practices that cover gender – or was it just a matter of organizational culture – the feedback was unequivocal. At the time of the preliminary analysis, only 18.8% of respondents flatly denied the existence of such policies in their companies or were rather convinced that there were no official policies targeting gender bias in place. Five among the policies that were either pre-selected or additionally reported by respondents were implemented in at least 20% of the organizations covered by the survey (Figure 2). Thus, it would be unreasonable to suspect that companies only set up minimalistic prohibition on discrimination in their statutes for legal or publicity reasons. It ought to be noted though that the numerical strength of large companies staff in the survey is not without an impact on this state of affairs, as major organizations may afford to allocate greater resources to ensure equality across all attributes, and simply show tendencies to formalize more. At this stage, it can be safely stated that support for setting up formal policies is huge throughout the sample, as there was only a single case of decreasing a relevant indicator when the official practices in force were confronted with those postulated by the respondents to be implemented (and this drop

was slight: from 63.4% to 61.4%). In the remaining four cases the raise was significant, and only 6.9% of respondents argued that no formal policies are actually needed.

Figure 2. Official policies targeting gender bias with 20%+ implementation rate.



The feedback shows that companies do employ measures to reconcile professional careers of employees and parenthood. In the same time, it is the area that employers need to take great care of. Respondents highlighted parenthood-related issues in a number of places:

> "women are usually more involved than their male counterparts in child care, child raising and domestic chores; so it is more difficult for them to reconcile these family responsibilities with an intense dedication to their paid jobs; this is not specific of computer science, of course";
>
> "[management shows] sexism in relation to women starting families";
>
> "[…] empower fathers to go on parental leave to the same extent that mothers usually do and support all genders when they return to the job afterwards (e.g. with funded training to help them catch up on new developments)".

What surprised us, however, is a rather one-tracked recipe of large companies to this vital issue. One cannot overstate the utility of nursery/infant schools at workplaces, just as paid parental leaves are a backbone of the pro-family policy. The latter, however, constitute a risk factor in certain circles as well – employers may be less keen to hire females or may offer them lower salaries due to accompanying costs. To counter that, some Nordic countries introduced

mandatory father quotas that are non-transferable and are lost if not used. Based on our personal experiences and the favourable specifics of the IT/CS market in this respect, we expected much stronger pressure towards flexible forms and working hours. The matter was admittedly raised by the respondents – but it clearly was of low priority.

It can be safely said that the question of the entire labour force's support for introducing formal parities and programs addressed exclusively to female employees causes greatest emotions. The doubt whether the promotional procedures were fair or not was confirmed. The preliminary results not only showed that companies would rather stick to formal parities when recruiting (often simply unnecessary – just to mention Carlsson (2011) or Charness et al. (2020)) and consider the matter closed. In fact, the largest gap (in both absolute and relative terms) between the policies officially implemented already, and those our respondents would like to see in place, relates to implementing formal parities when promoting. While existence of such policy was confirmed in only in 13.9% of the companies, 43.6% of the respondents put this particular policy on their wish list. In result, it would top two other postulated practices from the top five list (comp. Figure 2). Ultimately, respondents do not have much faith in existing mechanisms, which often prove discretionary. This confirms the results revealed in some other studies (Hoover et al., 2019; Majeed, 2019). This issue was also raised in open-ended questions:

> "[…] being overlooked for promotion […]"
>
> "hiring upper level positions is quite limiting to female candidates; even though we encouraged women and minorities to apply to a recent job opening very few had PhDs in CS, and even fewer had experience in management; all of the candidates that made the top 7 in our case were male".

Interest in gender-exclusive programs might be deemed marginal – while data collected so far exhibited only slight tendency contra enabling and funding such networking opportunities, unambiguously positive descriptive reflections to this topic were extremely rare:

> "[…] offers women-only courses on leadership […] which I found to be very good; courses like this in all sectors would be welcome, and, if operated in the same way, are effective"

Other statements in this regard were at most neutral. Generally, opposition to so-called positive discrimination is voiced strongly:

> "integrating female-only events to the more inclusive direction; that would promote better future also for the female CS experts, too, and the female-only events just highlight the current gender balance and underestimate the capability of female CS experts";
>
> "I don't feel companies should enable/fund networking opportunities that are exclusive to any particular gender or race; if we are wishing to encourage inclusion, a suggestion of division is not the way to go about that; speaking personally, if opportunities were presented with non-gendered bias in the writing, perhaps I would seek them out more actively";
>
> "if it is exclusive only for females then it is discriminating against all others";
>
> "[…] there is no such thing as good discrimination; instead encourage men to engage more in family life […] this would make it less beneficial for employers to favour men";

"empowerment is inclusion […] exclusive benefits are a negative as it creates an idea that hard work isn't necessary";

"[…] the so called 'positive discrimination' makes men sceptical about equality slogans".

6. ON-GOING WORK

Only a portion of collected data was scrutinized during the first stage of the analysis. On-going activities confront soft and hard measures – for instance, strong belief in adequate reactions of the management to reported bias seems somewhat surprising. Upper management in CS is, after all, dominated by men, and we have already shown that such belief does not translate to the process of promoting staff. Several interesting angles remain. Are females actually more hostile to other females than males are? What forms of hidden discriminatory practices were uncovered? How modus operandi looks like? Is a 'double jeopardy' issue, i.e. exponential discriminatory practices due to overlapping bias-related attributes a real thing?

7. CONCLUSSIONS

This study enabled us to reassess the mechanics behind the female 'leaky pipeline' within CS. We isolated the main trends and groups of hindrances, scrutinized a number of practices that companies already employ or might employ in the future to counter any form of bias, and outlined the directions of further analysis. Even partial data collected so far indicate a couple of flaws in the current state of affairs. First of all, we would encourage companies to carry out a comprehensive review of their promotion policies. Secondly, we would recommend a best practice of re-distributing parental leaves among both parents as much as legally possible – and supplementing it with flexible forms of labour provision.

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REFERENCES

Budig, M.J. (2014). *The Fatherhood Bonus and the Motherhood Penalty: Parenthood and the Gender Gap in Pay*. Retrieved from https://www.thirdway.org/report/the-fatherhood-bonus-and-the-motherhood-penalty-parenthood-and-the-gender-gap-in-pay

Carlsson, M. (2011). Does Hiring Discrimination Cause Gender Segregation in the Swedish Labor Market? *Feminist Economics*, 17(3), 71–102. doi:10.1080/13545701.2011.580700

Ceci, S.J., Ginther, D.K., Kahn, S., & Williams, W.M. (2014). Women in Academic Science: A Changing Landscape. *Psychological Science in the Public Interest*, 15(3), 75-141.

Charness, G., Cobo-Reyes, R., Meraglia, S., & Sanches, Á. (2020). *Anticipated Discrimination, Choices, and Performance: Experimental Evidence*. Retrieved from http://hdl.handle.net/11073/9231

Cheryan, S., Master, A., & Meltzoff, A.N. (2015). Cultural Stereotypes as Gatekeepers: Increasing Girls' Interest in Computer Science and Engineering by Diversifying Stereotypes. *Frontiers in Psychology*, 6, 49.

Cheryan, S., Plaut, V.C., Davies, P.G., & Steele, C. M. (2009). Ambient Belonging: How Stereotypical Cues Impact Gender Participation in Computer Science. *Journal of Personality and Social Psychology*, 97(6), 1045.

Craigie, T-A., & Dasgupta, S. (2017). The Gender Pay Gap and Son Preference: Evidence from India. *Oxford Development Studies*, 45(4), 479-498

Ehrlinger, J., Plant, E.A., Hartwig, M.K., Vossen, J.J., Columb, C.J., & Brewer, L.E. (2018). Do Gender Differences in Perceived Prototypical Computer Scientists and Engineers Contribute to Gender Gaps in Computer Science and Engineering? *Sex Roles*, 78(1-2), 40-51

Galpin, V. (2002). Women in Computing Around the World. *ACM SIGCSE Bulletin*, 34(2), 94-100.

Garcia, A., Ross, M., Hazari, Z., Weiss, M., Christensen, K., & Georgiopoulos, M. (2018). Examining the Computing Identity of High-Achieving Underserved Computing Students on the Basis of Gender, Field, and Year in School. In *Collaborative Network for Engineering and Computing Diversity (CoNECD)*. Washington, DC: ASEE.

Giannakos, M.N., Pappas, I.O., Jaccheri, L., & Sampson, D.G. (2017). Understanding Student Retention in Computer Science Education: The Role of Environment, Gains, Barriers and Usefulness. *Education and Information Technologies*, 22(5), 2365-2382.

Gorbacheva, E., Beekhuyzen, J., vom Brocke, J., & Becker, J. (2019). Directions for Research on Gender Imbalance in the IT Profession. *European Journal of Information Systems*, 28(1), 43-67

Gordon, N.A. (2016). *Issues in Retention and Attainment in Computer Science*. Retrieved from https://documents.advance-he.ac.uk/download/file/4652

Graf, N., Fry, R., & Funk, C. (2018). *7 Facts about the STEM Workforce*. Retrieved from https://www.pewresearch.org/fact-tank/2018/01/09/7-facts-about-the-stem-workforce/

Hewlett, S.A., Luce, C.B., Servon, L.J., Sherbin, L., Shiller, P., Sosnovich, E., & Sumberg, K. (2008). The Athena Factor: Reversing the Brain Drain in Science, Engineering, and Technology. *Harvard Business Review Research Report*, 10094, 1-100.

Hoover, A.E., Hack, T., Garcia, A.L., Goodfriend, W., & Habashi, M.M. (2019). Powerless Men and Agentic Women: Gender Bias in Hiring Decisions. *Sex Roles*, 80(11-12), 667-680.

Kindsiko, E., & Türk, K. (2017). Detecting Major Misconceptions about Employment in ICT: A Study of the Myths about ICT Work among Females. *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering*, 11(1), 107-114

Majeed, S. (2018). *This is What Women in Tech Wish They Knew Early on in Their Careers*. Retrieved from https://www.theladders.com/career-advice/this-is-what-women-in-tech-wish-they-knew-early-on-in-their-careers

Master, A., Cheryan, S., & Meltzoff, A.N. (2016). Computing Whether She Belongs: Stereotypes Undermine Girls' Interest and Sense of Belonging in Computer Science. *Journal of Educational Psychology*, 108(3), 424.

Miller, D.I. (2015). *A Metaphor to Retire*. Retrieved from https://www.insidehighered.com/views/2015/03/03/essay-calls-ending-leaky-pipeline-metaphor-when-discussing-women-science

Miller, D.I., & Wai, J. (2015). The Bachelor's to Ph.D. STEM Pipeline No Longer Leaks More Women than Men: A 30-Year Analysis. *Frontiers in Psychology*, 6, 37.

Nigel, M., Fox, N., & Hunn, A. (2009). Surveys and Questionnaires. In *The NIHR Research Design Service for the East Midlands/Yorkshire & the Humber* (pp. 1-48).

Parker, K. (2015). *Women More than Men Adjust Their Careers for Family*. Retrieved from http://www.pewresearch.org/fact-tank/2015/10/01/women-more-than-men-adjust-their-careers-for-family-life

Peters, A.K., & Pears, A. (2013). Engagement in Computer Science and IT – What! A Matter of Identity? In *2013 Learning and Teaching in Computing and Engineering* (pp. 114-121). Piscataway, NJ: IEEE.

Peters, A.K., Berglund, A., Eckerdal, A., & Pears, A. (2014). First Year Computer Science and IT Students' Experience of Participation in the Discipline. In *2014 International Conference on Teaching and Learning in Computing and Engineering* (pp. 1-8). Piscataway, NJ: IEEE.

Rayome, A.D. (2016). *Closing the Tech Gender Gap: How Women Can Negotiate a Higher Salary*. Retrieved from https://www.techrepublic.com/article/closing-the-tech-gender-gap-how-women-can-negotiate-a-higher-salary

Stephan, P.E, & Levin, S.G. (2005). Leaving Careers in IT: Gender Differences in Retention. *The Journal of Technology Transfer*, 30, 383-396

Stoet, G., & Geary, D.C. (2018). The Gender-Equality Paradox in Science, Technology, Engineering, and Mathematics Education. *Psychological Science*, 29(4), 581-593.

Sullivan, J. (2018). *Need Women Applicants? Why Micro-Targeting Women Triggers More to Apply*. Retrieved from https://www.ere.net/need-women-applicants-why-micro-targeting-women-triggers-more-to-apply

Virnoche, M., & Eschenbach, E.A. (2010). Race, Gender and First Generation Status in Computing Science, Engineering and Math persistence. In *2010 IEEE Frontiers in Education Conference (FIE)* (T1A 1-6). Piscataway, NJ: IEEE.

Vitores, A., & Gil-Juárez, A. (2016). The Trouble with 'Women in Computing': A Critical Examination of the Deployment of Research on the Gender Gap in Computer Science. *Journal of Gender Studies*, 25(6), 666-680.