Favorable Factors to Improve Gender Diversity in Cybersecurity Industry

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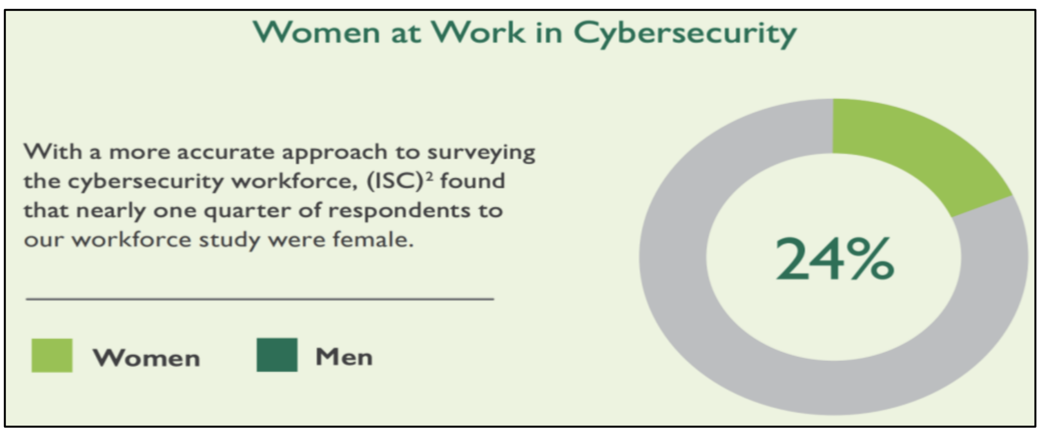
Introduction

The Cybersecurity profession is one where demand is outstripping supply. Based on the technological advancements and ever-increasing threat landscape there will continue to be an increasing need for skilled professionals into the foreseeable future. As per the 2018 cybersecurity workforce report ((ISC)², 2018), shortage of cybersecurity professionals is almost 3 million globally, and close to 500K in only North America. According to their survey, 63% of the organizations have shortage of IT staff dedicated to cybersecurity and nearly 60% said that their companies are at moderate or extreme risk of cyber-attacks due to this shortage. With this extreme shortage, another major concern is gender inequality in this field. As per report published by center for American progress (Warner, Ellmann & Boesch, 2018*)*, women are 50.8% of the total population, but percentage of women in cybersecurity accounts for only 24% of the complete workforce ((ISC)², *2019*). This is a very disturbing fact for organizational as well as national security, as cyberwarfare has been identified as 5th domain of warfare by North Atlantic Treaty Organization (NATO), (Paganini, 2016) and all upcoming wars are expected to be in cyber realm. This problem of underrepresentation and underutilization of women needs to be solved to shrink the increasing shortage of cyber professionals. Also, it has been stated (Kerby & Burns, 2013) that diversity (gender/racial) can have positive impacts on learning and performance outcomes, and is linked to improved innovation, better work culture and enhanced business outcomes. Both McKinsey & company (Hunt, Layton & Prince, 2015) and Center for American progress (Kerby

& Burns, 2013) suggest that companies with more diverse workforce perform better financially and drive economic growth.

Source: (2018 (ISC)² Cybersecurity Workforce Study, 2018)



Source: ((ISC)² Women in Cybersecurity, 2019)

Efforts are being made worldwide to attract and retain more women in global cybersecurity profession, but it has not made much meaningful impact as of yet, as this problem runs deep down in our value and cultural system and not at tertiary organizational level. "Beyond 11%" report (Kaspersky Lab, 2017*)* studied 4,001 young people (comprising of 50 - 50 male and female split) between the age group of 16-21, from UK, USA, France, Germany, Italy, Spain, Israel and the Netherlands, and revealed that before the age of 16, most young women have already decided against a career in cybersecurity. This study found that there is a perception problem around cybersecurity, 78% of young women have never considered a career in cybersecurity, it is for the 'geeks' and 'nerds' as per them. Reports ((Kaspersky Lab, 2017*)* & ((ISC)², *2019*)) state that lack of interest in STEM courses, mathematics, coding along with shortage of high-tech women role models and low visibility in cybersecurity roles are general reasons for lower percentage of women in this profession.

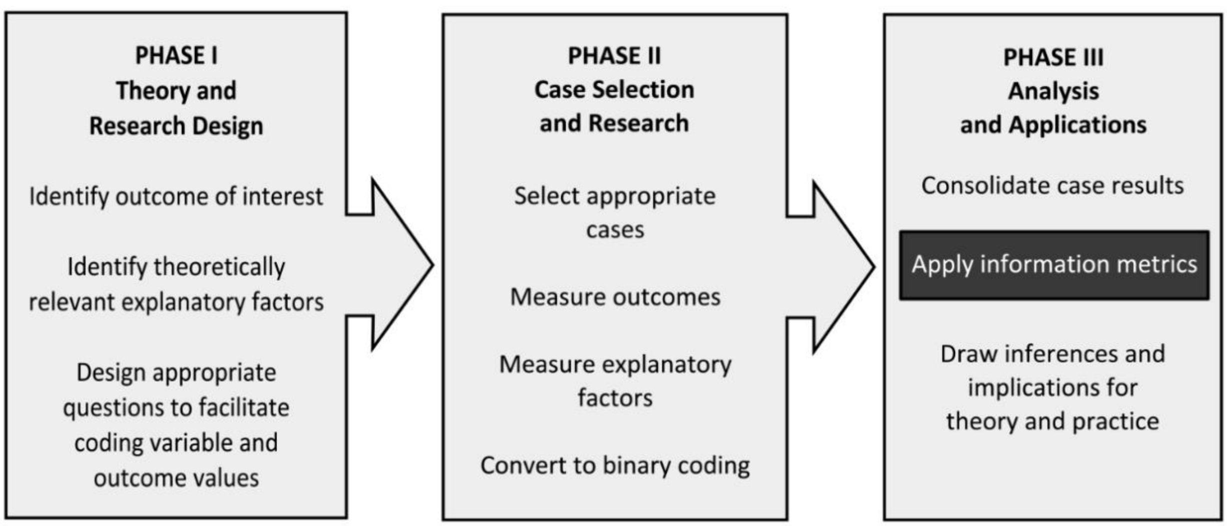
However, there are certain women leaders who have broken this glass ceiling and are flourishing in their high-tech roles, the purpose of this paper is to formulate a framework to identify external and internal factors from such women leaders, which can be further enhanced upon to formulate thoughtful policies and programs both at national and organization level to improve gender diversity in cybersecurity profession.

For the purpose of this paper, a book "*Nevertheless, she persisted: True stories of women leaders in tech"* (Gluckman, 2018), comprising of stories of 19 successful technical women leaders has been taken as a base. Few common external and internal factors are analyzed in these 19 different cases to identify the most impactful ones which decide whether a woman would choose to get into a cybersecurity related role or would prefer more managerial or other aspects of software development role. As per the analysis done in this paper, two most important factors which favored a particular woman to choose technology-oriented cybersecurity role are "early age interest in STEM related courses" followed by "Parental background in STEM degrees".

Research Design

Research Problem: To identify favorable factors which lead to a woman succeeding in or taking up cybersecurity profession.

Research design to solve the abovementioned problem statement is based on the structured – focused comparison method defined in the book "*Quantifying the qualitative: Information theory for comparative case analysis*" (Drozdova & Gaubatz, 2017). This method for structured – focused comparison of different case studies aids quantifying the qualitative data for more systematic analysis and identify the factors having maximum impact on the outcome. This method is divided in three phases as mentioned below:



Source: Drozdova & Gaubatz, 2017. Quantifying the qualitative: Information theory for comparative case analysis.

All the data collected and analyzed is bifurcated into these 3 phases for better understanding:

Phase 1: Theory and Research Design

- ***Identify outcome of Interest:*** Female Cybersecurity professional
- ***Identify theoretically relevant explanatory factors and relevant questions:*** Factors have been divided into two categories i.e. external and internal factors.
  - *External Factors:* National or state level factors in which the woman is raised, and she cannot do anything to change them. Universal factors of all women in same birth country
    - Birth country culture toward women in technology
    - Birth country education system
  - *Internal Factors:* Factors at family level and which are in control of the women herself.
    - Parental background
    - Early Interest in STEM
    - Personal Trait (Introvert/Extrovert)
    - STEM Background

Phase 2: Case Selection and Research

- ***Select appropriate cases:*** Complete book *Nevertheless, she persisted: True stories of women leaders in tech* (Gluckman, 2018). has been taken as the epic, with each woman story as a single case, 19 in cases in total.
  1. Telle Whitney: Former CEO, Anita Borg Institute
  2. Pam Kostka: CEO at All Raise, Former CEO loop and Bluebox security
  3. Yanbing Li: Senior VP and GM, Storage and Availability BU at VMware

4. Annabel Liu: Co-founder and VP of Engineering, Curated
5. Jennifer Anderson: Sr. Director of Engineering, Uber
6. Anne Holler: First Women principal engineer at VMware, member of technical staff at Uber
7. Patty Hatter: Senior VP McAfee, Strategic advisor and board member to multiple startups
8. Shilpa Lawande: CEO and Co-founder Postscript.us
9. Dahlia Malkhi: Principal researcher and Co-founder of VMware research
10. Alaina Percival: CEO and board member, Women who code
11. Christine Martino: COO of cybersecurity, Legal, Compliance, and Policy at Intuit
12. Marianna Tessel: CTO, Intuit
13. Dr. Malina M. Hills: Senior VP Space systems group at the Aerospace Corporation
14. Sarah Clatterbuck: Director of Engineering, Google
15. Ana Pinczuk: Chief Transformation Officer, Anaplan
16. Erica Lockheimer: VP of Engineering, LinkedIn
17. Orna Berry: VP of Dell EMC and GM of Israel Centre of Excellence
18. Lily Chang: VP, Strategic Transformation, JV VMware
19. Orna Berryman: Director of Cloud Program Management and Ops, Google

- ***Measure Outcome:*** As per industry standards taken from ((ISC)², 2019), a women is categorized to be working in cybersecurity domain if she has cybersecurity certification or if she is working in an official cybersecurity function or if she is an IT/ICT professional who spend at least 25% of her time working on cybersecurity responsibilities.

If woman comes under any of these 3 categories, then outcome is ‘1’ else ‘0’.

- ***Measure Explanatory Factors and convert to binary coding***
  - *External Factors:* National or state level factors in which the woman is raised, and she cannot do anything to change them. Universal factors of all women in same birth country.
    - Birth country culture towards women in technology: This factor is ‘1’ if country culture is perceived to be promoting equality in technology roles. If technology is culturally viewed as ‘Men’s world’, then this factor is ‘0’. Birth countries applicable in this case:
      - United States of America
      - China
      - Israel
      - India
      - Argentina
    - Birth country education system: This factor is ‘1’ If STEM courses are mandatory till high school i.e. class 10^{th}, if there is flexibility in choosing subjects at high school level then this factor is ‘0’. Same birth countries are applicable as above.

Information around external factors i.e. Birth country’s culture towards women in STEM and Birth country’s educational system enforcing STEM subjects in high/secondary school are based on the perception portrayed in each of the 19 cases and country wise STEM reports available online (Marginson, Tytler, Freeman, & Roberts, 2013) of each of the mentioned birth countries.

- *Internal Factors:* Factors at family level and which are in control of the women herself.
    - Parental background: This factor is '1' If parents are in STEM background, otherwise '0'
    - Early interest: This factor is '1' if woman shows early interest in STEM background i.e. before 15 years of age, else '0'
    - Personal trait: This factor is '1' if woman is an introvert, '0' if extrovert
    - STEM background: This factor is '1' if woman takes STEM courses at undergraduate level, otherwise '0'

Phase 3: Analysis and Application:

- ***Consolidate Case Results:*** As per the binary coding mentioned above, all the 19 cases are measured on those internal and external explanatory factors and end outcomes. All the binary units in below mentioned truth table, '1' and '0' are marked as per data available in the book (Gluckman, 2018). Information around external factors i.e. Birth country's culture towards women in STEM and Birth country's educational system enforcing STEM subjects in high/secondary school are based on the perception portrayed in each of the 19 cases and country wise STEM reports available online (Marginson, Tytler, Freeman, & Roberts, 2013) of each of the mentioned birth countries.

	Birth country culture	Birth country education	Parental Background	Early Interest	Personal Trait	STEM Background	Cybersecurity
Telle Whitney	0	0	0	0	0	1	0
Pam Kostka	0	0	1	1	0	0	1
Yanbing Li	1	1	1	1	0	1	1
Annabel Liu	1	1	0	0	1	1	0
Jennifer Anderson	0	0	1	1	1	1	1
Anne Holler	0	0	0	1	1	1	1
Patty Hatter	0	0	1	1	0	1	1
Shilpa Lawande	0	0	1	0	0	1	0
Dahlia Malkhi	1	1	0	1	1	1	1
Alaina Percival	0	0	0	0	0	0	0
Christine Martino	0	0	1	0	0	0	1
Marianna Tessel	1	1	1	1	0	1	1
Dr. Malina M. Hills	0	0	1	0	1	1	1
Sarah Clatterbuck	0	0	0	1	0	1	0
Ana Pinczuk	0	0	1	0	0	1	0
Erica Lockheimer	0	0	0	0	0	1	0
Orna Berry	1	1	1	1	0	1	1
Lily Chang	1	1	0	0	0	1	0
Orna Berryman	1	1	0	0	0	0	0

- ***Apply Information Metrics:*** This phase uses the backbone of information theory to further structure the collected information. *Quantify, count, compute* and *compare* are the four fundamental steps in this phase.

  All the results are plotted in binary, which provides a systematic understanding of different systems and how they impact the final outcome. First the variables are plotted in a truth table as showcased above, with 0 and 1 as the certain outcomes of independent variables. Then total frequency of each event's occurrence is counted followed by calculating of overall probability, joint probability and conditional probability. Once we have the probabilities, then computing the entropy or uncertainty is just a matter of putting those numbers in the formula. With conditional entropy and direction, we can compare each of the variable and see which one has the most impact on the outcome.

	Birth country culture	Birth country education	Parental Background	Early Interest	Personal Trait	STEM Background	Cybersecurity
Telle Whitney	0	0	0	0	0	1	0
Pam Kostka	0	0	1	1	0	0	1
Yanbing Li	1	1	1	1	0	1	1
Annabel Liu	1	1	0	0	1	1	0
Jennifer Anderson	0	0	1	1	1	1	1
Anne Holler	0	0	0	1	1	1	1
Patty Hatter	0	0	1	1	0	1	1
Shilpa Lawande	0	0	1	0	0	1	0
Dahlia Malkhi	1	1	0	1	1	1	1
Alaina Percival	0	0	0	0	0	0	0
Christine Martino	0	0	1	0	0	0	1
Marianna Tessel	1	1	1	1	0	1	1
Dr. Malina M. Hills	0	0	1	0	1	1	1
Sarah Clatterbuck	0	0	0	1	0	1	0
Ana Pinczuk	0	0	1	0	0	1	0
Erica Lockheimer	0	0	0	0	0	1	0
Orna Berry	1	1	1	1	0	1	1
Lily Chang	1	1	0	0	0	1	0
Orna Berryman	1	1	0	0	0	0	0
a	0.210526316	0.210526316	0.421052632	0.42105263	0.210526316	0.421052632	
b	0.315789474	0.315789474	0.105263158	0.10526316	0.315789474	0.105263158	
c	0.157894737	0.157894737	0.105263158	0.05263158	0.052631579	0.368421053	
d	0.315789474	0.315789474	0.368421053	0.42105263	0.421052632	0.105263158	
H(Y)	0.9980	0.9980	0.9980	0.9980	0.9980	0.9980	
H(Y|X)	0.9950	0.9950	0.7420	0.6180	0.9160	0.9970	
I(Y; X)	0.0030	0.0030	0.2560	0.3800	0.0820	0.0010	
Direction	Positive	Positive	Positive	Positive	Positive	Positive	

As stated in the book (Drozdova & Gaubatz, 2017), the magnitude of the mutual information I(Y;X) score provides a numerical scale for making a systematic comparison. It indicates the relative contribution of each factor to reducing uncertainty about the outcome. When mutual information is close to the original uncertainty value, it means that the factor almost perfectly predicts the outcome.

- ***Draw inferences:*** Above showcased analysis depicts that the most important factors which favors a woman choosing cybersecurity related career depends on their **early interest in STEM courses** followed by their **parental background**. Other factors seem to be negligible in supporting the cause.

For each of the case, all 6 factors are analyzed and plotted in the above showcased table on the basis of information mentioned in the book. These particular 6 factors are chosen because of their relevance in almost all of the cases mentioned in the book (Gluckman, 2018) as well as author's official website i.e. www.pratimagluckman.com.

Conclusion and Implications

If more thought is given over these two factors, then it actually strengthens the Beyond 11% report (Kaspersky Lab, 2017*)* that maximum females decide their career choices on the basis of their early age interest. These early age interests are usually strengthened by parental or any guardian support and having one or both parent in STEM background gives them early exposure to technology world and also a tremendous motivation to take it further in their career.

It can be concluded from this study that if government and educational institutions focus on incorporating STEM courses at an early age in more engaging and interesting way then this can help improve the overall ecosystem of women participation in core STEM courses and hence in more cybersecurity roles. Few suggestions in this area can be:

- Introducing interesting interactive courseware for better understanding of STEM courses instead of traditional textbook ways
- Introduce vocational studies or summer camps for early exposure to coding and animations to attract their interest at early interest.
- Introduce tools like abacus, math blocks, counting stacks, flash card etc. in regular school course curriculum and introduce more virtual games in the market to showcase both math and technology as interesting subjects and not 'nerdy' subjects.
- Don't only hire outstanding women but hire good women as well in tech related roles to achieve critical mass in cybersecurity workforce and make it more inclusive, which can further attract future generations to take interest in this area.

Bibliography

Gluckman, P. (2018). *Nevertheless, she persisted: True stories of women leaders in tech.* . FriesenPress.

Drozdova, K., & Gaubatz, K. T. (2017). *Quantifying the qualitative: Information theory for comparative case analysis*. Los Angeles: Sage Publications.

Boesch, D, Ellmann, N. & Warner, J., &. (2018, November 20). *The Women's Leadership Gap* (Rep.). Retrieved from Center for American Progress https://cdn.americanprogress.org/content/uploads/2018/11/19121654/WomensLeadershipFactSheet.pdf

ISC)². (2019, April 02). *Women in Cybersecurity*(Rep.). (2019, April 2). Retrieved https://www.isc2.org/-/media/ISC2/Research/ISC2-Women-in-Cybersecurity-Report.ashx?la=en&hash=270117229EA39FA1E7134CFB1C5BB1ACBDF8A88C

(ISC)², (2018, October 17). *2018 (ISC)² Cybersecurity Workforce Study*. Cybersecurity Professionals Focus on Developing New Skills as Workforce Gap Widens. Retrieved from https://www.isc2.org/-/media/ISC2/Research/2018-ISC2-Cybersecurity-Workforce-Study.ashx?la=en&hash=4E09681D0FB51698D9BA6BF13EEABFA48BD17DB0

Burns, C. & Kerby, S., (2013, January 30). The Top 10 Economic Facts of Diversity in the Workplace. Retrieved from Center for American Progress Progresshttps://www.americanprogress.org/issues/economy/news/2012/07/12/11900/the-top-10-economic-facts-of-diversity-in-the-workplace/

Paganini, P. (2016, June 18). NATO officially recognizes cyberspace a warfare domain. Retrieved from https://securityaffairs.co/wordpress/48484/cyber-warfare-2/nato-cyberspace-warfare-domain.html

Hunt, V., Layton, D., & Prince, S. (2015, February 02). *Diversity Matters*(Rep.). Retrieved https://www.mckinsey.com/~/media/mckinsey/business functions/organization/our insights/why diversity matters/diversity matters.ashx

Kaspersky Lab. (2017). "*Beyond 11%: A study into why women are not entering cybersecurity"* Retrieved from https://d1srlirzdlmpew.cloudfront.net/wp-content/uploads/sites/86/2017/11/03114046/Beyond-11-percent-Futureproofing-Report-EN-FINAL.pdf

Freeman, B., Marginson, S., Tytler, R., & Roberts, K. (2013). *STEM: Country comparisons*. Report for the Australian Council of Learned Academies. Retrieved https://acola.org.au/wp/PDF/SAF02Consultants/SAF02_STEM_ FINAL.pdf

Drori, G. S., & Netivi, A. (2013). *STEM in Israel: The Educational Basis for "Start-Up Nation"*(Rep.). Report for the Australian Council of Learned Academies. Retrieved https://www.researchgate.net/publication/306106534_STEM_in_Israel_The_Educational_Foundation_for_'Start-Up_Nation'

Gao, Y. (2013). *China's STEM System*(Rep.). Report for the Australian Council of Learned Academies. Retrieved https://acola.org/wp-content/uploads/2018/12/Consultant-Report-China.pdf

Roich, C. F. (2013). *Study of Science, Technology, Engineering and Mathematics (STEM) and STEM-related issues in Argentina*(Rep.). Report for the Australian Council of Learned Academies. Retrieved https://acola.org/wp-content/uploads/2018/12/Consultant-Report-Argentina.pdf