Exploring Software Engineering Gender Distribution

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Abstract. This paper investigates the biological, psychological and societal reasoning for the disparity in women in the software engineering industry and how a more diverse workforce can have an advantage in this sector. Studies show that diversity in a company positively correlates to its financial profits. Furthermore, a severe lack of women in software engineering causes companies to limit themselves to smaller talent pools, decrease the creative outlook on fresh ideas and resolution of problems. There are superficially inherent reasons why computing appeals to men more than women, observations to multiple reports and statistics show that men have a small advantage when it comes to mathematical and problem solving skills. Additionally, it is evident that a females' inherent interest lies in other fields related to 'people', whereas males are generally more interested in 'things'. However, while societal factors and bias plays a role in the discouragement of women from the software engineering industry, studies have shown that countries with more gender-inegalitarian societies show an increase in the number of women in software engineering and STEM. This emphasises the fact that the gender disparity in software engineering primarily emerges from personal choice rather than any discrimination or stereotyping.

1 Introduction

Recent reports contend that women continue to be severely underrepresented in technology-related fields. In 1985 women accounted for 37% of all computer science graduates, this number dropped steadily to 17% by 2011 with the widespread use of home computers, as a result, women make up only 25% of the computing workforce [13]. Not only is there a disparity of women in software engineering, but this is also seen throughout the STEM (Science, Technology, Engineering and Mathematics) subjects in college and as a result in the workplace. While this report is focused on the gender distribution in software engineering, significant evidence shows that similar statistics can be applied to both software engineering and STEM. This report aims to provide a consensus and insight into the reasoning of a gender disparity in the software engineering industry and how it can be improved. The underlying question is, are women forced out of computing due to stereotyping and discrimination or is it simply their personal and psychological interests that drive them away?

2 Related Literature

2.1 Methodology

We implemented a multivocal approach including both peer reviewed papers and non-academic papers. Search queries were executed on google.com and google scholar. When a paper/article was deemed relevant it was included in our reference list and where cited papers within the document looked relevant they were also investigated for possible further analysis, the same process was applied to them. The data was synthesized by each member of the team by selecting their subtopic and gaining an overall understanding of the topic. Then writing a relevant analysis on the topic adopting views/facts from other sources where necessary and referencing. When referencing non-peer reviewed papers the team was more cautious, only websites where there was some level of administration were chosen, most of these being major newspaper websites which the majority of the time would subsequently be referenced peer reviewed papers.

2.2 Inclusion/Exclusion Criteria

Papers/articles were included if they explored a similar topic to the one we were specifically looking for. Non-peer reviewed papers were more likely to be rejected as mentioned above, but the overall inclusion criteria was one of relevance and correctness.

2.3 Cited Peer Reviewed Papers Breakdown

	Number of Papers Identified	Number of Papers included in Analysis	Total
ACM	21	5	26
Journal of Intelligence	8	1	9
Journal of Science	6	1	7
Vocational Behavior	5	1	6
Sage Journals	9	1	10
Child Development	2	1	3
Technology & Culture	4	1	5
GATES	3	1	4
Population Space and Place	1	1	2
Gender, Science & Technology	1	1	2
Computing Sciences in Colleges	7	1	8
Social Development	3	1	4
Canberra: Australia Government P.S.	1	1	2
Journals of Economics & Business	11	3	14
Journals of Educational Discipline	16	3	19
Journals of Psychological Discipline	19	6	25
Total	123	29	152

3 Analysis

3.1 Psychological/Biological Gender Differences

Before examining the software engineering gender distribution, it is vital to discuss the physiological differences between men and women. This will give us an insight into the collective subconscious psyche and decision making of each gender, subsequently, we will find out the possible reason(s) for the low proportion of women in software engineering. Men and women are equally capable of performing software engineering tasks when it comes to physical attributes. Software engineering and computing, in general, does not provide a prerequisite in physical ability and fitness unlike other jobs in the field of physical labour where men excel. Differences arise in cognitive ability such as quantitative, mathematical, problem-solving and visuospatial awareness competence which directly correlates to typical software engineering skills [4]. A longitudinal study on mathematical sex differences suggests that until grade 5 (age 10-11) in school, girls and boys do not show any difference in mathematical achievement but thereafter (grades 7, 9, 11) boys pull ahead of girls [1]. In a similar study performed on the American SAT exams, men surpassed women overall but the difference was greater on items requiring spatial skills, shortcuts, or multiple solution paths [4]. Studies also show that men have a 4% higher average mathematics result in the SAT exams over the past 50 years [11]. This trend continues in the Irish Leaving Certificate, based on the statistics provided by the State Examination Commission twice as many men receive an A (≥85%) in higher level mathematics than girls [12]. In contrast, women outperformed men on problems requiring verbal skills or mastery of classroom-based content.

Quantitative and problem-solving tasks related to non-classroom-based content correlate to typical software engineering tasks and would give men a marginal advantage in the field of software engineering. These differences often arise during adolescence when boys begin to act in a more competitive manner [2]. This competitive nature makes young men choose mathematical subjects as it creates an opportunity for a higher wage and standard of living. As a result of interest in mathematics, young men tend to lean towards STEM subjects at third level education. Throughout second level education boys are encouraged to work hard at subjects that are likely to be useful for their desired career paths [1]. Although this does not prove how much these trends dissuade girls from having an interest in computing, research has shown that implicit biases do negatively influence females' interest in STEM fields [44]. While these differences are at a biological level they are also increased by environmental influences such as parents, teachers and societal expectations [1][6].

Multiple studies show that men have a higher visuospatial ability than women from an early age [4][5]. While there are few aspects of software engineering that test a person's visuospatial ability such as vector mathematics, they are negligible. From an early age, boys tend to play computer games which leads them to be interested in computers. Competitiveness and spatial awareness play a huge role in the ability to play video games, which correlates to the ability of boys being proficient in computing. This sparks an interest in the computing sector among boys. In the first year of

American colleges, students take part in a number of subjects, this allows them to explore their options on a major to specialise in second year. This gives girls an added opportunity to pick computer science if it was not their first choice when initially entering college. One study found that some girls did not have the requisite knowledge of computers in order to have a full understanding of the course compared to their male counterparts [3]. One inferred reasoning for this is the disproportionate amount of male to female gamers. Computer gaming aids in the understanding of basic use of computers such as file structures, downloading/running programs and basic day to day use, which attributes to men having higher confidence in computer use. “Only 27% of men reported not using a computer on a weekly basis, compared to 55% of females surveyed” [13].

Multiple studies in gender differences in self-perceived computer competency and efficiency show that men are much more confident in performing various computer tasks such as word processing, email, web browser and file transfer [8][9]. Although there was a huge difference in confidence, the results showed that there were no significant differences found between the genders in terms of actual competencies in the general use of computer software. Differences only showed in the hardware and maintenance side of computer use and perceived abilities of the individual.

On the contrary, women are significantly better at verbal, memory-related and classroom-taught content, which are relatively unassociated to software engineering problems, these advantages lead women to focus their attention to fields such as journalism, law and teaching. Their compassionate, gentle and sensitive nature also makes them excel in humanitarian fields such as nursing and human resources [3]. While previously mentioned points play a role in the low amount of women in computing, the biggest reason why women do not choose computing as a career is their lack of interest in that subject. While observing Holland’s hexagon or RIASEC (Realistic, Investigative, Artistic, Social, Enterprising and Conventional) model we can see that the highest gender differences occur in the ‘people–things’ dimension. Male interest in ‘things’ leads them into fields of STEM and trades while women being interested in ‘people’ leads them into humanitarian role paths such as nursing, teaching and psychology. The study also suggests that gender interest differences appear to be consistent across all cultures and times, proving a biological finding that contradicts social role theory or any societal influences [2]. Interestingly the same study found that this interest gap increases with more gender-egalitarian societies, solidifying why there is a higher number for women in software development in less developed gender-inegalitarian countries such as India [10]. Women who are perhaps in fear of not being hired choose to study in a field with a high graduate conversion rate in disadvantaged areas. Whereas women who are at less of an existential threat of unemployment and poverty choose to study what interests them irrespective of future hiring opportunities. “Women in countries with higher gender inequality are simply seeking the clearest possible path to financial freedom. And often, that path leads through STEM professions.” [15].

3.2 History of Women in Computing

Perhaps the gender skew observed in the software industry can be best explained when we look at the changing role of women in the patriarchal structure over the past hundred years. At the beginning of the 20th century, women were confined to their homes and were responsible for raising children while men worked. In recent years this trend has shifted. It is more acceptable than ever for both parents to work full-time while their children are being raised by a third party. During the world wars, it was women's responsibility to look after the home but also provide essential services outside of the home such as phone operators and 'computer coders' [29][18][33]. During the 1930s and 1940s the invention of household refrigeration, contraception, sanitary products for the menstrual cycle such as the tampon and widespread adoption of home baths and showers led to the flooding of women into the workplace, but not in the software engineering industry [16].

Although there were flashes of women flourishing in computing over the years, notably Joan Clarke who cracked the Enigma code in the 1940s, Admiral Grace Hopper who developed the first computer compiler in the 1950s, the six female programmers of the ENIAC in the 1980s; they were brief. In the early 80s software engineering was a common path for women, in 1984 women's participation in computer science degrees grew to 37% twice of what it is today. Men focused on the more 'glamorous' at the time hardware while the women wrote computer software. Programming was hailed as a more interesting version of secretarial work by the pop-culture cosmopolitan magazine [39], this typified the overall consensus of the profession at the time. Thereafter the numbers regressed, the monetary explosion of Silicon Valley led more men to becoming interested in software development pushing women out of the industry. The software industry was and still is hugely male-dominated. Female participation in ICT (Information and communications technology) has increased since 1995, but the ratio of male to female workers has not shifted [37].

In a study done by the University of Liverpool, we see the specific breakdown of roles within the software industry. Only 5% of gaming programmers are female, while the same study found that 2.4% of the women in the study were software engineers. [38]. Computing needs women because there are real benefits to having a more diverse workforce. The Computing sector is the fastest growing industry in Europe with Ireland being the fastest growing economy in Europe throughout the last four years [14][40]. This creates a huge appetite for software graduates, which is yet to be satiated.

So how can we make girls of ability to adopt a career computing? The two main reasons stopping young women entering the software engineering industry as discussed earlier in the analysis is their inaccurate perceptions of the computing industry and the stereotyping that they encounter for 'straying from the norm' [28]. Many girls incorrectly believe that they will not be good at computing [8][9]. The manifestation of stereotyping and discrimination is discussed below but it is clear that both of these issues ought to be addressed if we are to see a greater balance of women in software engineering.

3.3 Investigating Biases and Stereotypes

One of the main reasons cited to be having an effect on the number of women entering software engineering and STEM fields, in general, is bias. It has been claimed for years that stereotypes and social attitude have been dissuading women from these particular fields. According to a study done in 2017, there are six explanations for women's underrepresentation in STEM fields. Only one of these reasons is gender-related stereotypes and biases [44]. This indicates that bias and stereotypes do exist within the industry, and, although they cannot be blamed for the entire problem, they have a role to play.

It has been indicated by several studies that imagery used within computer science courses can be insensitive towards women and create an uncomfortable environment in which they do not perform as well as they might [41]. A prime example of such imagery is the 'Lena' image, which is commonly used in image processing. The Lena image was originally a centerfold in Playboy magazine in 1972 and a former editor-in-chief of IEEE Transactions gave two reasons for the popularity of this picture in image processing one of which was, "It is not surprising that the (mostly male) image processing research community gravitated toward an image that they found attractive" [41][46]. Use of such images can be considered degrading to women and it has been documented by psychologists that the physical objectification of a woman's body can result in reduced cognitive performance [47]. This creates an environment where men are set up to perform better than their female counterparts. It has been shown that objectifying images of women can cause both males and females to associate reduced competence levels with women whose physical qualities are emphasized [17]. This is significant because studies have shown that faculty expectations of women directly influence their performance in computer science [41].

Stereotypes also play a part in making women think that a future in STEM fields would not be something to which they are suited. It has been shown that people, to different extents, have a 'science-is-male' stereotype which increases as the field becomes more science intensive. The very thought that men hold such stereotypes has been suggested to cause women to decide not to continue pursuing a career in software engineering and having them drop out of computer science courses [7]. Computer and information sciences have been found to have a strong stereotype of being more for men by nearly a full standard deviation above the zero-point of no stereotyping [42]. These stereotypes are reinforced by men only being featured on the front of software packages, the main character in video games tend to be male and most computer salespeople tend to be male, which stops young girls from getting involved for fear of being stereotyped as a 'nerd' [43].

A study was done in two Malaysian computer science courses to determine the amount of gender bias prevalent, given that the majority of faculty lecturers in these universities are female. The study found that no gender bias with regards to computer science/IT is perceived by young Malaysians [45]. This all but proves that gender bias has a small effect on the proportion of females that choose a career in computing, and that the removal of such biases would have a positive on the gender distribution within these fields. Male students in Malaysia tend to start their degrees with more com-

puter skills than their female counterparts, but this difference in initial ability does not result in male students outperforming female students [45]. This shows that initial skill level does not determine concretely how successful one will be in their studies.

Due to the lack of females in computing, companies may be more inclined to hire females over males. This consequently can have a negative effect because it is in a company's best interest to hire the best candidate possible for the position regardless of their gender. If the candidates must be female or if one gender is favoured over another you may be restricting your scope on an already limited field. There are very few computing graduates and as stated by Jordan Peterson, "if you start putting arbitrary restrictions (such as gender) on their hiring you're going to end up not finding the ones (graduates) that there are" [23]. Of course, in accordance with the fair nature of hiring in this statement we must assume unconscious bias does not play a part, or to at least minimise it to a negligible degree.

As undergraduate software engineers we have a valuable albeit narrow insight into the gender distribution that we have experienced over the past four years in university. In the final year of our degree there are 106 students, only 15 of which are female. Out of the 33 modules we've sat, only 4 of them have been taught by females. Three of which being lectured by Dr. Monica Ward who has had 30 years of experience in the software industry and provided further insight on how she would suggest getting women involved in computing. She believes that we must spark interest from an early age, primary school preferably. This would provide a crucial initial curiosity for young girls, one that would not usually be part of their perspective. A feat she is currently working towards in tandem with the Department of Education, who are implementing a computer science subject on a trial basis as part of the Irish Leaving Certificate curriculum. In terms of University we can look at Carnegie Mellon University in Pittsburgh, Pennsylvania who have a near 50:50 split in their school of computing [26].

3.4 Benefits of Gender Diversity

To aid in understanding the possible advantages of gender diversity in the software engineering sector, we can examine the effects of a more gender diverse workforce in other career paths that share similar management and workflow techniques as software engineering. A research paper from McKinsey&Company compiled in early 2015 is one of the aforementioned relevant documents. The paper, titled 'Diversity Matters', monitored how diversity affected a company's financial performance using both leadership demographics and financial data taken throughout the quartiles of hundreds of companies in various countries. While the paper investigates both gender diversity and ethnic diversity, the data is separated into those two categories and analysed independently from one another. Thus, the findings of 'Diversity Matters' are highly relevant in identifying potential advantages through gender diversity for software engineering. Analysis of the data from the group of 366 companies revealed a significant connection between diversity and financial performance. Companies in the top quartile for gender diversity were 15% more likely to have financial returns that were above their national industry median [30].

The document also references other research papers that McKinsey&Company have produced in the past as while ‘Diversity Matters’ shows the correlation between gender diversity and financial performance, the research conducted does not investigate the possible causes for this. Combining the data gained from ‘Diversity Matters’ with the previously mentioned gender focused performance research revealed potential rationales as to why the organisational performance was so heavily influenced. A strong focus on women and ethnic minorities increases the sourcing talent pool. Diversity increases employee satisfaction and reduces conflicts between groups, improving collaboration and loyalty. Diversity fosters innovation and creativity through a greater variety of problem-solving approaches, perspectives and ideas.

In 2017, the Royal Academy of Engineering in the UK published a research paper titled ‘Creating Cultures Where All Engineers Thrive’. This paper acknowledged the need for a more diverse workforce from various other findings such as the previously stated paper above and as a result, another survey was conducted to analyse how engineering employees responded to a workplace that offered more diverse co-workers. The findings of the ‘Creating Cultures Where All Engineers Thrive’ [31] are based on the personal responses of 6,799 people currently employed in various engineering roles throughout the UK. The data collected from this survey was from different levels of expertise, with over 66% of candidates being members of professional engineering institutions and 48% being professionally registered all within the UK. The research paper revealed that morale within the workplace increased in conjunction with an increase in diversity, along with the performance of engineering employees. Inclusion benefits the performance of individual engineers with 80% reporting increased motivation, 68% increased performance and 52% increased commitment to their organisation.

In January of 2018 McKinsey&Company published another research paper titled ‘Delivering Through Diversity’ as an extension on their previous publications. This paper describes the correlation between diversity (of both gender and ethnic backgrounds) and financial profitability. The research was conducted in a similar manner as ‘Why Diversity Matters’ published in 2015, the survey was refined to provide more accurate results and the dataset increased to cover more than 1,000 companies spanning 12 countries. ‘Delivering Through Diversity’ reaffirms previous statements made and reinforces the importance of a gender diverse workforce within a company, including software engineers. Almost three years later, this number rose to 21% from the original 15% and continued to be statistically significant.

From analyzing the varying research papers mentioned above it is clear that the diversity of gender within all business types, and by extension software engineering, is of significant importance. With the severe lack of women in software engineering work environments, companies are limiting themselves to small talent pools, less motivated software engineers, inefficient creative problem-solving and are ultimately forfeiting a large financial gain. Such statistics demonstrate how severe the disadvantage is when a company does not have a gender diverse workforce.

4 Limitations of Research

One of the primary limitations of the research performed for this report was the time factor. There was a deadline of six weeks set for this report, subsequently we had to gather and cross-reference all data and refine it down to this report in that period. This restraint meant that a large amount of time could not be wasted researching one aspect of the report as thoroughly as desired. Given more time, the scope of this report could have been expanded. Every factor, cause, symptom and solution of the current gender ratio in software engineering may have been examined to a greater extent, providing a better understanding of the subject in general.

In the process of writing this report, we could only rely on studies that have been done in the past as we did not possess the capacity to carry out our own studies/experiments. Elsewise, we could have gathered more up to date results perfectly relevant to the report that was being constructed. Unfortunately, we had to fully rely on the results of studies carried out in the past. As a result, a lot of information in this report is second hand, and it is possible that circumstances have changed somewhat since some of the studies were carried out.

It was a noticeable limitation throughout the construction of this report that it was hard to find sources of information pertaining specifically to software engineering. Most studies carried out were pertaining to STEM fields in general. Due to the fact we were relying wholly on other studies, it was a disadvantage to us that most studies were done on STEM as a whole and not software engineering as this report aims to do. More studies done on the gender ratio specifically in software engineering courses/careers would have positively benefited this report.

5 Future Work/Directions for Future Research

If in the future another such research paper is being conducted, we have various recommendations based on the findings of this paper. We suggest, if possible, to collect their own data or utilise a more recent study on various topics discussed in this paper. These topics could include, a longitudinal study on mathematics ability on a set population, more recent statistics on the ratio of men to women in the workplace/third level education and a survey on the opinion/attitude of secondary level girls towards computing. An updated report from McKinsey&Company is also recommended if one is not conducting their own data collection from multiple companies in order to put into perspective the current standing of gender diversity within companies. We also recommend to reevaluate and update the career term of ‘software engineer’ to now encompass the multitude of new jobs that have arisen in the past three to five years, such as data scientist, network architect and security analyst. This will include potential career subcategories that are within the computing sector.

6 Conclusions

This paper has investigated the biological, psychological and societal reasoning for the disparity in women in the software engineering industry and how a more diverse workforce can have an advantage in this sector. It is clear that immediate action needs to be taken on the inhibiting gender distribution that exists in the software engineering world. As explored in the analysis, employers have an obligation to hire based on suitability for the position and not gender or any other arbitrary demographic. Furthermore, companies have the responsibility to examine and eliminate any biases that may exist within their hiring process to the best of their ability. Our research has come to the conclusion that, in general, the reason why there is a shortage of female software engineers is that most women are simply not interested in computing as a whole. While analysing a demographic as large as gender partition it is important to remember that we must analyse the prevailing population as a whole. Of course there will be individuals or groups which stray from the norm, but these individuals contribute to a small portion of the overall population. However, we can, and should take steps to attract individuals who may have an interest in the field through the methods outlined above.

References

1. Hilton, T., Berglund, G.: Sex Differences in Mathematics Achievement: A Longitudinal Study. The Journal of Educational Research 67(5), 231-237 (1974).
2. Lippa, R.A.: Gender Differences in Personality and Interests: When, Where, and Why?. Social and Personality Psychology Compass 4(11), 1098-1110 (2010).
3. Gurer, D., Camp, T.: An ACM-W Literature Review on Women in Computing. ACM 43(2), 121-127 (2002).
4. Gallagher, A.M., De Lisi R., Holst, P.C., McGillicuddy-De Lisi, A.V., Morely, M., Calahan, C.: Gender Differences in Advanced Mathematical Problem Solving. Journal of Experimental Child Psychology 75(3), 165-190 (2000).
5. Verderhus, L., Krekling, S.: Sex Differences in Visual Spatial Ability in 9-Year-Old Children. Intelligence 33(1), 33-43 (1996).
6. Benbow, C., Stanley, J.: Sex Differences in Mathematical Ability: Fact or Artifact?. Science 210(4475), 1262-1264 (1980).
7. Stereotype Threat and the Software Industry Gender Gap, https://spin.atomicobject.com/2012/08/01/women-and-the-software-industry-the-truth-about-stereotypes-retention-and-the-gender-gap/, last accessed 2019/03/04.
8. Atan, H.: Computers in Distance Education: gender differences in self-perceived computer competencies. Journal of educational media 27(3), 123 (2002).
9. Shotick J., Stephens, P.R.: Gender Inequities of Self-Efficacy on Task-Specific Computer Applications in Business. Journal of Education for Business 81(5), 269-273 (2006).
10. Why does India have a higher percentage of women in tech than the UK?, https://www.computerweekly.com/news/252437742/Why-does-India-have-a-higher-percentage-of-women-in-tech-than-the-UK, last accessed 2019/02/28.

11. 2016 SAT test results confirm pattern that's persisted for 50 years - high school boys are better at math than girls, http://www.aei.org/publication/2016-sat-test-results-confirm-pattern-thats-persisted-for-45-years-high-school-boys-are-better-at-math-than-girls/, last accessed 2019/02/20.
12. State Examinations Statistics, https://www.examinations.ie/statistics/?l=en&mc=st&sc=r15, last accessed 2019/02/28.
13. Women in Computer Science, https://www.computerscience.org/resources/women-in-computer-science/, last accessed 2019/02/25.
14. Technology Skills 2022 Ireland's Third ICT Skills Action Plan, https://www.education.ie/en/Publications/Policy-Reports/technology-skills-2022.pdf, last accessed 2019/03/06.
15. Stoet, G., Geary, D.C.:The Gender-Equality Paradox in Science, Technology, Engineering, and Mathematics Education, Psychological Science 29(4), 581–593 (2018).
16. Goldin, C., Katz, L.F.: The Power Of The Pill: Oral Contraceptives And Women's Career And Marriage Decisions. Journal of Political Economy v110, 730-770 (2000).
17. Tenenbaum, H. R.: You'd be good at that: gender patterns in parent-child talk about courses. Social Development 18, 447–463 (2009).
18. Gürer, D.: Women in Computing History. SIGCSE 34(2), 116-120 (2002).
19. Frenkel, A.M.: Women and computing. ACM 33(11), 34-46 (1990).
20. Whitecraft, M.A., Williams, W.M: Making Software. O'Reilly Media, Surrey (2010).
21. Sáinz, M., Eccles, J.: Self-concept of computer and math ability: Gender implications across time and within ICT studies. Journal of Vocational Behaviour 80(2), 486-499 (2012).
22. Morse, T.E.: Ensuring Equality of Educational Opportunity in the Digital Age. Sage Journals 36(3), 266-279 (2004).
23. Jordan Peterson Interview, https://www.youtube.com/watch?v=yZYQpge1W5s, last accessed 2019/03/01.
24. Women in wartime: the rise of the female public servant, https://www.theguardian.com/public-leaders-network/2014/nov/08/world-war-women-workplace-public-services, last accessed 2019/03/02.
25. Perry, D.G., Adam J., White, A.J., Perry, L.C.: Does Early Sex Typing Result from Children's Attempts to Match Their Behavior to Sex Role Stereotypes?. Child Development 55(6) 2114-2121, (1984).
26. Women in Computer Sciences: Closing the Gender Gap in Higher Education, https://www.cs.cmu.edu/afs/cs/project/gendergap/www/, last accessed 2019/03/06.
27. Women and IT by the numbers, http://www.ncwit.org/sites/default/files/resources/2012bythenumbers_web.pdf, last accessed 2019/03/04.
28. Beede, D.N., Julian, T.A., Langdon, D., McKittrick, G., Khan, B., Doms, M.E., Women in STEM: A Gender Gap to Innovation. Economics and Statistics Administration Issue Brief No. 04-11 (2011).
29. The First 1940s Coders Were Women–So How Did Tech Bros Take Over?, https://www.history.com/news/coding-used-to-be-a-womans-job-so-it-was-paid-less-and-undervalued, last accessed 2019/02/27.
30. McKinsey Report, https://assets.mckinsey.com/~/media/857F440109AA4D13A54D9C496D86ED58.ashx, last accessed 2019/02/20.

31. Creating Cultures Where all Engineers Thrive, https://www.raeng.org.uk/publications/reports/creating-cultures-where-all-engineers-thrive, last accessed 2019/02/21.
32. Delivering Through Diversity, https://www.mckinsey.com/~/media/mckinsey/business%20functions/organization/our%20insights/delivering%20through%20diversity/delivering-through-diversity_full-report.ashx, last accessed 2019/02/20.
33. Light, J.S.: When Computers Were Women. Technology and Culture 40(3), 455-483 (1999).
34. Cardia, E.: Household Technology: Was it the Engine of Liberation?. Society for Economic Dynamics 2nd edn, (2008).
35. Lennan, W.: Labour Force Australia 1978-95 (6204.0). Canberra: Australian Government Publishing Service (1996).
36. Teague, G.J.: Women in Computing: What brings them to it, what keeps them in it?. GATES 5(1), 45-59 (2000).
37. Raghuram, P.: Migrant Women in Male-Dominated Sectors of the Labour Market: A Research Agenda. Population, Space and Place 14, 43–57 (2008).
38. Prescott j., Bogg, J.: Segregation in a Male-Dominated Industry: Women Working in the Computer Games Industry. International Journal of Gender, Science and Technology 3(1), 206-227 (2011).
39. The Computer Girls: 1967 Cosmo article highlights women in technology, https://www.siliconrepublic.com/people/women-in-technology-the-computer-girls-cosmopolitan, last accessed 2019/03/03.
40. Irish IT Profile 2018, https://www.ics.ie/news/Irish_IT_Profile_2018, last accessed 2019/03/04.
41. Medel, P., Pournaghshband, V.: Eliminating gender bias in computer science education materials. ACM 17, 411-416 (2017).
42. Smyth, F.L., Nosek, B.A.: On the gender–science stereotypes held by scientists: explicit accord with gender-ratios, implicit accord with scientific identity. Frontiers in Psychology 6, 415 (2015).
43. Verbick, T.: Woman, Technology, and Gender Bias. Journal of Computing Sciences in Colleges 17(3), (2002).
44. Wang, M.T., Degol, J.L.: Gender Gap in Science, Technology, Engineering, and Mathematics (STEM): Current Knowledge, Implications for Practice, Policy, and Future Directions. Educational Psychology Review 29(1), 119-140 (2017).
45. Othman, M., Latih, R.: Women in computer science: No shortage here!. ACM 49(3), 111-114 (2006).
46. The Story of Lena, The Famous Test Image, http://visionexperiments.blogspot.com/2010/06/story-of-lenna-famous-test-image.html, last accessed 2019/03/04.
47. Moradi, B., Huang, Y. P.: Objectification theory and psychology of women: A decade of advances and future directions. Psychology Women Quarterly 32(4), 377–398 (2008).
48. The Truth About Sex Differences, https://www.psychologytoday.com/us/articles/201711/the-truth-about-sex-differences, last accessed 2019/02/25.
49. The More Gender Equality, the Fewer Women in STEM, https://www.theatlantic.com/science/archive/2018/02/the-more-gender-equality-the-fewer-women-in-stem/553592/, last accessed 2019/02/27.