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Paths and Barriers to Positions of Leadership in Software Development - A study through the female 'lens'

Bachelor of Science Thesis in Software Engineering and Management

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{Investigating female paths and barriers}
[An exploratory case study investigating the career paths female software developers take to achieve positions of leadership and the barriers they face along the way.]

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Abstract—Studies in the fields of Business, Management and Software Engineering have shown that women make up an important demographic of the work-force and are contributing members to their work environments, however there is still a significant gender-gap in many fields including software engineering. The gender gap in positions of technical leadership in software development is even larger despite the comparable performance between men- and women-led start-ups. This study aims to investigate the cause of the lack of female representation in technical leadership positions in software development by examining the paths female technical leaders have taken, the barriers or obstacles they have faced and the ways in which they have mitigated those barriers or obstacles.

Index Terms—

I. INTRODUCTION

Women make up a minority of people in management positions as well as in other positions within software development organisations and generally in science and technology related fields. It has been shown that women are more often stuck in junior positions compared to men of the same age [1], that the barriers facing women in stem and women in management are roughly the same [2], but the intersection of women in the software industry and women in management/positions of leadership is an area that not much is known about at this point. Research has shown that when women are in positions of leadership/management, the companies thrive [3], increased gender diversity in stem has also been shown to increase good communication and productivity, and decrease conflict [4], but there is very little research about female leaders in software development and engineering specifically. Although women and female leaders have been shown to be an asset to the workplace, a large gender gap in software development and especially positions of leadership in Software Development remains.

A study of women in positions of leadership within software industry needs to be done to understand why women leaders are so lacking despite the benefits they bring. Past studies have focused on women in stem, or women in management/leadership in general. Previous studies related to our topic tell us that women are opting for non-technical leadership roles in technology [2][3][5]. The number of female developers and women working in technology increases every year, but women are overwhelmingly stuck in junior software development role [1], and we do not yet know why there are so few women in leadership positions. One problem is that there is a major gap of information and research in the area. In addition, there exists several barriers to female participation in software development. For example, on GitHub open source projects contributions, Wang [6] reported that to establish confidence(in their competence), female developers need certain levels of social attraction i.e., being liked by the other community members. On the other hand, according to Ruiz [7], due to the differences in competencies of women and men in the practice of software development there is a tendency to associate personnel manager roles and social skills with femininity, thereby expecting such skills from female candidates. Ruiz elaborates on the different perspectives of male and female software developers regarding product quality stating that where men focus more on product quality and process aspects, women are more interested in the clients' requirements [7].

By conducting a case study on women with technical backgrounds working in positions of leadership in software development, this study will attempt to give insight into the niche of women in positions of leadership in software development and provide data about an area on which there is little research. The contributions of this study are twofold: firstly, the results of the interviews conducted for this study showing the paths that women have taken to achieve positions of leadership through software development will help prepare women thinking of a career in the IT industry by showing them career paths taken by other women in the field who advanced into a position of leadership. It will help prepare women currently in the software industry who are thinking of applying for a position of leadership what types of professional barriers or obstacles the women before them have faced, and how those women overcame said barriers or obstacles as well as what types of companies, software development projects, and software development development styles are most conducive to creating, supporting or hiring female leaders. Secondly the results of this study will help educational institutions in

creating the female leaders of tomorrow. By understanding the career paths, profiles or personas of a typical female leader in the software industry, the barriers or obstacles facing women in becoming technical leaders, and the importance of role models in women's career choices, educational institutions will be able to create or modify existing programs and environments that are more effective in producing female leaders in software development.

II. LITERATURE REVIEW

Studies of gender and gender diversity in software development teams have increased significantly in recent years [1][4]. Much of the focus has been on investigating the effects of gender-diverse teams on team's productivity [8], communication patterns [4], ways to increase or support gender diversity [9][10], or simply investigating levels of gender diversity in software development teams [11]. These studies observed that gender-diverse teams show increased productivity [8], have good communication patterns [4], are empowered in practices such as agile development [11] and brainstorming [10]. However, there are very few studies that have investigated gender-diversity, particularly women, in leadership roles in software development teams/companies. The gender gap in learning to code is shrinking, and more women are choosing Computer Science as a degree major, women know the top in-demand programming languages, and are working in tech, finance and education sectors where technical backgrounds are desired if not necessary [1]. The percentage of women in positions of leadership in tech is still the minority [5], as women age they find themselves in junior roles at higher percentages compared to men of the same ages [1]. There is a need for more research investigating the reasons for the gender gap in technical leadership positions, and barriers to having more women in technical leadership roles. More women in positions of leadership will lead to more potential role models. Quimby and DeSantis found that role models have a small but significant influence on women's career choices and that role models may be especially important for high school and college age females in pursuing a (gender-) nontraditional career [12].

A. Diversity concept

For the purpose of this study diversity refers to gender diversity in the field of software engineering, software development, and computing. '(Women in) Position(s) of leadership (in tech)' is often mentioned in this paper, and women in positions of leadership with technical backgrounds were interviewed for this study; The definition of a woman in a position of leadership in tech/with a technical background for the purpose of the study is: being female in a leadership position (such as senior developer, product owner, project manager, tech lead, team lead, engineering lead/manager, Director of Engineering, VP of Engineering, CTO, CIO, COO, CEO), working in the technology field (such as a tech-based company or start-up) with a background in software development (studied or has degree/certification in Software Engineering/Computer Science/ or related field), has previously worked as a software developer or in a technical position (data analyst, data scientist, information security analyst, IT, Network/System admin, or related) leading technical people who also currently work in the above fields.

B. Overview of diversity research in SE

Colwill and Townsend [3] explored the impact of women leaders on organizations aiming to be globally competitive. Colwill and Townsend conclude that the values of future organizations may be more suitable for women, and that a blend of traditional male and female values are necessary for the global success of organizations. Although this paper does focus on women in organizations, it doesn't limit the scope to women with technical backgrounds as this thesis intends to do. McCullough [2] studied barriers to participation for women in Stem and concludes that more research is needed in the area. Particularly, the author [2] reported that women in STEM leadership need to overcome hurdles in both their content areas and in leadership areas since barriers to women in stem overlap with the barriers to leadership. Other barriers reported in the study include implicit bias, discrimination, family obligations, and lack of mentors/role models [2]. Colwill and Townsend's scope is women in STEM and it states that more research is needed.

According to Adams and Weiss in Gendered Paths to Technology Leadership [5] the lack of women in STEM has been a concern in years. As our society shifts more and more toward technology based companies, the demand for STEM jobs increases. Women make up roughly half the population and therefore inclusion in STEM positions will be increasingly necessary. The results of the paper show that women aspiring to be technology leaders are assuming roles that focus more on business and change management than technology and that the stereotype of women having better people skills may be to their advantage in "preparing them for advancement" [5]. Adams and Weiss found that achieving a senior level management position in technology requires not only technological expertise but business knowledge and personnel management as well. They also found that people in technology management, regardless of gender, spend more time as business experts than as technologists. Adams and Weiss compare the paths of both men and women, they do not focus on finding distinct paths but rather the amount of time spent as technologists vs. business experts and role satisfaction among males and females. Adams and Weiss' scope is people in positions of technology leadership, which is much broader that the scope of this paper.

Finally According to a study conducted by Hacker Rank [1], in which a total of 14,000 software developers were interviewed, women of all ages, more so than men, find themselves stuck in junior roles. Hacker rank found that women ages 18-24 were 1.1x more likely to be in a junior role compared to men; from age 25-34 the likelihood increased to 1.8x and from age 35+ the likelihood jumped to 3.5%. One point of consideration is that it's not clear from the study

whether women are starting their careers later than men. This study also intends to investigate when and how women are starting their software development careers.

There is some degree of diversity research in software engineering, most of which is aimed at gender diversity in lower-level or junior positions. The purpose of this study is to investigate female leadership-roles, not by comparing to men as most gender-diversity studies do, but by examining different possible paths taken by women to achieve technical leadership roles in software development.

C. Women in leadership positions in SE

The focus of papers on women in leadership in software engineering have been on leadership style [13][14], performance of the enterprise [15], preventative causes to women from applying to certain positions [16].

1) Leadership Style: ”Leadership” has been defined in the literature , as ”behavior of an individual ... directing the activities of a group toward a shared goal” and ”... ability of an individual to influence, motivate, and enable others to contribute toward the effectiveness and success of the organization ...” [17][18]. Although women have been shown to be effective leaders, they are still underrepresented in engineering and technology which can be problematic, leading to waste of talents and lack of creativity in the workplace [13]. A Norwegian study investigating female leadership characteristics and it's effect on project outcomes [13] had inconclusive results but found a correlation between perception of team leadership and perception of task management; the study was able to confirm that communication was a crucial factor in team success. A study on female-led innovative Italian startups investigating how women approach decision-making, networking, innovation, creativity, and co-creation [14] found that women led start-ups (where all owners and directors are women) make up only 4.5% of all innovative Italian start-ups. The results of the study showed that female start-up leaders emphasize the importance of team and talent diversity, and value the contributions that come from having a diverse team. The study also found that ”participative leadership that fosters integrated thinking and participatory processes of co-creation” and ”a strong focus on personal relationships and networking as an added value of the business model” were critical to success of the birth and growth of the start-ups in the study.

2) Performance: Female entrepreneurship is one of the fastest growing business populations around the globe and makes compelling contributions to employment, innovation and wealth creation of all economies around the world [19][20][21][22]. However there are diverging thoughts in literature about the success of female-led start ups vs male-led start-ups. An Italian study found that there were no profound differences in female-led startup size or profitability [15], although female start-up were on average slightly larger (with female-led startup having an average on 11 employees and male-led startups an average of 9 employees). Female-led startups were also shown to be slightly more profitable than their male-led counterparts (1.33% sales profitability to

0.68%), which was contrary to previous literature. Analysis indicators, including revenue generated per employee, added value per employee, total asset turnover ratio, and working capital turnover ratio, found that women-led start ups outperformed men's in every category except added value per employee where women-led startups lagged 4.6% behind their male counterparts. However the result is that women-led startups were shown to be more efficient than men's. The study also examined financial structure and found that women-led start-ups raise an average of 6.9% less capital that men-led startups but were also more indebted and therefore had a higher leverage ratio (22.00 for women and 10.14 for men). Finally financial management was taken into consideration where liquidity and current ration were slightly higher in men-led startups (1.36 and 1.55 to 1.33 and 1.54)however interest expense to revenue ration was lower in women-led start-ups (0.88% to 1.02%). The final results show that women-led start-up do not lag behind men generally however they do, on average, have less owner equity and funding [15].

3) Barriers: A Finnish study was conducted to investigate female barriers to applying for certain software engineering roles [16]. Finland has one of the highest rates of gender equality of education and employment levels in Europe [23]; however women still face some barriers to entry in certain careers. The study found that negative experiences, equal learning opportunities, attitudes toward computing, and self efficacy (one's own belief in their ability) were statistically shown to affect women's tendency to apply to software engineering roles. Early negative experiences in the field and a perceived lack of equal opportunities in school reduced the likelihood that some women would be working in software engineering roles in the future. These were fully mitigated by self efficacy and attitudes toward the field of software engineering. General self-efficacy had no effect, suggesting that early negative experiences and perception of male-domination had an impact on female computing self-efficacy and their likelihood of finding work in the field. The scope of this study was limited to women in Finland and therefore it proposes expanding the geographic scope for further investigation.

Previous studies touch upon the fact that there are fewer women in positions of leadership, even though (contrary to perceptions and literature on the topic) they are not underperforming compared to their male counterparts, but make no mention of why that might be the case. This study attempts to investigate why there seems to be so few women in positions of leadership in software development by interviewing women in Western Europe to investigate perceived barriers to entry into technical positions of leadership; while to some degree expanding upon the Finnish study.

III. RESEARCH APPROACH

The research approach of this thesis is exploratory case study [24]. A case is particularly effective in studying phenomena when the boundary between the phenomena and its context are unclear, as is common in software engineering [24]. The purpose of an exploratory case study is to find

out what is happening in a particular area, seek new insights and generate ideas and hypotheses for new research [24]. The exploratory case study research methodology is selected because of the fact that there is a gap of knowledge in the area. It has been suggested that this paper could qualify as a field study, however field studies typically require site-visits, participant observation, ongoing research [25]; they can be very expensive and can take years to complete. This is a topic that would benefit from more in-depth research such as a field study, however due to the time constraints, the exploratory case-study method was chosen and conducted. Qualitative data will primarily be collected through semi-structured interviews, some participant background data will also be collected from the provided CV's of the interview participants. This case study follows the suggested guide outlined in previous literature stating that a case study consists of five process steps: Case Study Design, Preparation for Data Collection, Collecting Evidence, Analysis of Collected Data, and Reporting [24].

A. Case study design

Robson 2002 [26] states that a case study design should contain information of what is to be achieved, what is to be studied, a frame of reference, research questions, methods of data collection, and a data selection strategy. In designing a case study there are also ethical considerations that must be made to accommodate sensitive data [27]. Following the ethics proposals made by Runeston and Höst [24], informed consent was required of interview participants before interviews took place. Participants were made aware: that the interview was recorded before hand, of any and all uses of the collected data, and all interview participants remain anonymous to ensure confidentiality.

This study aims to identify the paths to positions of leadership for women with technical backgrounds, the profile of a female leader, the barriers or obstacles faced on the chosen career path, and the barrier or obstacle mitigation strategies used by these women to achieve their positions of leadership. In order to achieve those outcomes, women in positions of leadership in software development with technical backgrounds were interviewed I. Runeston and Höst's work was used as a reference and basis for creating the Interview Guide Questions (see Appendix). Prior to interviews, the interview guide was piloted with a senior level software engineer and a senior level software development consultant. Participants for the study were selected based on criteria of being women with previous backgrounds in software development currently leading or managing others in a software development effort; the extent of the participant selection criteria is explained in the 'Diversity Concept' section.

B. Research Questions

The RQ's were formed on the basis that this thesis is an exploratory case study. The RQ's were formulated to provide answers that give a clearer understanding of the topic and help to define the problem and it's context(guide to research questions). The main research questions (RQs) of the thesis are:

1) RQ 1: Is there a typical career path for a woman with a technical background to a position of leadership?
   - RQ 1A: What is the profile of a female leader in software development?
2) RQ 2: What Barriers to positions of leadership are women with technical backgrounds facing?
   - RQ 2A: What key factors exist in companies with female leaders with technical backgrounds?

Rationale for RQs:

RQ1: Through a review of existing literature(Section II) it has been established that although women are valuable to the software development workplace they are still more likely than their male counterparts to to be in a junior role regardless of age. The goal of this RQ is to investigate the reasons why women are stagnating or not advancing as quickly in their careers in software development. RQ1A: This addresses the hypothesis that women are keeping themselves from leadership positions; through actions such as not applying to higher level roles, or opting for entrepreneurship, etc. We want to know what paths, if any, lead women to leadership roles. RQ2: Investigates barriers, the barriers to management facing women are well documented, as are the barriers to women in STEM and specifically software development to some degree. This questions aims to investigate whether the intersection of software development and management (positions of leadership) comes with a distinct set of (or lack) barriers to women not present outside of the intersection. RQ2A: Investigates if there is a certain type of woman more prone to achieve positions of leadership. Investigates the person. RQ2B: Investigates the context, the structures around the person. Investigates if there are certain project types, company types, company cultures, (etc.) or qualities that promote or attract female leaders.

1) Validity: According to Runeston and Höst [25] validity concerns affect the trustworthiness of the results of a study. By addressing validity issues from the starting phases of a case study, researchers can mitigate any factors that would contribute to bias and falsehood of the results.

2) Construct Validity: Construct validity ensures that the results of the study reflect the aims set forth by the research questions [24]. A possible threat to construct validity of this study would be unclear or misinterpreted interview questions.

TABLE I
PARTICIPANTS

ID	Role When Interviewed	Path
T1	VP of Engineering	Stay Technical
T2	Software Architect and Designer	Stay Technical
T3	Tech Lead	Stay Technical
M1	CIO	Aim For Management
M2	Senior Consultant	Aim For Management
M3	Consultant	Aim For Management
M4	Agile Project Leader	Aim For Management

In order to mitigate construct validity in this study, the interview guide was created to answer research questions that were the result of recommendations proposed by Runeston and Höst [24]. The interview guide was also piloted with two senior level professionals in the software industry and was revised according to feedback given on the clarity of the questions. Another way this study mitigates possible misunderstandings in the interview questions is by conducting semi-structured interviews that allow for a bit of dialogue and clarification in the moment by the researcher. A construct validity threat of this study is that detailed background questions were not asked about each and every position in the career path of the participants. Some participant provided CV's with job descriptions of the positions and others described their positions from which responsibilities were extracted by the researcher. A suggestion for improvement would be to ask for a detailed account of the responsibilities of each role in the career path for more consistent and accurate results.

3) Internal Validity: Internal validity refers to whether a study can refrain from confounding independent variables possibly active at the same time [24]. Ways to mitigate this validity threat are to ensure that the proper steps are taken throughout selection, data collection and analysis. Because this is an exploratory case study, there is not much comparison of existing data that occurs and therefore the main internal validity threat is data analysis. Data was be analysed according to industry standards [28]. Findings of the data will be compared with existing literature on the topics. Another possible threat to the validity of this study is that it attempts to investigate a multi-faceted problem in a simplistic way. It is impossible to know why there are so few women in positions of leadership in software development from this study alone. The findings point to many possible contributing factors, however, cannot scientifically prove the claims.

4) External Validity: External validity refers to the ability, or to what extent the findings of the study can be generalized [24]. Due to the nature of this exploratory study, there are two main external validity threats that can occur. First is the interaction of selection and treatment: the extent to which the results of the study can be generalized from the context of women in positions of leadership is questionable. Also questionable is the degree to which the results are specific to women in software development. Although this study does not make any claims that the findings are only female-specific, the study could be interpreted that way. The literature states that men largely face similar barriers as women, however that was outside the scope of this study and therefore not considered. Further investigation is needed in order to make any claims regarding whether or not the findings are gender specific (i.e. women only). The nature of this study is specifically geared toward providing insight on- and investigating the profile of a female leader in this field, paths that women have taken to achieve positions of leadership, barriers they have faced, possible mitigation strategies, and any advice they would give to future female leaders, not necessarily providing conclusive answers.

The second external validity threat is the interaction of history and treatment. Much of what has been said in the interview seems to cast doubt on the results of past literature regarding barriers to women in software development. It's possible that previous literature is outdated, and that gender and social dynamics at play in the industry have advanced since the date of publication of the literature references therefore making history a contributing external validity threat; just as a recreation of this study 10 years in the future might provide different results due to diversity and equality advancements in the industry. It is also possible that the literature is correct and the small and very diverse sample size of this study skewed the findings to the point that they contradict the literature.

Data was collected from female leaders in different countries in Europe; local culture could be a contributing factor that affects both internal and external validity. The size of the study is another validity threat. The small sample size of 7 total participants make it hard to draw solid general conclusions. Although saturation of data was reached in some areas, more participants would aid in drawing conclusions. This study cannot make any scientific claims based on the findings alone, but it can serve as a basis for future work.

5) Reliability: Reliability refers to the extent to which a study can be reproduced without error; theoretically producing the same results [24]. In order to mitigate reliability threats, all aspects of data handling in the study are derived from literature in the field of the study. All steps in this study have been outlined for possible reproduction. A major reliability threat of this study is the sample size of the participants. The study can be reproduced, however there is a possibility that the result may be drastically different with a different sample(more participants, geographically different sample, participants from the same geographical area, participants with more homogeneous work experiences, etc.).

IV. DATA COLLECTION

The data in the study was collected through semi-structured interviews. 52 women in positions of leadership in tech(as defined by this paper) were found and contacted via colleagues of the researcher and various online professional networking platforms (LinkedIn, 50inTech) with an invitation to participate. 0f those 52, about 14 people responded with intention to participate or directing the researcher to other possible participants. A total of 9 one-on-one interviews were performed, due to scope 2 of those interviews were ruled out. A total of 7 interviews that have been included in the results. The interviews were conducted online, took between 30 min and 1.5 hours, and were recorded with the permission of the participants. The participants in the study come from a variety of backgrounds and countries in Europe. All participants have a background in software development and currently hold a position of leadership in a software development organization. Please see Table **??** for for more info on the interview participants. The interviews were conducted with a plan to cease when a point of saturation of data was reached. According to Fusch and Ness [29] saturation is reached when no new

data, no new themes, and no new coding patterns emerge, and there is the ability to replicate the study. Although there is no one-size-fits-all approach, saturation of data in qualitative case studies can occur with as few as six interviews depending on population sample size. In the case of this interview, data saturation was reached in some but not all areas by the last interview. All interviews were transcribed by the interviewer using denaturalist transcription [30] where grammar was partly corrected, and interview noise (e.g., stutters, pauses, etc.) were mostly removed.

V. Data analysis

A qualitative thematic analysis following open coding was performed on the transcribed interviews to categorize and organize the answers [24][26]. The method of analysis will be thematic analysis [28].

A. Thematic Analysis

Thematic analysis is a well-established method of identifying, analysing, and reporting patterns in qualitative data and research; and is frequently used in software engineering research [28]. Cruzes et. al. identify five key steps to thematic analysis for research synthesis [28]. The first step is to extract data [28]; the data for this study has been extracted from existing work in the field through a literature analysis and from participants via interviews. The second step is to code the data [28]. Coding allows the researcher(s) to organize and group data into categories. This is done by identifying interesting concepts, categories, findings, and results in a systematic way for the entire data set. The answers to the interview questions are then labeled (or coded). The third step is to translate codes into themes [28]; which can include sub-themes, and higher order themes. The higher order themes used in this study were the research questions. The fourth step is to create a model of higher-order themes [28] by exploring how the emerging themes relate to each other. The final step in thematic analysis is to asses the trustworthiness of the interpretations that led to the synthesis [28]. See Appendix for examples of the coding tree 3456.
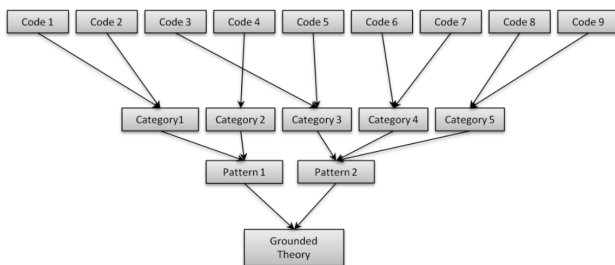

Fig. 1. Example of coding method

Interview coding in this study was done using NVivo, a qualitative data analysis software. Coded interview answers were then organized based on which research question(s) they answer, compared with findings from the literature analysis and placed in the final report along with validity threats and limitations to the study. See Appendix for views of the coding tree created in NVivo.

VI. Findings

Among many of the participants was a common theme of having a position of leadership in practice but not in title until years later. The types of leadership positions also vary greatly from one path to the other.

A. Typical Career Path (RQ 1)

The participants ranged in career experience from 3 to 30 years. However two career patterns emerged regardless of experience level. The "Stay Technical" path which was experienced by 3/7 of the participants and the "Aim for Management" Path which was experienced by 4/7 of the participants. See the Path Table **??** on the following page for a detailed look at the participants paths and the responsibilities of each position held.

1) The "Stay Technical" Path: The first pattern that emerged was among participants whose career strategy was to "Stay Technical", or had no strategy but stayed technical. These participants did not desire to manage people, they wanted to stay in technically focused roles:

"I was always very reluctant to take on any leadership roles. So, or like former management roles, I should say... But I was very keen on staying within the tech field and not becoming like a project manager or something like that... I always wanted to become a software architect because that felt like that was the more technical career path." - T1

"Well, I always had as a goal to be a very strong leader. I have always had persons that I've looked up to that are very technically skilled and very respected within the company. And that is something that I always strive towards." - T2

"I want to be a CTO in five years from now. So I guess that's one big doubt that I have is, if I want to stick to technical side of leadership or if I want to move to the people management side. And I think that to be a CTO, you can stick to the technical side." - T3

These participants all came from technical educations: 2/3 Electrical Engineering, 1/3 IT. The highest educational level among this group was BSc. for 2/3 path members and MSc. for 1/3. In this group the average length of time from career start to first position of leadership in practice was 2 years. This group, on average, would not achieve a position of leadership in title until 7 years later (or 9.3 years after career start). Meaning that 2 years after starting their careers they were performing as senior-level employees (i.e. the role of a position of leadership as defined by this document) but employed under 'Junior' or mid-level titles. Once they started performing as a senior-level employee, it took an average of 6 years to achieve a title of 'Lead', 'Senior', or 'Manager'. The average These participants had a average career length of 15.6 years at the time of the interviews.

Fig. 2 — Career paths table (rotated). The table below reconstructs the figure; each participant's career is shown as a sequence of Position (Pos.) / Responsibilities (Resp.) pairs.

▼ Stay Technical

ID	Education	Career Length	Position (Pos.)	Responsibilities(Resp.)	Pos.	Resp.	Pos.	Resp.	Pos.	Resp.	Pos.	Resp.	Pos.	Resp.	Pos.	Resp.	Pos.	Resp.	Time Till First POL in Practice	Time Till first POL in Title	Strategy	Path
T1	BSc: IT	20	Software Engineer	Software Construction, Software Testing	Software engineer/ Solutions Architect	Software Design, Software Construction	System Specialist	Software Construction, Software Design, Software Testing	Software Engineer/ Test Manager	Software Construction, Software Maintenance, Software Design, Software Quality, SE Management	Software Engineer (First POL in practice)	Software Construction, Software Maintenance, Software Design, Software Testing, Software Configuration Management	Engineering Manager (First POL in Title)	Software Process, Software Requirements, Quality, SE Management, Software configuration Management, Software Construction	Director Of Engineering	Software Process, SE Management, SE economics - No longer Programming as main function	Vp of Product and Technical Engineering	SE Management, SE economics - No longer Programming as main function	4 Years	16 Years	Stay Technical	Stay Technical
T2	MSc Electrical Engineering / BSc Electrical Engineering	16		N/A	Software Engineer/ First POL in practice	Software Construction, Software Maintenance, Software Design, Software Quality, Software Testing, Software Configuration Management	Technical Leader (First POL in title)	Software Construction, Software Maintenance, Software Design, Software Configuration Management	Product Manager	SE Management	System Manager	Software Design, Software maintenance, SE Process, Software Quality, Software Testing, Software Construction	System Architect	Software Configuration Management, Software Design, SE Methods and Models, Software Quality, Software Requirements					1 years	4 years	Stay Technical	Stay Technical
T3	BSc Electrical Engineering	11			Junior Software Engineer (First POL in practice)	Software Design, Software Configuration Management, Software Construction, SE Testing, SE Management	Embedded Software Designer	Software Design, Software Configuration Management, Software Construction, Software Configuration Management	Software Engineer/ Scrum Master	Software Design, Software maintenance, SE Process, Software Quality, Software Testing, Software Construction	Senior Software Engineer (First POL in Title)	Software Design, Software Configuration Management, SE Management	Staff Engineer	Software Design, Software Configuration, Quality, Software Process, Software Requirements, Software Construction on the side			1 year	8 years	N/A but Stayed Technical	Stay Technical

▼ Aim For Management

ID	Education	Career Length	Position (Pos.)	Responsibilities(Resp.)	Pos.	Resp.	Pos.	Resp.	Pos.	Resp.	Pos.	Resp.	Pos.	Resp.	Pos.	Resp.	Pos.	Resp.	Time Till First POL in Practice	Time Till first POL in Title	Strategy	Path
M1	MSc Management / BSc Mathematics	30	Junior Consultant	Software Configuration Management, Software Maintenance, Software Construction, SE Process	Consultant (First POL in practice)	Software Construction, Software Design, Software Maintenance, Software Design, Software Quality, SE Management	Manager (First POL in title)	SE Management, Software Process, SE Methods and Models, SE Economics - No longer programming as main function	Senior Manager	SE Management, Software Process, SE Methods and Models, SE Economics - No longer programming as main function	Partner	SE Management, SE Process, SE Methods and Models, SE Economics - No longer programming as main function	Application Shared Compentency Director	SE/Project Management, SE Process, SE Methods and Models, SE Economics - No longer programming as main function	Vice President (Americas) / Vice President (Customer Engagement) / Senior Vice President Information Management	SE/Project Management, SE Economics - No longer programming as main function	CIO	SE/ ProjectManagement, SE Economics - No longer programming as main function	2.5 years	5 years	N/A but strong mentor advocating for "higher" positions	Aim For Management
M2	MSc Process Engineering / BSc Process Engineering	27	Export Sales	N/A	Business Developer	SE Process, SE Management, SE Economics	Senior Manager (First POL in title and practice)	SE Process, SE Management, Quality Management, Software Methods and Models	Product Structure Manager	Software Design, SE Management, Quality Management, Software Requirements	IT Planning Manager	Software Process, SE Management, SE Economics	PDM Integrations and Data Manager	Above Code: SE Process, SE Economics, SE Management - No longer programming as main function	Stake Holder Manager	SE Management, Project Management	Head of Program and resource Management / Capability Unit, IT R&D	SE economics, SE/Project Management	2 years	2 years	Aim For Management	Aim For Management
M3	BSc Economics / BSc Computer Science	20	Software Developer (First POL in practice)	Testing, Construction, SE Management	Manager (First POL in title)	SE Management, SE Economics	Business Developer	SE Management, SE Economics, Models, Quality Management, SE Economics	Business Development	SE Economics, SE Management, High level Software Requirements	CEO	SE Economics, SE Management, Project Management	Strategy Consultant	Project Management, SE Economics					3 years	6 years	Aim For Management	Aim For Management
M4	BSc Software Engineering	3	Scrum Master/ Function Tester	Testing, SE Process, Software Construction, Software Maintenance	Software Engineer (First POL in practice)	Software Management, Software Requirements, SE Economics, Project Management, Quality Management, Software Methods and Models - No longer programming as main function	Agile Project Leader/ Head of Product (First POL in title)	SE Management, Software Requirements, SE Economics, Project Management, Quality Management, Software Methods and Models - No longer programming as main function											1 year	3 years	Strategy - aim for management	Aim For Management

Fig. 2. Career paths of the participants depicting positions(Pos.) along with the correlating responsibilities(Resp.)

The leadership positions in this path are distinct in both the nature of their titles and the associated responsibilities. The nature of the titles in this path are software-oriented and generally reflect the technical responsibilities of the position, i.e. Software Engineer, Embedded Software Designer, System Architect, etc. The members of this path have more technical responsibilities earlier in their careers than the "Aim for Management" participants. Up to and until their first position of leadership in practice, all members on this path shared the same 4 common responsibilities of Software Configuration Management, Software Construction, Software Design, and Software Testing. All 4 responsibilities were present in their first positions of leadership in practice while any prior positions included one or more, but not all 4 responsibilities. All path members' first position of leadership in practice was in a role titled Junior Software Engineer or Software Engineer. During the period between the first positions of leadership in practice and in title members of this path may have all or some of the responsibilities held in the first position of leadership in practice but at the first position of leadership in title, the additional responsibility of Software Quality appears. A defining characteristic of this path is that during and/or after the first position of leadership in title, members still have the responsibility of Software Construction. After this point in the path is can be observed that Software Construction disappears as a primary responsibility in the position while responsibilities of Software Quality or Quality Management, and Software Requirements appear. At this point we reach current day for 2/3 of this groups members, but for T1, the member with the longest career in the group, the path moves away from daily technical work in to the requirements of Software Engineering Management and Software Engineering Economics.

An interesting observation from the path is that 2/3 path members were, at some point in their careers, a Software Architect. This may be due to sample size. The other path member is also an interesting case because their path seems to take on some characteristics of the "Aim for Management" path from the position following their first position of leadership in title. This may be an indicator that there are more than the 2 paths found in this study.

2) The "Stay Technical" Leader Profile [RQ 1A]: 2/3 members in this path had an early mentor who encouraged, advised about, or demonstrated a technical interest or career. Members of this group cited analytical skills (2/3 members), eagerness to learn (2/3), and a positive/motivating attitude (3/3) as personal traits that have had a positive impact on their careers. Members also cited lack of confidence (2/3) as a personality trait that had a negative impact on their careers. One member perceived that a lack of confidence played a hand in career stagnation:

"...you start working with more and more very talented people and sometimes you feel you're not enough or like you are not at their level, and I found that it just your head talking. Imposter syndrome can also be a tool. You have to know that

you that you have it and then it can be a tool to challenge yourself and to overcome it." - T3

When asked about the reason she was in junior and mid-level for so long:

"I think that was imposter syndrome, I was not able to sell myself during interviews. Learning to sell yourself in interviews and learning to value yourself more than sell yourself, to valorize yourself during interviews is a skill that took me years and I may start now to have it. Because especially women are educated to be modest. And I come from a Catholic family. You know, you have to be the good girl that is humble and that stay at her place. And when you go to interviews, that's very counterproductive." - T3

The most common motivating factor in career choice and reason for getting into software development in this path was a thirst for knowledge(2/3). All members of this path cited the reason for the choice of a career in software development was an affinity for software or tech in some way:

"The love of mathematics and ... logical thinking." -T3

"I think it was in general just curious about technology and computers specifically." - T1

"I have always been interested in computers. When I was a teenager ...my father was very much into computers and we had a lot of gadgets at home. And my father taught me how to program." - T2

An interesting observation from the members of this path is that, while the stereotype and expectation is that female candidates are better at non-technical or personnel management roles [7], it's not universally true in practice. One member interviewed for a personnel-management role at the suggestion of her manager:

"I have been leading from from a technical perspective. ...A suggestion from my manager (was) that maybe I could try to be a line manager instead. And that is why I actually applied for (that) job. But to be honest, ... I'm glad that I didn't get it because I really feel that my passion is within the technique and I really want to focus my career on that. I'm not really interested in being a line manager. And so I kind of took it to as a confirmation that (it) is not really for me, even though that they maybe prefer to have me as a line manager." - T2

Feedback given to T2 after the interview for the line manager position:

"The feedback was that I need to improve my people and leadership skills. So very very high skills on like the business strategy, and innovation, and leadership in general. But people leadership was something that I got feed back that I need to work on." - T2

3) The "Aim for Management" Path [RQ 1]: The second pattern that emerged was among the participant's whose strategy was to "Aim for Management". One member of this group had no specific career strategy but had a strong mentor encouraging her toward upper management:

"I met for the first time with my mentor ... when I was probably 25. And he convinced me first that I could do better and I could climb the ladder. That yes, I had the qualities to be a senior consultant, to be a manager. And then convinced me that I also had the capabilities and the qualities and skill to become a partner(in the company)." - M1

The other participants had a desire or a natural inclination to manage people and teams:

"Yeah, I had a plan that I wanted to become a manager." - M3

"I think I always feel interested in being in leadership positions. Usually I've been quite good with people." - M2

"I really was attracted to the word management." - M4

These participants came from a variety of educational backgrounds, all of which had both a technical and non-technical element to their educations: BSc. Mathematics then MSc. Management, BSc. then MSc. Process Engineering, BSc. Economics then MSc. Computer Science, BSc. Software Engineering and Management. The highest education level among the members of this path was MSc. for 3/4 and BSc. for 1/4. In this group the average time from career start to first position of leadership in practice was 2.12 years. The average time from their first position of leadership in practice to their first position of leadership in title was 1.8 years (or 4 years after career start). These participants had a average career length of 20 years at the time of the interviews. M4 however was a major outlier in this metric as her career path was 3 years at the time of interview, 17 years behind the next closest "Aim for Management" group.

The position titles in this path tend to be more general, business oriented titles i.e. Consultant, Senior Manager, Agile Project Leader. The titles give little insight into the technical requirement of the position. This career path fewer technical responsibilities over compared to the "Stay Technical" path. This is especially apparent early in this path. The responsibilities are varied but the most common responsibilities up to the first position of leadership in practice are Software Construction (3/4), Software Maintenance (2/4), Software Process (2/4) and Software Testing (2/4). At the first position of leadership in practice Software Testing disappeared as a responsibility for 3/4 members Between the first position of leadership in title and the first position of leadership in practice common responsibilities are Software Construction (3/4), Software Quality(3/4), Software Engineering Management (3/4), and Software Maintenance(2/4). At the first position of leadership in title Software Construction is no longer a responsibility of the position. At this point Software Engineering Management, Software Process, and Software Methods and Models

are responsibilities of all 4 positions, Software Quality or Quality Management is a responsibility of 3/4 positions. As this path continues the common responsibilities seen in all members and positions is Software Engineering Management to higher and higher levels of abstraction. Another common responsibility after the first position of leadership in title is Software Engineering Economics - present in 3/4 members paths. The member whose path did not include Software Engineering Economics (see M4 in 2) is 3 years into her career. Comparatively, the other members of this group are 20, 27, and 30 years into their careers. Software Engineering Economics appeared a responsibility an average of 10 years after career start. Presumably M4 will experience that requirement later in her career.

An interesting Observation about this path is that 2/4 members left "big" positions (CEO, Head or Program and Resource Management) and went on to become independent consultants.

4) The "Aim for Management" Leader Profile [RQ 1A]: All 4 have higher education degrees, 3/4 of these path members have at least one non CS/IT/Software related degree. The only common positive personality trait that had been helpful in the careers of these path members was communication skills, cited by 2/4 members. There were no common unhelpful personality traits cited among group members. Motivating factors in these path members' career choices included job location (2/4) and a thirst for knowledge (2/4). A motivating factor in the choice to leave a position for 2/4 of the path members was due to managerial issues:

"In the I.T. department, especially getting the requirements were not, not in line with the resource given. And then also that it wasn't managed very well. The whole organization. so it didn't provide a very good basis for the work." - M2

"In my previous job, I really wanted to do management. And I mean, management, management, managing projects, not technical management. I'm talking about managing deadlines, managing payments, making strategic plans, coming up with like implementation plans and road maps. and I couldn't do that because I wasn't given the chance to do that... So, but I moved on. And then I did get the chance at another company." - M4

None(7/7) of these path members had an early mentor. The most common reason for entering software development was by coincidence (2/4). When asked about future career goals the only commonality was uncertainty (2/4):

"No, not not necessarily. I would not say (I have) a goal." - M1

"That's a very very tough question for me right now because I have no idea." - M3

5) Common Traits Among all Participants (RQ 1A): All 7 participants had the support of their families in their education choice. Participants, regardless of path, also reported that a personal trait that had been helpful in their careers was a

positive/motivational attitude (4/7) as a personality trait that had been helpful in their career path. The traits "easily bored", "flexible", "organizational skill", and "service minded" were found in equal quantities in both paths (1 instance of each trait per path). While this may be inconclusive, it could be a basis for further work to examine the degree to which personality traits differ between paths. They were also tied (1 of instance of each per path)when it came to the career goals of "owning their own businesses", and reaching the "top level" of a company.

B. Barriers to women in Positions of Leadership (RQ 2)

One of the questions asked to participants of the study was "Have you faced any barriers or obstacles in your career path?/What barriers or obstacles have you faced in your career?". Because of the language barrier with some participants, and the semi-structured interview style, the question not always asked the same way in every interview. Some participants discussed multiple different barriers, some discussed many different instances of the same type of barrier, and 2/7 participants didn't feel they faced any gender-related barriers(or at least none they wanted to mention). They did however mention anecdotal barriers faced by other women in their companies. It is unknown if those women fit the scope of the study, therefore the barriers they reportedly faced are not are not reported in the findings, nor are they used to draw any conclusions, but will be mentioned in relation to the women who did not face any barriers personally.

The participants of this study were working in 3 different countries at the time of the interview: Finland, France, and Sweden. The most common barriers experienced by all participants were Unclear Hiring Practices (3/7) and Bias, Discrimination, and Exclusion (4/7). Within the "Stay Technical" path the only barrier experienced by more than one member was Bias, Discrimination, and Exclusion (2/3), however one member faced many different instances of many different barriers. Within the "Aim for Management" path there were 4 common barriers experience by members: Unclear Hiring Practices (2/4), Lack of Knowledge (2/4), and Bias, Discrimination, and Exclusion (2/4). Participants were also asked about their company cultures (RQ 2A), those answers are added to this section to give some context to the barriers faces by participants in their own words.

1) Unclear Hiring Practices: According to 3/7 participants in the study, unclear hiring practices were a barrier they faced in their careers. Among participants this barrier manifested itself in the form of upper management or C-Level positions being filled with little or no transparency about the process and requirements to attain this position. In once case a position was filled by a person who lacked the necessary skills and created a problem for the company. Of the participants that experienced this barrier within their organizations, 2/3 were on the "Aim for Management" Path. A correlation was found between this barrier and the perception of a participant that the company did not live up to it's stated culture values. What participants said about unclear hiring practices:

"...In the company I work right now... there are a lot of interesting jobs on the high level but... it's not possible to send an application and say I want that job. I don't know how they even get it. My feeling is that to get those positions you need to be male, you need to work with other males having similar positions and you need to play in the same football team. and … it's not that they have qualifications that I or other women doesn't have, it's something else.. And we can talk about quota-ing women in leading roles. When I was younger I was saying "oh no, no, don't do that because we are going to get the jobs because we are qualified. But men are quota-ing each other in all the time but they are not saying that .. that are not saying it's quota-ing in, they are saying it's because 'he was a nice guy' ...there are so many examples. I worked in a private(ly) owned company and one day, (we got) a new CIO, and when I asked why is he getting the job, it was like "oh, we know him, he's a nice guy, and he had nothing to do right now. And actually he didn't do **** in his ..position. He was there for 5 years and then he quit. It was like 'this is a nice guy, I played football with him when he was a little guy and now he has nothing to do and yeah, we can (make) him CIO of the whole company because yeah.. we like him'.

[Interviewer:]'And how did that work out for the company?'

Actually I guess that was a **really** bad decision because he was afraid of conflicts, he was afraid of making decisions, but he was really really good in workshop leading and information, IT architecture and stuff like that so if they had given him a position like that he would have done a great job. Now a lot of other bosses quit (because of bad leadership) and the company went very bad for a while and it took them many years to recover. Because he was a nice guy, and he **IS** a nice guy but he was not a good boss." - M3

"As I grew into leadership, I've seen I've seen the glass ceiling. I've seen a lot of women having like the first or maybe second level management positions. But then it's just no-one. A lot of those roles are not publicly announced. And you have to... know someone in order to be promoted to those roles in many of the organizations I've seen. So that has been a barrier that there are no women there." - T1

"I think that there was like two or three times. And they would have chosen me but (put) an end to it because it was in another part of the organization. So then they weren't allowed to hire from another (part of the) organization. Due to head count restrictions. And so that was a bit of a pity because well, that's kind of an obstacle I could mentioned also that, it was rather rigid how you could move across the entities of the company, even though it was kind of talked about that the career rotation was encouraged. But then in practice it wasn't often possible." - M2

The above quote from participant M2 was in response to a question regarding interview feedback from job interviews where participants were not hired. When the participant says "...they would have chosen me..." it was understood in context as having been confirmed by the interviewers for the position

in question. This quote is also indicative of a larger management problem within the organization as this participant stated earlier in the document. For this participant, although it was a barrier, it was an organizational barrier relating to the company structure rather than a perceived gender-related barrier. The purpose of this study is not to identify purely gender-related barriers, but to investigate any and all barriers that female leaders in tech face in their career paths. This response appears to be more company- or position-specific however which should be noted for validity. Because this instance was not able to be generalized it will be excluded from any perceived gender-related conclusions.

2) Bias, Discrimination, and Exclusion:: This barrier appeared for 2/3 members on the "Stay technical" path and 2/4 members of the "Aim for Management" path. For the participants, this barrier comes in many forms. Some of the participants are actively facing these barriers today and some described instances of facing this barrier earlier in their careers. A correlation was found between this barrier and the participants perception of a negative company culture trait of: the culture values stated by the company do not translate to support for the barriers facing women within the company. This barrier manifested as participants perceiving subconscious or implicit bias against them by their colleagues in the form of ideology such as: women have worse technical ability, better personnel management skills, and in some cases the action of being judged more harshly:

"I think a lot of unconscious biases around that woman aren't as good as programmers, for example, or in technical subjects has been something that I have to overcome many, many times and in every new job I've always had to prove myself, I think so that otherwise people always underestimated what I was able to do." - T1

"There has been other biases, I would say, in the early on in my career. A lot of the time I think maybe it's the same bias that as a woman, I should not be so interested in programming... like, oh, you're a woman, so you are probably good at projects, management and structure and those kind of roles." - T1

Some of the participants experienced this barrier in the form of perceived harsher judgement compared to their male counterparts or even blatant discrimination:

"It feels like it's not so easy for women also if they have reached those levels to help other women because they tend to be calm, criticized if they (do) for being biased, they promote other women, while less men seem to be because that is like the norm. You're not biased if you promote a man, but if you promote another woman? And that would be more scrutinized." - T1

"I had a (male) boss that, when I told him I want to be in a leading position he said: 'Oh, but what should **you** do? We already have a woman in (a) top management (position)'. ...I didn't even know what to say to that." - M3

M3 explained that her boss has implied that because there was already one woman in a leadership position at the company, there was no need to put any more women in leadership positions. The perception was that the unspoken and unofficial female quota was filled.

" I do feel that my salary is not been very fair in that way: with people in the same sort of path as me, with the same experience as me. So when I found out about that, I started becoming a little more aggressive towards 'why am I making less than person X who is doing just (the minimum)' . So that was kind of a barrier in the way that, well, it puts me down." - M4

M4 went on to explain that her company originally employed her as a project manager, and they were impressed with her work. They fired her male superior and had her replace him as Head of Product, however she learned that she made significantly less than her male colleagues in similar positions at similar places in their careers. M4 experienced a pay-gap so significant that she jokingly said thinking about it would make her cry, and perceived that the reason for the gap was not due experience or professional ability compared to her colleagues.

Another form this barrier took for the participants is perceived purposeful social or professional exclusion in the workplace. One participant experienced being ignored by her colleagues. She also had the perception of having been sabotaged in her efforts to achieve a promotion when her boss set her up to fail by telling her not to put too much effort into a presentation. Following his advice is exactly why she was told she was passed over for the promotion. This same participant also observed that as women gained positions in management, power moved upwards in the organization. She explained that whenever a woman rose to power, the power moved further up in the organization. If a woman replaced a man and her boss in the new position was also a man, then her responsibilities and power in that position would not be the same as the man who previously filled her position. In fact where he previously had autonomy and control over decisions, that power would move to the next level above her when she achieved the position.

"I also been to meetings with a lot of men and they were actually not even talking to me because I was a woman or different than them." - M3

"I applied for a job as a higher boss in an agency in Sweden and I didn't get the job. ...Maybe it was because the one who got it had a better resume, I don't know, but ..I was supposed to prepare a case and the interviewer said 'don't put effort on that one, just go with the flow'. So I just did go with the flow and then I had the feedback that 'Oh you didn't have a PowerPoint showing, you didn't have a real long presentation prepared'. I was like 'You said I shouldn't have that.'" - M3

M3 went on to explain that at one point in her career, she was interviewing for a position of leadership for which she was to prepare and present an example case to demonstrate

her skills. The interviewer advised her not to put too much effort into the case, that it would be very casual and she should not do a PowerPoint presentation or anything too "formal". She did not get the position in question. When she asked for feedback she was told that the reason she was not chosen for the position was because she did not present a PowerPoint and was considered unprepared in that regard. Essentially, the feedback was that M3 did not get the position because/although she did exactly as the interviewer advised. During the interview with M3 I said this scenario sounded like intentional sabotage, and M3 agreed.

"If there are a lot of women put on leading positions, the power seems to tend to move upwards in the organisation." -M3

M3 explained here that, in a previous organization in her career path, although some women were advancing to positions of leadership, if their predecessor was male and the current manager or supervisor of that new position of leadership was male, the decisions and responsibilities (power) of the position that were held by the female's predecessor would move up a level (to her manager or supervisor) when she attained the position in question.

One participant noticed that the company was great at hiring women, but not great at including them in the organizational decision-making even in positions of leadership, leading to a sense of exclusion.

3) Lack of Knowledge: This was cited as a barrier by 2/4 members of the "Aim for Management" path for different reasons. Both participants experienced this barrier early on in their careers. One participant experienced this barrier as a result of educational quality. The other participant was put into a management position seemingly before she was professionally ready, then received no professional support in the position, even when requests were made to her boss, which resulted in her leaving the position:

"It was my first manager role. I had a male boss and he was like 'just go, just go with the flow' and I felt like I was on the ocean in a sailing boat that I have no idea how to steer because he was not supportive. Everything was like 'Just go, just go, just try, just try' and I needed some more frames because I was new. Then I quit that job because of that." - M3

4) Work Life Balance: Participants were asked about their work-life balance during the interview. All 7 participants had a positive expression regarding their work-life balance. 6/7 participants indicated they had a favorable work life balance, even in cases where the participant:

"It's a constant struggle. And I think I tend to work too much and I try to constantly sort of take a step back... On the other hand, ...I have a really flexible working hours so I can go home a bit earlier and be with my kids. And then when they go to sleep, I can work. So it's both good and bad, but I think... I tend to spend too much time on work." - T1

One interesting observation from this group was that one participant cited their family as a barrier with the implication

that she was capable and willing to work so much more but was, in a way, held back by her family. Existing literature names work-life balance as a predominant barrier for women in STEM, the findings of this study do not support that.

C. Barrier Mitigation

Participants were asked if they had any advice for female junior software developers in mitigating barriers, or general career advice. The advice from each participant was not necessarily linked to the barriers they faced. In fact there was no overlap found between advice give, and barriers faced. However there was a distinct different in the types of advice offered on each career path.

1) The "Stay Technical" Path: The most common advice to female juniors wanting to go into management was to get experience, all 3 path members here emphasised the importance of understanding the technical aspects of your job on this path:

"You can copy paste from StackOverflow, the solution, but you have to understand why that solution works. And maybe that takes time because for example, one very familiar example is understanding what happens when you type Google.com on your browser like from end to end. And it can be like a two sentence answer or you can be a one page answer, and if you want to be a leader, you have to be curious enough to go and to have the one page reply because in technical positions, and in a technical environment. If you're not strong enough, technical people will not trust you so you have to build the technical confidence." - T3

"I mean, learning as much as possible and when it comes to leadership, there is so, so many things you can learn and so many things you can try even before you have a formal leader position to try out things in your role trying leading others." - T1

"So, I mean, getting a lot of practice. I mean, you cannot become an expert if you if you're not practicing it a lot. So that is something that is absolutely a must for being a technical leader. You need to have a good, technical skills, and a lot of experience. So it's just learning by doing. That's the only way." - T2

The other common piece of advice on this path was to be bold(2/3):

"Learn to speak up, to be vocal. Fight your shy side, your introvert side. You have to take out your ideas." - T3

"If you want something, you have to go for it. You don't have to wait for others to prepare the path for you." - T3

"I would also say that my best advice is just do it. Don't be too afraid to try, do not be afraid to fail. It's hard sometimes. But that's my best advice, I would say just. Just do it." - T1

2) The "Aim for Management" Path: The most common barrier mitigation advice from these path members was to try to resolve issues that may arise, especially when under appreciated in a role or not getting the professional support needed to perform the role properly; but if that doesn't work, change employers (2/4):

"I guess I would try to do some changes first but not if I see that it's not possible then I will leave, yes." - M3

Another barrier mitigation strategy suggest by path members of this group was to project confidence (2/4):

"I make sure that my confidence will outshine everyone." - M4

It's worth noting that in the 3 years since she started her career, M4 had already reached her first position of management at the time of the interview, about 2 months later she was promoted to Head of Product at her company. Anecdotally, her advice seems to work.

General career advice common among these group members was to follow your passion (3/4):

"You need to really define what is really the core motivation for you that will make sure that you will wake up every morning and be happy to go to work. If you can be clear with that, it's it. It will guide you. It will. It will bring you and never regret anything." - M1

"Make sure you follow your heart." - M3

"I think it's very important to think that what do you really want to do and why? And then kind of try to work toward those goals." - M2

Other common advice in the group was to gain experience and knowledge in the field (2/4), don't settle for something mediocre just because it is offered to you (2/4), and to network with people (2/4).

An interesting observation about the types of advice given on the different paths is that the advice from the "Stay Technical" path members is more about asserting your technical ability, while the "Aim for Management" path advice is more about making connections and going after what you want.

D. Company Profiles (RQ 2A)

No correlation was found between company demographics and specific path barriers. All 7 participants worked at companies using agile development processes. 5/7 participants worked at companies where: there was an existing set of values known to employees of the company, the company was perceived as diverse by the participants, and the participants perceived the company to be actively working on diversity; with practices such as leadership reform, outreach and sponsorship of female in tech centered meet-ups, internal networking and advancement programs for women, workshops for female employees, monitored policies and practices such as KPI's and explicit policies relating to qualification for promotions and salary increases, changing job advertisement

language to be more inclusive and temp check monitoring employee feelings about diversity and bias within the company. There were 3 data points intersecting between negative company traits and barriers. No conclusion can be drawn from the three data points alone, however there was expected to be a stronger correlation between negative company culture traits and barriers faced. An interesting observation made during the study is that women in Sweden faced the highest number of barrier combined, a total of 9 different barriers, while women in France and Finland faced a combined total of 6 different barriers. A reason for the difference could be sample size, 4/7 participants are from Sweden.

VII. DISCUSSION

A. Answering the Research Questions

This paper attempts to investigate 'Why are there so few female leaders in tech?'. To accomplish that goal, 4 research questions(RQs) were established.

RQ 1 asks 'Is there a typical path to leadership for women with a technical background to a position of leadership.'. The study found 2 general paths to female leadership in software development among the participants. The "Stay Technical" path and the "Aim for Management" path. Two factors that appeared to play a role in the path a participant chose were: the presence of an early tech mentor, and their career strategies. It is not possible to say whether an early mentor has an effect on career strategy. This finding supports previous literature in the area which states that mentors play a small but significant role in female career choices [2][12]. Women on the "Stay Technical" path were found to advance to leadership positions much more slowly than women on the "Aim for Management" Path. 4/7 participants (2 on each path) felt some form of discrimination, bias, or exclusion at work, and some felt that they were more harshly judged because they were a woman, that they were pushed toward personnel management, and that they had to prove their technical ability more than their male counterparts. These findings support related literature which states that women are perceived to be less skilled as technologists/more highly skilled as business experts, and that the stereotype of being more highly skilled at personnel management help to prepare them for the role, and for progression in that area to some degree [5]. Literature also states that women in tech are opting for non-technical roles [2][3][5]. While that may be true of women with non-technical backgrounds, and it is true for 4/7 participants in the study, all participants in the study started in technical roles. Later they either opted to stay technical or, for the majority, move away from technologist roles.

A finding in this study that was not seen in previous literature was the discrepancy between the time women assumed a position of leadership in practice, and the point at witch they achieved a position of leadership in title. The "Stay Technical" path participants achieved a position of leadership in practice an average of 2 years after career start and a position of leadership in title and average of 7 years later (or 9.3 years after career start). The 'Aim for Management' path participants

achieved a position of leadership in practice an average of 2.1 years after career start and a position of leadership in title an average of 1.8 years later (or about 4 years after career start). The findings suggest that female technologists are quicker to advance to "secret" leadership roles - roles they perceived as positions of leadership, technical or otherwise - however more than twice as slow to achieve a position of leadership in title. When trying to answer the question of why there are so few women in technology leadership, this finding seems to suggest that there are many more women, at much earlier stages in their careers, in technology leadership than is suggested by the literature [1]; and that women in tech are underrepresented because they are performing in leadership positions without the validation and recognition of a title for years on end. Women aren't stuck in junior role, they are stuck in junior titles. This is an interesting finding, however the small sample size, and drastic variation of the participants career lengths casts doubt on it's reliability. Another contributing factor to the confusion of this finding is that there are no industry wide standards for job roles and correlating responsibilities. There are of course general guideline and understanding, however each company and organization adapts those to fit their needs. This is especially true of smaller-organizations, entities with cross-functional organizational structure, and start-ups. The frequency of this phenomenon in the industry is unclear, so it is hard to position this finding for an argument. This is another aspect of the study can could benefit from further investigation in the future.

RQ 1A asks "What is the Profile of a female leader in software development?". The study found that there are similarities between members of the same path and also some general similarities among all participants regardless of path. All 7 participants had the support of their family members. The path of the participant seemed to correlate to their education. The "Aim for Management" path participants tended to be more highly educated, and have more varied educations compared to the "Stay Technical" path participants. Early mentorship did seem to play a role; every one of the the participants who had an early tech mentor received a more technically focused education and was found on the "Stay Technical" path. None of the members of the "Aim for Management" path had early mentors. 4/7 participants in the study cited having a positive or motivational attitude as a personal trait that had aided them in their careers, 3/4 of those participants were on the "Stay technical path. The "Stay Technical" path participants seemed to be more passionate about their job roles and responsibilities, however 2/3 also cited a lack of confidence as a negative contributing factor in their careers. While there did appear to be some distinct traits, due to the limited sample size, it's unclear whether the finding can be generalized. Further investigation is needed on whether these traits play a role in the career achievements of female software developers.

RQ 2 asks "What barriers to positions of leadership are women with technical backgrounds facing?". The findings indicated that members of different paths faced slightly different barriers, and that women in the "Aim for Management" path and women in Sweden had faced the highest quantities of barriers in the study. Further investigation would be needed to not only find the typical barriers for each path, but the degree to which types of barriers, and frequency of barriers are dictated by location or culture. The barriers that stand out most among the findings are the the perceptions of bias, discrimination, and exclusions faced by 4/7 participants (2 from each path), and unclear hiring practices (3/7). The participants on the "Aim for Management" path had the perception of facing more barriers, both individually and overall, than participants on the "Stay Technical" path. That is an interesting finding because women on the "Aim for Management" path report progressing to a position of leadership in title more than twice as fast as women on the "Stay Technical" path, despite perceiving more barriers or obstacles. If the "Aim for Management" participants do face more barriers, how are they progressing more than twice as fast in their careers? Further investigation is needed in this area as well, to understand how much the barrier are reliant on paths as opposed to other factors, such as job availability, job satisfaction, etc. One common Barrier mitigation strategy mentioned by participants was to move on from a position if the barriers are not able to be overcome. Could this also play a role in rapid career progression? The "Stay Technical" path members cited passion for technology, and eager to learn (2/3) as motivating factors and positive traits that helped in their careers - truly honing their technical skills- and progressed slowly. Some "Aim for Management" path members, walked away from jobs when the barriers became insurmountable, and progressed more quickly. Further research on what factors contribute to faster software development career progression would be interesting.

An interesting finding of this study relates to a common barrier mentioned in previous literature: work life balance. Previous literature states that work-life balance and child-rearing was a significant barrier for women in STEM [31][5]. All 7 participants seemed to feel positive about their work life balance, regardless of whether or not they had kids. Even the participants who said they did not currently feel balanced, or felt the worked more than they needed to, did not have outwardly negative comments. The finding here do not support the literature. None of the participants cited work-life balance as a barrier. The topic was only commented when participants were specifically asked about their work-life balance.

RQ 2A asks "What key factors exist in companies with female leaders with technical backgrounds?". There were some common company traits among the participants regardless of path: All 7 participants worked a companies employing agile methodologies. The participants had positive things to say about their company cultures. 5/7 participants worked at companies where: there were clearly established cultural values and the participants perceived the company to be diverse and also actively working on diversity. It is unclear whether the individual participants were attracted by these values or if such company values attract more female employees in general. One participant emphasised the importance of working somewhere

that is aligned with your values. Another participant also revealed that they had quit a job because in their eyes, the company did not live up to its own stated cultural values. Further investigation would be needed to separate what company traits are industry standards and what traits, if any, attract and retain female leaders in software development.

B. Implications

The barriers reported in previous literature were not corroborated by the finding of this study. Work-life balance especially was reported in literature to be a major barrier, findings for this study indicate that even when the work-life balance is tipped heavily toward to work side, it's largely not seen as a barrier. Implications for academia are that there is reason to conduct further research in this area. The different paths also had differing educational backgrounds, the path and profile data analysed could be helpful in advising female students interested in a specific career path in software development. Knowing the general required responsibilities and most common educational patterns could provide a road map for female students interested in positions of leadership.

Implications for industry, the findings of this study can provide a road map for female junior developers currently in the field and interested in moving to a position of leadership. Knowing what types of responsibilities they are likely to have at future point in their careers can help them get a jump start on preparing for future positions. It's also helpful for them to know about the role-acknowledgment gap: the gap between the first position of leadership in practice and point that their leadership is acknowledged with a title change. Knowing this problem exists if the first step to closing the gap. The advice from female leaders in the field may also be helpful to those interested in pursuing a career in software development regardless of gender.

C. Recommendations for Future Work

There are recommendation for further work in almost every section of this paper, there are so many ways in which this study could be expanded upon. this section will focus on the most critical recommendations that would enhance the study. Firstly, the study is limited by the number of participants. although data saturation was reached in the barriers section, it was not reached in other areas. Ideally a further study would include enough participants to account for differences in: national and company culture, geography, company structure and organizational make-up, participant career stages. When it comes to Paths, further research could dig deeper into the responsibilities of each position held by the participants in their careers. The interview questions should be specifically geared to understand the nature of each position in order to accurately depict the possible paths. The findings of this study seem to suggest that there are more than 2 paths, possible sub-paths or more path characteristics to leadership in software development. When it comes to the profile of a female leader in software development, further work could expand on personality traits, and development and career

preferences. The finding of this study on the profile of a female leader were inconclusive, a further investigation could examine whether such things play a factor at all in female leadership in software development. When it comes to barriers, further work could examine perceived barriers vs scientifically proven barriers which would require time and resources that were not available for the purposes of this study. When it comes to company traits, further work could examine the contributing factors to specific barriers, for which a larger sample size is needed. Further work could also examine what traits are positive and negative indicators for gender diverse talent attraction and retention and to what degree the company traits inform career progression for women in software development. Finally further work could also recreate the study to include the male lens: men's paths and barriers to positions of leadership in software development, along with the traits of a male leader in software development and the company traits that are most conducive to creating and retaining male leaders in software development.

VIII. CONCLUSION

The main motivation of the study was to find out why there are so few women in positions of management in software development. A lesson learned through conducting this study is that the issue of the lack of female representation in positions of leadership in software development is a multi-faceted problem. This study barely scratches the surface, but does seem to find some interesting ways in which the problem can be further explored. Can this study alone provide an answer to why there are so few women in positions of leadership in software development? No, it cannot.

This study presents a literature review of the problem area. The literature and findings indicate that while women are underrepresented in technology and specifically software development, the gender gap is closing. While women in positions of leadership in software development are the minority, women are performing the responsibilities of positions of leadership in software development long before their efforts are validated with a title.

This study investigates the paths women take to positions of leadership and the barriers they face along the way as well as examines their personal and company traits for added context and framing of the case study object. Two distinct paths were found. One technical: the "Stay Technical" path which is characterized by the role titles, and responsibilities being more technical and software development focused in nature, and one management focused: the "Aim for Management" path which is characterized by the disappearance of technical responsibilities and the addition of Software Engineering Management (and business oriented) responsibilities as the path progresses.

The barriers faced, and time taken to reach positions of leadership by the participants did vary by path, suggesting that the path taken also may play a role in the female leadership opportunities in software development. The "Aim for Management" path participants perceived facing more barriers than the "Stay Technical" path participants. It is unclear to what degree

personal and company traits play a role in female leadership in software development. There are very clear limitations to this study which can be addressed by further research in the area. One major limitation is that the data gathered represents the perceptions of the participants, not empirical scientific data. The most important further research opportunity for this study, is a recreation with a much larger sample size of participants.

ACKNOWLEDGMENT

APPENDIX

The Appendix includes a list of the reference figures in the paper and where they can be found, snapshots of the NVivo coding categories and the interview questions used in this study. The NVivo coding categories were divided by their relation to specific research questions.

LIST OF FIGURES

Carreer path

Attributes Classification Sheet

Name	Type
Current Daily Responsibiities	Text
First POL Reflected in Title	Text
Position	Text
Tech Stack	Text
Time Till First Position of Leade...	Text

Fig. 3. List of coding categories in relation to RQ 1

Profile

Attributes Classification Sheet

Name	Type
Support of family	Text
Reson for Software	Text
Positive Traits	Text
Negative Traits	Text
Motivating Factors in Career Ch...	Text
Highest Education Level	Text
Early mentor	Text
Degree Field	Text
Current Career Goals	Text
Career Strategy or Plan	Text
Career Length	Text
Average Length of time per pos...	Text

Fig. 4. List of coding categories in relation to RQ 1A

Barriers

Attributes Classification Sheet

Name	Type
Advice to Female Juniors	Text
Barrier Mitigation Strategies	Text
Barriers or Obstacles	Text
Interview Feedback	Text
POL Strategies	Text
Work-Life Balance	Text

Fig. 5. List of coding categories in relation to RQ 2

Company Key Factors

Attributes Classification Sheet

Name	Type
Company Age	Text
Company Living up to Values	Text
Company Size	Text
Company Values Realting to Fe...	Text
Development Process	Text
Development Team Roles	Text
Development Teams Size	Text
Diversity a Priority	Text
How does company forster dive...	Text
Professional Mentor	Text
Suggestions for Diversity impro...	Text

Fig. 6. List of coding categories in relation to RQ 2A

Interview Questions:

Background:

1. What degrees and/or certifications do you hold?
    1. When and where were they earned?
2. Why did you get into software engineering?
3. Did you have support of family and friends in your education choice? Did you have a scholastic mentor or advisor?
4. What has been your professional career path up to date (title and duration of each position, including internships and significant (side) projects)?
    1. Which of those jobs was your first position of leadership?
5. Do you now or have you ever had a have a career strategy or career plan or goals? What is/was it?
    1. What is your goal? Time line?
    2. Motivating factors in your career choices?
    3. Where are you headed in your career?
6. If you attained a promotion within a company to a managerial position, did you have the support of your superiors? Who's initiative was the promotion?

Context:

1. What is your current job title?
2. What is your current geographic working location?
3. What are the size, age, and sector/industry of your company?
4. Can you describe the typical software project that you would work on?
    1. What is the average software development team size, process or development style, length/duration?
    2. What (if any) are the typical roles, remote/onsite within the project teams?
    3. What is your role in relation to the project (software development) team? / What do your typical interactions with the project or project members consist of?
5. What are your daily responsibilities?
    1. What area of Software Engineering do they most closely relate to?
    2. Personal traits that have been an advantage/disadvantage in your career.
        1. What are the effects or impacts of those on the software development effort?

Barriers:

1. What barriers or obstacles would you say you have personally faced in your career path and why?
2. In your opinion were those barriers specific to you?
    1. To your knowledge were others in your position facing similar barriers?
3. In positions for which you interviews but were not hired, did you receive any feedback from the interviewer(s)?
    1. What was the feed back?
4. Before attaining a position of leadership in your field, did you have strategies (explicit or implicit) for attaining a position of leadership?
5. Did/Do you have any strategies for overcoming barriers?
    1. Do you have any advice for female software developers in junior positions who want to move to positions of leadership (in overcoming barriers)?
6. How would you describe your work-life balance?

End/Conclusion:

1. What values does your current company hold as it relates to diversity or female empowerment? Past companies?
2. Does your company seem to live up to those values? In what ways?
    1. Do your companies values translate to support for the barriers facing women?
3. Is diversity a priority in your company?
    1. What, if anything does your company do to foster diversity of talent?
4. What could your company do to create a better working environment for diverse people/ women?
5. Is there any thing else you would like to add?