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The Gender(ed) Gap(s) in STEM

Explaining the persistent underrepresentation of women in STEM careers

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I dedicate this dissertation to my late grandmother Helvi Vasara.

1 Equal Career Paths for Women – NOW! https://tasaarvoisestiuralle.fi/in-english/

2 Tekniikan akateemiset TEK (Academic Engineers & Architects in Finland); www.tek.fi

CONTENTS

TABLES

FIGURES

INTRODUCTION

1.1 The gender gap in STEM

> Engineering has proved remarkably resistant to gender change, in spite of three decades of public and private sector backed efforts in many countries to improve the representation of women in its ranks (Lee, Faulkner & Alemany, 2010, p. 90).

"We need more women!" This has been the rallying call in academic literature and the selling point of numerous projects, campaigns and initiatives that seek to increase the number of women in STEM (Science, Technology, Engineering, Mathematics). The gender gap in STEM refers to the tendency for women to be less likely than men to pursue studies and careers in STEM fields. Women enter especially engineering/technology[3] studies at lower rates than men and tend to leave at higher rates, and this trend remains consistent into early and mid-career (e.g., Wilson & VanAntwerp, 2021). The underrepresentation of women in STEM – particularly in physical sciences and in engineering/technology – is a worldwide phenomenon, affecting numerous countries with varying cultural, economic, educational, and social settings. According to UNESCO (2020), the percentage of females studying engineering, manufacturing and construction, or ICT (information & communications technologies) was globally below 25 per cent in over two-thirds of countries. Nevertheless, the gender gap is not universal: higher percentage (35 % or above) of students in engineering, manufacturing and construction are women in several countries for example in South-East Asia and Eastern Europe (Singh & Peers, 2019).

As a widely recognized phenomenon, the gender gap in STEM has prompted a plethora of studies especially since the 1980s. While numerous studies have focused on deciphering gender differences in college-level studies of STEM subjects, others have investigated girls' and boys' interest and abilities in mathematics or IT, their perceptions of engineers and scientists, and the influence of peers, teachers, and parents. Scholars have studied STEM workplaces and identified supporting and hindering factors, both individual and organizational, for women pursuing careers in STEM fields. Meta-reviews covering this

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3 'Engineering' is often categorized into four main branches: chemical, civil, electrical, and mechanical (Sax et al.,2016) while 'technology' includes engineering as well as information and communications technologies. However, the line between 'technology' and 'engineering' is often hard to draw. In common usage, 'engineering' is often considered a subfield of 'technology' but the terms are overlapping and often used interchangeably. Please see article 1 in this study for more discussion on this question of terminology.

vast literature include for example Blickenstaff (2005), Ceci, Williams and Barnett (2009), Ceci et al. (2014), Cheryan et al. (2017), Jansson and Sand (2021) and Kanny, Sax and Riggers-Piehl (2014).

Why is the underrepresentation of women in STEM considered such a problem? The main reasons highlighted in the literature are the following. Firstly, every person should have an equal opportunity to pursue any field of study or employment based on their motivation, interests, and skills (cf. Blickenstaff, 2005). The gender gap means that women's opportunities have been limited in STEM fields which offer interesting and well-paid jobs. Secondly, technology is vital in solving the problems of today and tomorrow, particularly the wide-ranging challenges brought about by climate change. Developing better technology requires talented people with varying experiences and viewpoints. For example, in the acclaimed book "Invisible Women", Criado Perez (2019) elaborates the consequences of ignoring women in the development of technology. Considering the ('white') able-bodied male as the default 'human' often causes inconvenience for many women (for example, when the devices meant to be hand-held are simply too large) but can even be fatal, such as when the seatbelt of the car does not protect accurately in an accident (Linder & Svedberg, 2019).

Thirdly, STEM fields are important for economic growth and prosperity. For example, in Finland, the Federation of Finnish Technology Industries has calculated that technology companies need 130 000 new employees in the next ten years, or 13 300 annually (Teknologiateollisuus, 2021). This would mean significant upscaling, as these companies currently employ about 320 000 persons (Teknologiateollisuus, 2022a). Thus, many technology companies also in Finland have been eager to participate in various 'more women into STEM' initiatives, such as Mimmit koodaa[4] and Women in Tech Finland[5] to attract a more diverse pool of candidates.

It is important to recognize that the 'size' of the gender gap, i.e., the underrepresentation of women compared to men, depends on how STEM is defined. The STEM concept can even be problematic as it is often ambiguous and used inconsistently (Manly, Wells & Kommers, 2018; see also article 1). Manly et al. (2018, p. 1) underline that "given the prevalence of inconsistent and/or unreported STEM definitions, we posit that literature on gender and STEM currently requires excessive

4 https://mimmitkoodaa.ohjelmistoebusiness.fi/in-english/

5 https://womenintech.fi/

assumption and interpretation", warning that the lack of clarity in the literature is likely to lead to confusion or error. In particular, the 'science' part of the definition may mean natural science, physical science, social science, or any science. Manly et al. (2018) illustrate how the definitions impact the percentage share of women in these fields and thus the 'size' of the gender gap. Additionally, there is considerable variation between and within STEM subfields: the percentage share of women ranges from a small minority for example in mechanical engineering or telecommunications to majority in biology and chemistry related subjects (e.g., Cheryan et al., 2017; Su and Rounds, 2015; article 1 in this study).

1.2 The gender gap in STEM in Finland

Finland provides an interesting setting to study the gender gap in STEM. Like its Nordic counterparts, Finland ranks highly in many comparisons of gender equality. For example, in a comparison of all 27 EU countries by the European Institute for Gender Equality (EIGE, 2022), Finland holds 4th place (after Sweden, Denmark, and Netherlands) in the overall Gender Equality Index. However, Finnish higher education and the labour market are characterized by steep gender segregation (e.g., Keski-Petäjä & Witting, 2018). While women dominate in education, health, and social care, they account for less than 20 per cent of those who have earned a degree in technology (Statistics Finland, 2022). According to a recent article by Eurostat (2023), the percentage share of women as scientists and engineers in Finland is among the lowest in Europe and clearly below other Nordic countries.

The underrepresentation of women in engineering/technology was identified as a problem in Finland already in the 1980s and several projects have since attempted to attract more girls and women (e.g., Putila & Pihlajamaa, 2002). Nevertheless, the percentage of women obtaining degrees in technology (at all levels) in Finland merely increased from 16 to 20 per cent between 1987 and 2017 (Keski-Petäjä & Witting, 2018). The percentage share of women among new students in engineering/technology in Finnish universities has been increasing steadily but slowly, fluctuating around 20 percent in the 1990s (Yrjänheikki et al., 2002), around 25 per cent from 2005 to 2017 (article 1) and passing 30 per cent in 2019 (Teknologiateollisuus, 2022b). Despite this positive trend, women studying technology still need to adapt to a strongly masculine environment (Anteroinen & Nikku, 2022; Kaukonen, 2020), like their predecessors in earlier decades (Nitovuori, 2003; Salokangas, 2002; Vähäpesola, 2009).

Furthermore, gender differences within technology seem entrenched: the glaring overrepresentation of men in the more 'technical' fields (e.g., machine engineering, telecommunications) continues while women gravitate towards architecture, chemical engineering, environmental, and interdisciplinary studies (article 1; cf. Tanhua, 2022).

Horizontal gender segregation or the gender differences between study fields and occupations is further compounded by vertical gender segregation, meaning that women and men occupy different positions in the STEM labour market in Finland (Naukkarinen, Bairoh & Putila, 2021; cf. Paloheimo, 2015; Vuorinen-Lampila, 2016). Based on comprehensive Finnish register data, Naukkarinen et al. (2021) illustrate how men with Master's degrees in Engineering/Technology are more often employed in technical occupations and are overrepresented in managerial positions, whereas women are significantly underrepresented in both manufacturing work and in expert occupations within ICT and R&D, and overrepresented in non-technical occupations (such as accounting and communications). Studies conducted in other countries also find that careers in STEM differ for men and women: men are more likely to obtain permanent positions, have higher pay, and advance in their careers (e.g., Holth, Almasri & Gonäs, 2013; Sassler, Michelmore & Smith, 2017; White & Smith, 2021; Xu, 2017).

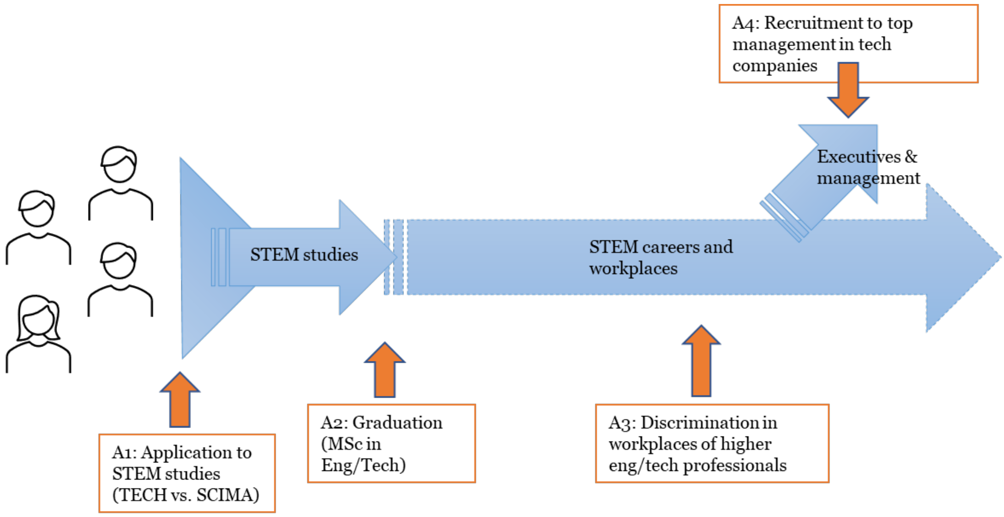
1.3 What this study contributes

Despite the apparent win-win for gender equality, technology, and society at large, the underrepresentation of women in STEM endures. What could explain the persistence of the gender gap? This study classifies and discusses various explanations instead of trying to explain the gap and its endurance with a single overarching theory. The vast scholarly literature on women/gender and STEM is classified into two broad groups of studies which are labelled 'mainstream' and 'critical'. Recognising these two groups is important because both continue to co-exist in parallel scholarly universes with very limited or even non-existent discussion or cross-referencing between them. Each new study builds on the theoretical foundations of one of these groups but drawing on both is rather unusual. As this study draws on explanations from both camps, I seek to bring some clarity to the burgeoning literature on women in STEM. Furthermore, this study discusses to what extent the findings in international literature apply in the Finnish context.

In this study, I argue that the (low) number or percentage of women in STEM is not the central problem. Rather, the problem is the persistent gender(ed) inequality within STEM, manifesting in various ways in different contexts and in different times. Hence, my goal is not to define what could be an 'acceptable' level of the gender gap but to point out some of the ways in which gender matters in STEM. In many studies on this topic, the focus in on women only, rendering men as the invisible presence or the undefined norm (e.g., Powell & Sang, 2015; Tassabehji et al., 2021). Thus, another contribution of this study is that it covers both women and men. I would have included also gender minorities, as called for by example Haverkamp et al. (2021), but despite my efforts, the data had its limitations in this regard.

The underrepresentation of women has often been approached through the metaphor of 'the leaky pipeline', suggesting that women are opting out of STEM fields either by considering other choices or failing to progress through to the different stages of the pipeline (Blickenstaff, 2005; Naukkarinen et al., 2021; Petray et al., 2019). In this study, I am using the term 'STEM career pipeline' to indicate how individuals progress from STEM studies to STEM careers and workplaces. My reasoning for using the pipeline metaphor is twofold. Firstly, it is a well-known and widely used metaphor in the (mainstream) literature and can be considered useful for identifying 'leakage points' (cf. Dubois-Shaik & Fusulier, 2016; Naukkarinen et al., 2021). Secondly, it draws attention to the numerous points wherein gender (male, female, or other) makes a difference. Hence, I am applying the pipeline metaphor, whilst being aware of and subscribing to the criticism levelled at the 'leaky pipeline' (e.g., Alegria & Branch, 2015; Petray et al., 2019). Petray et al. (2019) argue that the metaphor is limiting as it suggests a singular career pathway into which the individuals - with the ability to fit in - are funnelled. Moreover, it may lead to an oversimplified understanding of gender dynamics in STEM fields as it indicates that all women (and men) experience the same pressures and respond to them in similar ways (Alegria & Branch, 2015).

The findings of this study illustrate gender gaps along the STEM career pipeline (Figure 1), starting from applying to STEM studies and ending with recruitment to top management in technology companies. In Finland, careers in technology start already during studies, as individuals are first employed in summer jobs and later on through internships, part-time work alongside studies, and by conducting master's thesis projects for technology companies. This ensures high employment rates at the time of graduation (article 2). Therefore, it is essential to include application to studies in STEM fields as part of the gender gap in the STEM career pipeline.



STEM career pipeline and the four gender gaps covered in the articles.

Figure 1 attempts to depict some of the important points raised in the criticism of the (leaky) pipeline metaphor: for example, the arrow leading from STEM studies does not fully cover the beginning of the arrow of STEM careers, suggesting that persons graduating with STEM degrees may 'leak' to other fields. Moreover, the fuzzy edges of the arrow demonstrating STEM careers indicate that the pipeline is permeable; for example, a person may have a career in STEM or hold a job in a STEM workplace without having a degree in the field; or a person with a STEM degree may choose to leave STEM for other fields.

1.4 Research problem, research questions and outline of the dissertation

The research problem of this study is: Why does the gender gap in STEM persist? In order to find the answer, I have formulated the following research questions:

- *RQ1. What kinds of explanations for the gender gap in STEM have been provided in the research literature?*
- *RQ2. In what way does the gender gap manifest in different stages of the STEM career pipeline in Finland?*
- *RQ3. Drawing from the data, what are the main factors contributing to the persistence of the gender gap in Finland?*

This study consists of four articles (Figure 1 and Table 1) that cover four gender gaps along the pipeline of STEM careers in Finland: application to university STEM studies, graduation with Master's in engineering/technology, gender-based discrimination in technology workplaces, and recruitment to top management in technology companies. The articles contain different data and discuss somewhat differing theoretical perspectives. While each article has its own precise research questions (see Table 2 in section 3), the articles are linked to the overall research problem via the three research questions of this study.

Articles, authors and publication status

Nr.	Title of article	Author(s)	Status of publication
1	STEM : a help or a hinderance in attracting girls to engineering?	Naukkarinen, Johanna & Bairoh, Susanna	Published in: *Journal of Engineering Education*, 2020
2	Gender Differences in Professional Identities and Development of Engineering Skills Among Early Career Engineers in Finland	Naukkarinen, Johanna & Bairoh, Susanna	Published in: *European Journal of Engineering Education*, 2021
3	"Qualified women are not promoted" or "women are favoured"? Contradictory experiences of gender-based discrimination in the workplaces of higher engineering graduates	Bairoh, Susanna & Putila, Sanna	Published in: Työelämän tutkimus, 2021 (in Finnish)
4	"Do we hire only women then?" Executives navigating gender equality targets and meritocracy in technology companies	Bairoh, Susanna	Revision under review in: Gender in Management

The outline of my dissertation is as follows: In section 2, I introduce and discuss explanations for the gender gap in STEM, covering both mainstream studies and those drawing from critical feminist perspectives. In section 3, I explain the data and methods used in the articles, and findings in section 4. In section 5, I discuss the theoretical contributions of this study as well as implications of the findings. Finally, I present my conclusions in section 6.

1.5 My positioning

> I talk about 'women' because my research participants generally talk about women, even when they champion diversity and inclusion over gender equality. I am not naïve about doing so. For me, a lack of reflexivity about this point implies the risk that this project will simply be another white, middle-class, straight, able-bodied, ciswoman dealing with the same old white, middle-class, straight, able-bodied, ciswoman problems (women in positions of power) in the same old white, middle-class, straight, able-bodied, ciswoman (exclusionary) ways. (Utoft, 2020, p. 42).

In feminist research, and indeed much other research, recognizing one's own position and potential bias is highly relevant. I can describe myself as middle-aged, middle-class, straight, 'white' Finnish ciswoman, and one could suggest (as Utoft, 2020), that I should know better than to add one more study from this viewpoint to the literature on the gender gap in STEM. However, I am bold enough to believe that my study has merit and that I can contribute to research in this field.

Firstly, I have been working in technology-related organizations for 30 years, observing and experiencing the phenomena I discuss in this study. While studying social sciences at University of Helsinki in the 1990s (1992-1998), I worked in an association dedicated to developing ICT to assist organizations and society (in 1991-1997). In 1998, I conducted a study on the Internet as a tool for learning for a department of University of Helsinki while in 1998-1999, I worked in an association for IT professionals in Helsinki. In 2000-2009, I worked in a research and consulting company focusing on ICT markets and providing research services to ICT and end-user companies. In 2010-2011, I conducted a three-part study "More women into ICT!" for the Federation of Technology Industries in Finland. Since 2011, I have been working at TEK, the professional organization and labour union for higher engineering professionals. As TEK's Research manager, I am responsible for managing the association's research activities as well as conducting studies. Since 2015, most of these studies, including the articles in this dissertation, have focused on gender equality, diversity, and inclusion in engineering/technology workplaces and studies. Therefore, I have first-hand, as well as second-hand, experience and understanding of the field.

Secondly, I have been reading and interrogating literature on the topic for over 25 years, more systematically after starting my part-time doctoral studies at Hanken in 2005. While I lean towards critical feminist epistemology and find social constructionist views most persuasive, I have also kept reading mainstream research and can recognize its merits. I do not claim 'objectivity' but instead see myself as a complex and structuring body, as described by Haraway (1998, p. 589): "I am arguing for the view from a body, always a complex, contradictory, structuring, and structured body, versus the view from above, from nowhere, from simplicity. Only the god trick is forbidden". While I certainly harbour conscious and unconscious biases, I do try to recognise them and be sympathetic to various experiences of 'otherness' and intersectionality, which I continuously try to learn more about.

In the beginning of my career, I kept wondering why there were so few women in ICT and started to read studies on the topic. However, when I started my PhD studies, I intended to study the situation of ethnic minorities and Diversity Management in ICT companies, and indeed published a working paper overviewing research on Diversity Management (Bairoh, 2007). However, what I discovered in my first potential case company in 2008 was that 'diversity' in the field of technology was still constructed as about 'women'. Therefore, my topic drifted first towards women in ICT and later to women/gender in technology and finally in STEM. Hopefully, this study provides one step forward in better understanding this complex and surprisingly enduring phenomenon.

1 EXPLAINING THE GENDER GAP IN STEM

> Why do women enroll in STEM majors at lower rates than men? Despite the simplicity of this question and the wealth of research that has sought to answer it, the efforts of scholars, policy makers, and practitioners have remained relatively unsuccessful in closing the gender gap in STEM. (Kanny et al., 2014, p. 128)

The vast scholarly literature on the gender gap in STEM can be categorized in various ways[6]. In this study, this literature is classified into two main groups which I label 'mainstream' and 'critical', following the classification of (feminist) engineering education studies by Beddoes and Borrego (2011; also Beddoes, 2012). The mainstream group consists of studies that Beddoes and Borrego (2011, p. 291) call "liberal feminist": these assume that the categories of women and men are given and comparing these groups helps us to understand why women are underrepresented. Studies in this group tend to explain the gender gap in STEM as a 'natural' consequence of the (innate) differences between men and women, often utilise psychological theories, and appear to

6 This review is "state-of-the-art" type (cf. Patrick, Martin & Borrego, 2022) synthesizing and building on the women and STEM literature used in the articles. It does not attempt to be a systematic review of the huge literature on women/gender and/in STEM.

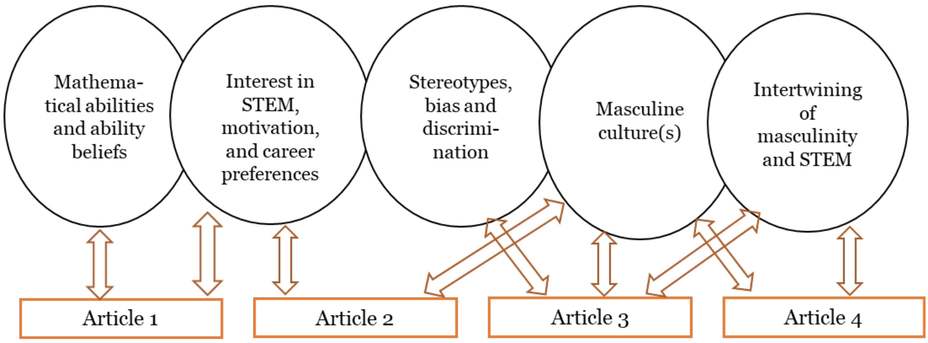
offer explanations justifying the status quo. Such research includes, for example, Ceci et al. (2009), Ceci et al. (2014), Su and Rounds (2015), and Stoet and Geary (2018).

The critical group includes studies which draw on critical feminist perspectives, consider the gender gap as constructed, and aim to understand how it is perpetuated. Critical feminist perspectives tend to refer to standpoint feminism as well as intersectional, interactional, post-modernist, post-structural, and masculinity studies, or various combinations of these (see Beddoes and Borrego, 2011). The studies in this group include, among others, Faulkner (2014), Galea and Chappel (2021), Powell and Sang (2015), Seron et al. (2016), and Tassabehji et al. (2021). Scholars in this group see (radical) change as worth pursuing and are calling for various stakeholders to actively participate in this process. Nevertheless, there are also mainstream studies that reach similar conclusions, such as Cheryan et al. (2017), Cheryan and Markus (2020) and Master and Meltzoff (2020).

Based on meta-reviews of the women in STEM (mainstream) literature conducted by Ceci et al. (2009), Ceci et al. (2014), Cheryan et al. (2017), Kanny et al. (2014) and Wang and Degol (2017), explanations of the gender gap mostly draw on the following basis: Mathematical abilities and ability beliefs; Interest in STEM, motivation, and career preferences; and Stereotypes, bias and discrimination. In addition, based on reviews such as Blickenstaff (2005) and Jansson and Sand (2021) that include also critical studies, two more explanatory categories can be added: Masculine culture(s) and the Intertwining of technology and masculinity/ies. The four articles in this study cover all these categories of explanations albeit to varying extent (Figure 2).

It is important to recognise that studies conducted in the previous decades may reflect a somewhat different world than more recent studies. Ceci et al. (2014, p. 76) argue that the number of women in science at all levels has increased so dramatically that research based on data prior to the 1990s “may have little bearing on the current circumstances women encounter”. Additionally, Kanny et al. (2014, p. 128) stress that “perhaps the reasons for women’s underrepresentation have changed over time and the literature has not accurately identified new or evolving explanations for the gender gap in STEM”. This point needs to be borne in mind when discussing the explanations, including and highlighting the most recent research as appropriate.

Figure 2 portrays how the four articles draw on and discuss the five groups of explanations covered in this study. The order of the explanations is partly based on extant literature, partly on the order of the articles, reflecting how my understanding of the phenomenon has developed while conducting this study.



Explanations for the gender gap covered in the articles.

Please note that whenever 'STEM' in a particular study includes subjects/fields other than engineering, technology, mathematics, and natural sciences, this is mentioned in a footnote.

1.1 Mathematical abilities and ability beliefs

> Are fewer women in these fields because they lack spatial skills that form the basis of higher mathematics, which, in turn, is critical to success in STEM fields, as some suggest? And is this due in part to hormones? (Ceci et al., 2009, p. 250)

> It seems clear from the literature that whatever biological differences there are between men and women, there is very little difference in scientific or mathematical ability, and certainly not enough to explain the under-representation of women in STEM careers. (Blickenstaff,2005, p. 373).

Several meta-reviews of the mainstream literature (e.g., Ceci et al., 2009; Ceci et al., 2014; Cheryan et al., 2017; Wang & Degol, 2017) find it vital to discuss whether the gender gap in STEM is rooted in gender differences in mathematical abilities. Despite considerable efforts at proving otherwise, Ceci et al. (2009, p. 249) conclude that "the data are not consistent enough to claim that the dearth of women in STEM careers has been shown to be primarily a result of direct consequence of biological sex differences (e.g., genes, hormones) impeding women's aptitude at math or spatial cognition, which, in turn, preclude their entry into STEM careers". Similar conclusions are also drawn in other reviews

(Ceci et al., 2014; Wang & Degol, 2017): examining average test scores and grades reveals only minor differences in mathematical abilities between males and females (Cheryan et al., 2017).

Concluding that the gender gap in STEM is not explained by gender differences in mathematical abilities and thus “not purely biological” (Ceci et al., 2009, p. 251), nevertheless, has not prevented certain mainstream scholars from clinging to biology as part of the explanation, and it keeps resurfacing in various forms. For example, in their recent article, Stewart-Williams and Halsey (2021, p. 7) insist that the gender differences in STEM have a substantial biological component and argue that regardless of the ultimate explanation, “the evidence for an inherited contribution to the relevant sex differences is strong” - a view that is vehemently supported by Ceci, Kahn and Williams (2021).

Rather than mathematical abilities, men and women differ in their belief in these abilities. Master and Meltzoff (2020, p. 166) use ‘ability beliefs’ as an umbrella term to cover several types of beliefs that have been measured in previous research, such as “self-efficacy” (beliefs about current ability to succeed in a task or domain), “perceived competence,” “self-confidence,” or “academic self-concept” (which can be measured for perceived abilities in a specific academic domain). Studies show that ability beliefs predict STEM interest and outcomes above and beyond prior performance (Master & Meltzoff, 2020; also Eccles & Wang, 2016; Hencke et al., 2022; Kanny et al., 2014, Perez-Felkner, Nix & Thomas, 2017). For example, Perez-Felkner et al. (2017) found with longitudinal US data that gender differences in mathematical ability beliefs, such as boys perceiving their ability to be stronger than girls, held even for those on the highest ends of the distribution of mathematics ability. Therefore, the authors underline that ability beliefs and their influence cannot be explained by differences in innate talent.

Critical scholars have highlighted how engineers take pride in their mathematical ability and see that being math-savvy sets them apart from other professionals – and for women, differentiates them from other women (Faulkner, 2007; Powell, Dainty & Bagilhole, 2012; Rhoton, 2011; Seron et al., 2018). Seron et al. (2018, p. 141) describe how the young women in their US-based study experienced that excellence in math and science set them apart from other women: “As they took advanced courses in math and science in high school, many of these young women also report that they were one of very few, or the only ‘girl’ in their class”. Similarly, women engineering students in the UK held stereotypical views about the type of people best suited to a career in engineering, suggesting, for example, that men are suited to engineering because of the way the male brain works (Powell et al., 2012). Powell et al. (2012) point out that this was despite women stating that they were motivated to study engineering because they were good at maths and science. As the studies by Powell et al. (2012) and Seron et al. (2018) demonstrate, women studying engineering may express belief in a biological or innate difference between men and women and explain their own abilities in math and science as exceptional compared with their female peers.

While we can thus conclude that gender differences in mathematical abilities are not a viable explanation for the gender gap in STEM, the stereotype of men being more 'naturally' suited for mathematics - and hence for (physical) sciences, engineering and technology - still thrives. The endurance of this stereotype is strongly entangled with the persistence of the gender gap, as I discuss in later sections. Moreover, gender differences in ability beliefs clearly impact interest in and motivation to study STEM subjects, to which I now turn.

1.2 Interest in STEM, motivation, and career preferences

> Interests have been consistently shown as a critical predictor for career choice and career attainment. (Su & Rounds, 2015, p. 1)

> Boys show greater motivation than girls for many STEM fields starting at an early age, but motivation is malleable, and can be changed. (Master & Meltzoff, 2020, p. 169)

Lack of interest in STEM, especially towards certain STEM fields such as engineering, is a widely applied and often used explanation for the gender gap. One influential study on the topic is Su and Rounds' (2015) article investigating gender differences in interests as an explanation for the differential distribution of women in STEM[7] fields. Drawing on person-environment (P-E) fit theories, Su and Rounds (2015, p. 3) argue that: "Because females are socialized to possess higher social values in interacting and helping people, they are more likely to be drawn to occupational fields with work tasks that are perceived to fulfil these values, such as teaching, nursing, or medical science, rather than fields that are perceived to be low in these values, such as physical science and engineering". The authors meta-analyse norm data on basic interests published between 1964 and 2007 and find gender differences in interests to vary largely by STEM field, with the largest gender differences in engineering disciplines, favouring men.

7 Su and Rounds' (2015) definition of STEM includes social sciences (which in their definition also covers, for example, economics and psychology), medical science, and medical services.

Although Su and Rounds (2015) mention gendered career choices, socialization, and other factors affecting men and women differently, these are not discussed in any detail. The authors explain that while the literature has consistently shown the influence of social contexts (e.g., parents, schools) on students' interest development, little is known about the link between biological factors (such as brain structure, hormones) and interest development. Su and Rounds (2015, p. 16) argue that "[t]o the extent that gender differences in interests are explained by biological factors, the effectiveness of social and educational interventions for increasing girls' interests in STEM fields may be constrained". Alas, we are back in the (assumed) biological differences discussed in the previous section.

In their widely cited and popularized article, Stoet and Geary (2018) find what they call the 'educational gender-equality paradox': the graduation gap in STEM between men and women is larger in more gender-equal countries. Using Finland as an example, Stoet & Geary (2018, p. 1) underline that "[w]ith these high levels of educational performance and overall gender equality, Finland is poised to close the STEM gender gap. Yet, paradoxically, Finland has one of the world's largest gender gaps in college degrees in STEM fields.[8]" The authors find that although girls perform similarly or better than boys on generic science literacy tests in most of the 67 nations in the study, boys are more likely to perceive science or mathematics as a personal academic strength than girls. Inspired by expectancy-value theory, Stoet and Geary (2018) argue that substantive differences in STEM-related education pathways potentially emerge when boys are relatively better in science and mathematics and girls are relatively better in reading.

In the study by Stoet and Geary (2018), the gender gap in STEM is perceived to result from the (apparently unconstrained) choices of individuals, partially impacted by the need for economic security. One of the less discussed findings of Stoet and Geary (2018) is that in nearly half the studied countries boys overestimated their science self-efficacy, and this overestimation by boys was larger in countries with high gender equality scores. Does this result indicate that boys in more gender-equal countries are simply deluded? More likely, it signals that enduring and powerful stereotypes about boys' competence in science and mathematics impact their (and girls') assessment of their own capabilities (Breda et al., 2020; Cech et al., 2011; Wynn & Correll, 2017). Furthermore, while Stoet and Geary (2018) use Finland as an example to illustrate their findings, they do

8 STEM degrees in this study include tertiary graduates in natural sciences, mathematics, statistics, information and communication technologies, engineering, manufacturing and construction.

not mention any country-specific features. Since they are comparing 67 nations, this is understandable. Nonetheless, it means that essential and relevant context information remains beyond the scope of their study. An example would be that educational fields and the labour market in Finland are among the most gender segregated in Europe (Keski-Petäjä & Witting, 2018; cf. Bettio & Vershchagina, 2009), as discussed earlier.

Several mainstream researchers do emphasise the importance of contextual factors in shaping the interest and motivation to pursue STEM studies and careers. Kossek, Su and Wu (2017) underline that what appear to be women's individual choices are shaped by social context factors. They point out that "individuals' career perceptions and experiences are embedded in social contexts reflecting the climate for gender inclusion and interact with these contexts to shape women's career equality outcomes" (Kossek et al., 2017, p. 228). Similarly, Kanny et al. (2014) stress that instead of explaining the underrepresentation of women in STEM simply with lack of interest, the literature has increasingly pointed toward contextual influences, such as environmental and social context, that are perceived to shape women's aspirations (cf. Sax et al., 2018).

Critical studies have highlighted the importance of contextual factors well. As Wong (2015, p. 985) aptly points out, that "[y]oung people's science aspirations are not merely individual choices but are also shaped and influenced by wider social structures and identities within which they are located". Wynn and Correll (2018) summarize that even for highly qualified, motivated women majoring in STEM fields, the use of stereotypically gendered or geeky images can negatively impact reported interest. Cheryan et al. (2017, p. 22) emphasise that women's interests are fundamentally shaped by the culture of STEM fields: "Just because women are excited to go into other fields does not mean that they would not have been equally excited to go into computer science, engineering, and physics if the cultures signalled to them that they belong there". Petray et al. (2019) even argue that it is currently impossible to separate individual preferences from social pressures, such as gendered career expectations.

Gendered career paths and gender inequality have also been explained by the interaction between women's interests, values and goals, as well as the characteristics of the work environment (Kossek et al., 2017; see also Glosenberg et al., 2022). The career preference perspective draws on person-environment (P-E) fit theories, holding that the pursuit of congruence with work environments provides the basis for the motivation and behaviour of the individual across all career stages (Kossek et al., 2017). According to Kossek et al. (2017, p. 233), the dynamics of the P-E fit "explain why women disproportionally opt out of technological work environments that are less compatible with social interests and why women forgo some career advancement opportunities that are perceived as competitive rather than collaborative". Hakim's preference theory (e.g., Hakim, 2002) suggests that the three lifestyles (home-centred, work-centred, adaptive) are major determinants of women's fertility, employment patterns, and job choice (e.g., part-time/full-time) but no longer determine occupational choice as "[w]omen are no longer excluded from certain occupations because they are (assumed to be) not as work-centred as men" (Hakim, 2002, p. 454).

Engaging critically with the preference theory, O'Connor, O'Hagan and Gray (2018) seek to problematise gender as a dichotomous variable by looking at variation in the enactment of femininity(ies) in male dominated STEM contexts. O'Connor et al. (2018) show how social practices variously prioritise, reconcile or devalue career and non-work relationships while largely maintaining the hierarchical relationship between masculinity(ies) and femininity(ies) in an organizational context that privileges conventionally masculine career characteristics. The authors identify four types of femininities within STEM in academia (careerist, individualised, vocational, and family-oriented[9]) and, unlike Hakim (2002), underline that all of these are constituted in relation to the meanings attached to the masculinist STEM career which performatively render women outsiders (please see more in section 2.4).

To summarize: while individual women certainly have differing interests, values and preferences regarding their careers in STEM, and these may differ from those of men, these differences alone do not explain the gender(ed) gap(s) in STEM. As Cheryan et al. (2017) point out, differing preferences may explain women's and men's educational and career choices but the question then becomes why their preferences differ and whether these preferences could be changed. Moreover, framing the problem in terms of individual characteristics places the blame on individuals and fails to acknowledge structural inequities (Sax et al., 2018). These structural inequalities include stereotypes, bias and discrimination which are discussed next.

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9 These four femininities in STEM differ interestingly from the four masculinities identified in an earlier study (O'Connor, O'Hagan & Brannen, 2015, see section 5.3).

1.3 Stereotypes, bias and discrimination

> The idea that women are routinely discriminated against in STEM, while true in earlier generations, is no longer true. (Stewart-Williams & Halsey, 2021, p. 17)

> [O]ur diarists frequently acknowledge the likely existence of explicit gender discrimination previously in the profession, but generally deny its existence in the present. (Seron et al., 2018, p. 156)

Under conditions of uncertainty about how to make judgments, stereotypes influence evaluations of self and other (Wynn & Correll, 2017). Prior studies suggest that endorsement of stereotypes about the group precedes the development of gender differences in self-concepts, albeit the data is limited (Master & Meltzoff, 2020). Master and Meltzoff (2020) distinguish two types of gender stereotypes pertaining to STEM: stereotypes about who likes or is associated with a field (stereotypes about interest) and stereotypes about who is good at or has superior ability in a field (stereotypes about ability). The combination of both types of stereotypes contributes to the underrepresentation of women in STEM by acting as a gatekeeper: "Women may worry both that they do not fit the image of a STEM person and that they do not have the ability to succeed in STEM" (Master & Meltzoff, 2020, p. 161, italics in the original).

Wynn and Correll (2017) illustrate how both types of stereotypes function among technical employees in Silicon Valley companies. While men and women held similar beliefs about the skills required to be a successful tech worker (analytical, questioning, and highly mathematical), women were significantly more likely to believe that successful tech workers embody particular 'cultural' traits (e.g., obsessive, assertive, geeky) than men did. Furthermore, women less often believed that they had the skills of a successful tech employee and were significantly less likely to believe that the required cultural traits described them. Wynn and Correll (2017, p. 1) find that cultural alignment is of particular importance: "[B]ecause women are less likely than men to believe they match the cultural image of successful tech workers, they are less likely to identify with the tech profession, less likely to report positive supervisor treatment, and more likely to consider switching career fields". The authors point out that current policies focusing primarily on increasing the interest and skills of young women neglect the fact that stereotypes continue to hinder women as they progress in their careers.

It is important to recognize that "bias can exist in cultures and not just in people's heads" (Cheryan & Markus, 2020, p. 19) and that stereotypes affect men as well as women (Ekonen, 2014; Wynn & Correll, 2017). In a study of careers in male-dominated high-tech firms (Ekonen, 2014), women and men described how they had to find a balance between stereotypes associated with femininity and masculinity: Women managers explained that they had to overcome stereotypes of the typical woman manager whereas men managers felt that there were stereotypical expectations of how a male manager builds a career in these organisations. According to Ekonen (2014), it thus appears that both men and women faced challenges in male-dominated high-tech organisations when trying to reconcile their career-related hopes and plans with stereotypical expectations of what is an acceptable way for women and men to build their careers.

Mainstream women in STEM literature rarely addresses workplace discrimination in a systematic way and some scholars openly dismiss its importance in explaining the gender gap in STEM. For example, Ceci et al. (2009, p. 247) argued that "[m]uch of the evidence of discrimination in the proximal environment is dated or anecdotal and not compelling as an explanation of why women are underrepresented in math fields". Similary, Ceci et al. (2014, p. 76) claimed that gender-based discrimination is a historical barrier and no longer a valid reason for women's underrepresentation. Other researchers, nonetheless, find that discrimination towards women is a prevalent problem in STEM fields. According to Cheryan et al. (2017), discrimination is apparent across a range of STEM fields and creates obstacles for women that their 'white' male peers do not face.

Scholars drawing on critical approaches underline that downplaying or tolerating discrimination is an important coping mechanism for women in STEM (see also section 2.5). According to Chapple and Ziebland (2017), successful women scientists rarely suggest that their own careers have been hampered by gender discrimination although some acknowledge it may have affected those of other women. Powell, Bagilhole and Dainty (2009) found that women engineering students were reluctant to admit they had been discriminated against and even sought ways to justify their colleagues' actions. In Rhoton's study (2011), some women faculty in STEM disciplines distinguished themselves from other women in two ways: by asserting that other women who believe there are barriers to women's success will likely encounter them precisely because they are looking for them, or by claiming that women colleagues overreact or otherwise respond inappropriately to instances of gender bias, thus exacerbating discrimination.

Critical studies illustrate how women seek to overcome negative stereotypes and experiences of discrimination by demonstrating their competence as engineers, believing that their gender will eventually become insignificant (Faulkner, 2011; Hatmaker, 2013; Powell et al., 2009; Powell & Sang, 2015). This may be due to women adopting the professional culture of engineering characterized by meritocratic ideology and individualism (Seron et al., 2018; see also Rhoton, 2011). For example, women engineering students in the study by Seron et al. (2018) acknowledge that explicit gender discrimination may have previously featured in the profession, but generally reject its existence in the present.

Overall, many mainstream as well as critical studies recognise the importance of stereotypes and their impact on the recruitment and retention of women in STEM. While there is lack of mainstream studies on discrimination, many critical studies highlight how tolerating (often subtle) unequal treatment is a coping mechanism used by many women. However, women may also deny the existence of discrimination, or believe it belongs to the past and not to (their) present. Possible explanation for this is the strong meritocratic ethos prevalent in science and technology organizations (Seron et al., 2018; Rhoton, 2011), linked with the masculine culture(s) which are discussed next.

1.4 Masculine culture(s)

> In STEM fields, a masculine culture is a social and structural environment that confers a greater sense of belonging and ability to succeed to men than women. (Cheryan et al., 2017, p. 8)

> We argue that these findings reflect a gendered spectrum of belonging—the dynamic forms of inclusion or exclusion that women experience according to their race, sexuality, and gender presentation. (Alfrey & Twine, 2017, p. 30; italics in the original)

Critical scholars have established that masculine culture(s) constitutes a major obstacle to the realisation of gender equality in STEM fields (among others, see: Faulkner 2011; Jansson & Sand 2021; Powell & Sang 2015; Seron et al., 2016). Certain mainstream studies have also highlighted the impact of male-normative or masculine cultures on the underrepresentation of women (e.g., Cheryan et al., 2017; Wilson & VanAntwerp, 2021). Masculine cultures are characterized by stereotypes of the field that are incompatible with how women see themselves, by negative stereotypes associated with women and their abilities, perceived bias and discrimination, and lack of female role models indicating career development problems (Cheryan et al., 2017). According to Wilson and VanAntwerp (2021, p. 11), normative male dominance "prevents women from expressing their opinions freely, feeling that their work is valued, gaining recognition for their accomplishments, receiving unbiased feedback for professional growth, and feeling cared about at work". Nonetheless, it is important to remember that not all women are repelled by masculine cultures, just as these are not appealing to all men (Cheryan et al., 2017).

Male-dominated fields may be characterized by 'masculine defaults': these features exist in cultures that value, reward or consider normal, neutral or necessary traits or behaviours associated with men (Cheryan & Markus, 2020). As Wilson and VanAntwerp (2021, p. 13) explain, male normative cultures exist when the expectation is that all workers are (and will be) male, or at least conform to stereotypical male traits: "By their very nature, male normative cultures reject or undervalue female traits and in so doing, deny women the approval and acceptance that are essential to developing the social bonds necessary to feel that they belong in the workplace". Moreover, as masculine defaults are based on 'white' heterosexual men, they also restrict men from ethnic minorities or sexual minorities (Cheryan & Markus, 2020; cf. Leyva, Massa and Battey, 2016).

Critical studies indicate that the culture in STEM education and workplaces adheres to a rather narrow masculine norm that perpetuates gendered inequalities and undermines women's belonging (Faulkner 2007; Jansson & Sand 2021; O'Connor, 2020; Seron et al., 2016). Hatmaker (2013) shows four ways in which interpersonal interactions marginalize the professional identity and belonging of women: by amplifying gender, by imposing gendered expectations, by tuning out (e.g., by ignoring ideas or input), and by doubting technical abilities. Although the women employed various coping strategies, the interactions left them feeling devalued as an engineer (Hatmaker, 2013). On the other hand, while Alfrey and Twine (2017, p. 45) find that gender fluidity provided conditional acceptance for (certain) women, it did not challenge the underlying idea that the most competent designers of software solutions were "white, Asian, and imagined to be male".

Higher education institutions in STEM fields reproduce gender inequality through their 'normal' structure and culture (O'Connor, 2020; Blair-Loy & Cech, 2022). O'Connor (2020) shows how at a structural level, 'normal' practices perpetuating gender inequality include the greater structural availability of senior posts in male-dominated staff areas, ideas about a 'normal' linear career path (while women are allocated to 'housekeeping' activities) and the criteria and procedures involved in recruitment and promotion. Additionally, O'Connor et al. (2018) point out that the most common career orientation for women in STEM academia (careerist femininity) requires remaining silent about sexism and making constant and creative efforts to 'blend in'. The 'normal' (masculine) career paths fail to acknowledge caring responsibilities and thus may force women to seek alternative paths (e.g., Cech & Blair-Loy, 2019; Holth, Bergman & MacKenzie, 2017; Niemistö et al., 2021). Blair-Loy and Cech (2022) argue that the professional culture in (academic) STEM is characterized by two schemas, work devotion and scientific excellence, which reproduce inequality since gender, racial/ethnic, and LGBTQ biases are embedded within them.

The culture(s) in engineering/technology, in particular, have been described as chilly or even hostile towards women (e.g., Britton, 2017, Miner et al., 2019; Wynn & Correll, 2018). According to Wynn and Correll (2018), features of chilly culture include openly sexual references, stereotypical images, emphasis on hobbies and behaviours that are associated with men and masculinity, excluding or belittling women, and having low number of women. Seron et al. (2016) show how cultures and practices of professional socialization during engineering studies lead women to develop less confidence that they will fit into the culture of engineering. The authors find that informal interactions with peers and everyday sexism in teams and internships are particularly salient building blocks of persistent gender segregation within the profession.

Women apply different adaptation strategies to demonstrate that they belong in the masculine culture(s) of STEM fields. These include acting like 'one of the guys' and adapting to gender-based discrimination (Powell et al. 2009; also: Alfrey & Twine, 2017; Hatmaker, 2013). Hatmaker (2013) discusses two types of identity construction strategies employed by women: impression management tactics and coping strategies. The author illustrates how women engineers who engaged in identity negotiation tactics appeared to expend a good deal of effort and thought towards building their professional identity. As Hatmaker (2013) points out, this extra work places a strain on women engineers that simply is not felt by (most) men. Johansson, Morell and Lindell (2020) explain that doing gender in workplaces dominated by masculine values often requires women to control their femininity to comply with gendered behavioural and embodiment scripts. Alfrey and Twine (2017) find that femininity, or adherence to traditional gender roles, can be a liability for women in male-dominated technology firms.

Another adaptation strategy highlighted by critical scholars is downplaying the importance of gender (Britton, 2017; Faulkner, 2011; Korvajärvi, 2021; Nash & Moore, 2018; Rhoton, 2011; Vellamo, 2022). Nash and Moore (2018) argue that women in their study seemed to be caught in an ideological dilemma between recognizing sexism and gender bias in their organizational contexts and seeing their organizations as gender neutral. As Faulker (2011, p. 283) explains: "It seems that, by refuting or playing down the significance of gender, women engineers are better able to strengthen or protect their fragile membership as engineers, while playing up gender and heightening their visibility as 'women' can be seen (and felt) to threaten their belonging in the community of practice".

The impact of the masculine culture on men in STEM fields has been studied far less than its impact on women. Masculinity is most often invisible (Johansson et al. 2019; cf. Collinson & Hearn, 1994; Hearn & Collinson, 2018) and men only appear indirectly or implicitly in many studies, as references in women's comments (Tassabehji et al., 2021). Nonetheless, critical studies indicate that it is easier for men to feel 'at home' in engineering/technology, and their skills or competence are seldom questioned (Faulkner, 2007; Faulkner, 2009; Seron et al., 2016; Tassabehji et al., 2021). For example, Seron et al. (2016) illustrate how professional socialization during engineering studies fostered the belonging of men whereas the experiences of women were quite different. Faulkner (2009) suggests that there is room for a wide range of masculinities in engineering workplaces and that they therefore suit most men, although men who embody hegemonic masculinity find it easier to fit in.

We can thus summarize that masculine culture(s) in STEM fields, particularly in engineering/technology, have been widely studied by critical scholars and recently by certain mainstream researchers. While this explanation for the gender gap is commonly used in critical studies, it has, nevertheless, received less attention in mainstream research. Another explanation that is hardly addressed in mainstream research is the intertwining of masculinity and STEM, as is discussed next.

1.5 Intertwining of masculinity and STEM

> I believe the continued male dominance of engineering is due in large measure to the enduring symbolic association of masculinity and technology by which cultural images and representations of technology converge with prevailing images of masculinity and power (Faulkner, 2001, p. 79).

> We have shown how connections between men, masculinity and technical knowledge are created in everyday practices and are neither natural nor universal, and that these connections are made in a variety of ways, by different actors and in different contexts. (Jansson & Sand, 2021, p. 15)

Advocates of feminist studies of science, such as Evelyn Fox Keller, Sandra Harding, Donna Haraway and Helen Longino, have argued that women are unsuccessful in science because science itself is a masculine/ist enterprise (Blickenstaff, 2005). For example, Haraway (1988, p. 581) strongly rejected the conventional idea of objectivity in science as a view from above, calling it “the god trick of seeing everything from nowhere”. Instead, she introduced the concept of ‘situated knowledges’ as the form of feminist objectivity: “Feminist objectivity is about limited location and situated knowledge, not about transcendence and splitting of subject and object. It allows us to become answerable for what we learn how to see” (Haraway, 1988, p. 583). While usually not recognized in mainstream studies of women/gender and STEM, Haraway’s concept of ‘situated knowledges’ has remained central to feminist epistemology and science studies, as well as to attempts to understand the role of modern science in society (e.g., Thompson, 2015).

The work of Wendy Faulkner (2000, 2001, 2007, 2009, 2011, 2014) has profoundly influenced numerous critical researchers studying women/ gender and STEM. Two decades ago, Faulkner (2001, p. 82) advocated what she called ‘feminist technology studies’ or FTS which emphasizes that both gender and technology are socially shaped and so potentially re-shapable: “[A] parallel is drawn between the social construction of gender and the social construction of technology, in which each are seen as performed and processual in character, rather than given and unchanging”. Faulkner explained that the FTS approach obliges us to view gender as an integral part of the social shaping of technology, thus challenging any presumed neutrality of technology by focusing on how gender might enter or be expressed in the very design of technologies. Moreover, it challenges determinist views of technology by recognizing that individual technologies are subject to significant interpretative flexibility in both their use and design (Faulkner, 2001; Bray, 2007).

Instead of asking whether technology or STEM is gendered, the key question is: How is it gendered? Faulkner (2001, p. 89-90) summarized that technology is gendered because key actors are predominantly men; the gender divisions of labour are strong; cultural images of technology are strongly associated with hegemonic masculinity; and technology is an important element in the gender identities of (certain) men. Husu and Koskinen (2010, p. 137) discuss that the male domination in arenas of excellence in technology and engineering represents the product of 'triple dominance': First, there is the male dominance of most of the fields of technology and engineering, both numerically and in terms of leadership positions. Second, this is reinforced by further processes of homosociality, inclusion and exclusion in both the control, gatekeeping and decision-making on excellence, and the award of excellence itself. And third, these gendered processes of gendered excellence are becoming increasingly international rather than national, with their own patterns of international networks, organisations and institutions.

Faulkner (2000) highlighted the frequency of (gendered) dualisms about technology, such as people-focussed vs. technology-focussed, social vs. technical, hard vs. soft, etc. She argued that the tendency to dualize within engineering and the form engineering dualisms take are co-produced by factors related to engineering and to the performance of gender more widely. Her concept 'technical/social dualism' (originally presented in Faulkner, 2000) epitomizes the crux of the problem: being technical and being social are deemed to be mutually exclusive, such as in the stereotype of the antisocial technology-obsessed man. Goddard et al. (2021) point out that the separation of the technological from the social appears to construct a gender-neutral self-understanding wherein, nonetheless, gender is concealed instead of bypassed. "Perversely, gender-blindness simply perpetuates gender subordination in a world where it already exists" (Goddard et al., 2021, p. 5).

The association of masculinity and technology is strongly linked to the continuing male dominance in engineering, underlined Faulkner (2001). Engineering and pleasure in technology are felt and perceived to be gender authentic options for men but gender inauthentic options for women (Faulkner, 2011). Thus, the term gender in/authenticity captures the apparent congruence of gender and engineering identities for men and their non-congruence for women engineers. Moreover, women engineers are often invisible as engineers but highly visible as women; hence the (in)visibility paradox (Faulkner, 2007; Faulkner, 2011). "Gender (in)authenticity and the (in)visibility paradox create issues for women engineers which men engineers by virtue of being men rarely have to experience. Through numerous subtle and not so subtle dynamics, women engineers are perceived, and can feel themselves, to be not quite 'real engineers' or 'real women'" (Faulkner, 2011, p. 287).

Technical/social dualism, gender in/authenticity and in/visibility paradox are concepts that have been widely used in the critical literature on women/gender and STEM. For example, Convertino (2019) shows how the dominant discourses of underrepresentation and gender difference that characterize gender inequality in Computer Science create subject positions which simultaneously mark women as highly invisible and visible. Tassabehji et al. (2021) illuminate how forms of masculinity constituted within software development put women in the ambivalent position of being either female or a coder, but not both. It is important to acknowledge, furthermore, that gender in/authenticity not only applies to women but also LGBTQ+ individuals who feel out of place in engineering as a field masculinized heteronormatively, privileging men whose gender identities align with their male biological sex (e.g., Leyva et al., 2016).

To summarize, feminist studies of science highlight that men – or more precisely, particular types of men – have been able to define the terms of technology development. Nonetheless, public discourse on gender in/of technology has mainly focused on denying the importance and existence of gender differences (Vehviläinen, 2005), and mainstream studies do not tend to address the intertwining of masculinity and STEM.

2 DATA AND METHODS

The articles shed light on the research problem – the persistence of the gender gap in STEM – by investigating four gender gaps along the STEM career pipeline in Finland. Each article uses different data and deploys somewhat differing theoretical perspectives.

1. *Article 1 uses macro-level register data focusing on gender differences among applicants to Bachelor-level STEM university studies.*
2. *Article 2 uses pooled survey data gathered by TEK*[10] *and technical universities to investigate the development of engineering skills and professional identity among recently graduated men and women (MSc Eng/Tech).*

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10 TEK (Academic Engineers and Architects in Finland) is the professional organization and labour union for higher engineering professionals. Please see more: www.tek.fi

3. *Article 3 combines quantitative and qualitative data from two TEK surveys, comparing men's and women's differing experiences of gender-based discrimination in the workplaces of higher engineering professionals.*

4. *Article 4 is a qualitative article based on interview data gathered by TEK. The article analyses how executives navigate gender equality targets and the ideal of meritocracy in technology companies in Finland.*

2.1 Article 1: Application to STEM studies

In this article, we were interested in analysing applications to study engineering/technology (TECH) programmes as against applications to biological or physical sciences, mathematics, or computer science (SCIMA) programmes, and how these differ by gender. Since all applications to university as well as polytechnics (i.e., so-called 'universities of applied sciences') are completed through the Studyinfo. fi portal, we sought to gain this data for our analysis. The portal is maintained by the Finnish National Agency for Education (EDUFI). The nationwide portal has been in use since 2015, and the first full-year dataset was from 2016. Therefore, after drafting our research proposal for the study in the spring of 2017, we requested the 2016 data from the Board of Education in May 2017 and obtained it in September 2017.

In the data, application choices are presented as six-digit codes. These codes conform to the national study programmes' classification by Statistics Finland which is based on the Unesco International Standard Classification of Education. Each applicant can choose up to six study programmes, and these are provided in a ranking order (Choice1, Choice2, etc.). In the application process, this order is binding. This means that the applicants are offered only the study place located highest on their preference list to which they have enough points to be accepted. The data also contained certain background information on the applicants (gender, nationality, language, and country of residence). Since we were interested in the Finnish education system, we used this information to omit applicants who did not reside in Finland[11].

11 We excluded applicants not residing in Finland in the second revision of the article (submitted in October 2019) due to comments from the reviewers.

Summary of research questions, data and methods in the articles

Article	Research Questions	Data	Methods
1	Q1. What kinds of choice patterns can be identified among applicants who primarily wish to study engineering/technology (TECH) and applicants who primarily wish to study biological or physical sciences, mathematics, or computer science (SCIMA)? Q.2 How are these choice patterns gendered, i.e., how do the patterns differ between males and females?	Opintopolku applicant data from Studyinfo.fi database (2016); 9,104 individuals based on their first application choice (TECH/SCIMA)	Percentage shares, crosstabs, significance tests (Pearson's Chi-square)
2	Q1. How do the perceived importance and development of professional skills differ between early career women and men engineers? Q2. Can the gender differences in Q1 be explained by different gender distributions in various fields of engineering education?	TEK Graduate Survey 2018-2019 (only Engineering/Technology graduates)	Percentage shares, crosstabs, significance tests (Mann-Whitney U), factor analysis (PCA), regression analysis
3	Q1. How common is gender-based discrimination in the workplaces of higher engineering professionals? Q2. What kind of experiences of gender-based discrimination do higher engineering professionals have, and how do they differ according to gender? Q3. How does the masculine culture in the field of technology manifest in the experiences of discrimination?	TEK member survey (Labour Market Survey) 2015 (only Engineering/Technology graduates); TEK Equality Survey 2020	Percentage shares, crosstabs, significance tests (Pearson's Chi-square), content analysis of open comments
4	The aim of the study is to understand how executives in technology companies relate to targets for gender equality, particularly pertaining to top management.	TEK interview data from March-May 2019 and May 2021: 19 interviews of executives in 10 technology companies (six CEOs, nine HR managers, four senior managers)	(Reflexive) thematic analysis

In our study, we first identified the two groups that we were interested in, based on their primary application choice (Choice1) as follows:

- *TECH: Applicants whose first application choice (Choice1) was engineering/technology studies at a university (B.Sc.).*
- *SCIMA: Applicants whose first application choice (Choice1) was biological or physical sciences (biology, chemistry, physics, and related subjects), mathematics, or computer science at a university (B.Sc.).*

The original data contained all applicants to Bachelor-level studies for the year 2016 (151,369 individuals) and their application choices. In our study, we included the application choices of 9,104 individuals (of whom 98.7% were Finnish citizens). After selecting the target groups, all application choices were checked and unified so that each choice category contained only one six-digit code. All six application choice categories were recoded for analysis purposes. Moreover, the first application choices (Choice1) of the TECH applicants were recoded into 10 engineering/technology categories for further analysis, and the first application choices (Choice1) of SCIMA applicants were recoded into 10 categories in a similar fashion.

The analysis methods applied in this exploratory study were mainly descriptive (percentages, crosstabs) while the significance of gender differences was tested with Pearson's Chi-square tests. The main background criterion was the gender (male/female) of the applicant. In this dataset, gender is a binary variable.

In this study, I conducted all the data handling, statistical analysis, and testing. Since we were requested to make major revisions for publication, this meant several rounds of analysis and rewriting of the results. We first submitted the article to the *Journal of Engineering Education* in August 2018, and secured acceptance with our third revision submitted in December 2019. The article was published in April 2020.

2.2 Article 2: Newly graduated engineers

Our aim was to evaluate the professional identities of newly graduated engineers in Finland by analysing their perceptions of professional skills. Based on previous studies, we anticipated that gender impacts how early-career engineers perceive the importance and development of their professional skills. However, we expected that the field of engineering may have a significant impact as well.

For this study, we used cross-sectional survey data from the TEK Graduate Survey, collected between January 2018 and December 2019. The TEK Graduate Survey is a joint process organised together by TEK and all Finnish universities awarding master's level university degrees in Engineering and Architecture. All these universities share a process where feedback related to academic study is collected from every student at the time of their graduation, and the response rate has consequently been high (in 2018, 83 % and in 2019, 76 %). While all universities have access to their own data, the full data may be obtained from TEK for research purposes based on an application and decision by TEK's Research Steering Group. Author 1 applied for the data in April 2020 and we received the data in June 2020.

In the survey, the respondents can identify their gender as male, female, or other. However, since only ten persons identified themselves as 'other' in our data, their responses were excluded from the analysis. We also excluded architects since we wanted to focus on engineering/technology graduates. Therefore, the data for this study contained 4 104 respondents (3,133 males = 76.3 %, and 971 females = 23.7 %). The respondents are asked to rate 29 professional skills items on a Likert scale of 1–6 (1 = Not at all, 6 = Very much) on three aspects: (a) the importance of these items, (b) their development in studies, and (c) their development at work during the studies. To assess differences between male and female respondents, Mann–Whitney U tests were conducted to identify statistically significant differences and Hedges' g values were calculated to estimate the effect size.

Since we found that the difference between male and female respondents was most significant in relation to the importance of the 29 items, we conducted a factor analysis (principal components analysis, PCA) of the importance scores. A correlation matrix of all 29 variables (importance scores) was produced to analyse the suitability of the data for exploratory factor analysis, and the level of correlation was considered adequate ($r \geq 0.3$) at least with one other variable. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was 0.936 (marvellous), all the KMO measures were higher than 0.9, and Bartlett's test of sphericity was significant ($p < .0005$). Therefore, the PCA analysis was deemed appropriate.

The PCA with varimax rotation revealed five components that had eigenvalues greater than one (Model F1). These five components explained 51.4 per cent of the total variance and adding a sixth component increased this to 54.8 per cent. The scree plot showed an inflection point at component 5. However, the rotated component matrix revealed that several variables had high factor loadings on more than one component (cross-loadings). Therefore, another factor analysis (Model F2) was conducted with a fixed number of factors increased to six. The rotated component matrix still showed several cross-loadings, and thus another factor analysis (Model F3) was conducted with a fixed number of factors (six) and with a different rotation method (Oblimin). In this model, the variables fitted sufficiently well to the six components. Therefore, we decided to proceed with F3, although the variance explained (55 %) was somewhat lower than recommended in the literature (<60 %), and the sixth component had an eigenvalue lower than 1 (0.98).

We used Cronbach's alpha to evaluate the internal consistency of the identified six factors. These ranged from 0.65 to 0.84, and thus, the internal consistency of the factors was considered adequate. Four items could have been deleted since their loadings are below the 0.5 threshold, but we decided to retain them, mainly to keep more items in the analysis. For each factor, we then summated the item scores and divided them by the number of items within the factor to calculate combined means on the original scale (1–6).

In this study, I conducted all data handling and quantitative analysis. We submitted the article to the *European Journal of Engineering Education* in September 2020. After minor revision, the article was accepted for publication in May 2021 and published in June 2021.

2.3 Article 3: Gender-based discrimination at the workplace

The study examined gender-based discrimination in Finnish workplaces of higher engineering professionals. Our aim was to determine the prevalence of discrimination and how it was experienced by both men and women. We were particularly interested in how the masculine culture of engineering is reflected in the experiences of discrimination of both women and men.

We had two sets of data which were based on two surveys carried out by TEK, containing both quantitative (numerical) and qualitative (open comments) data. The open responses given in both surveys were in three languages (Finnish, Swedish, English) and we translated all the comments in the article into Finnish.

Dataset 1: TEK's member survey (Labour Market Survey) is conducted annually as an online survey. In 2015, in addition to several other issues, the survey included questions about experiences of discrimination. The link to the survey was sent to all members in working life (approximately 40 000 people). Data collection took place between October and November 2015, and the response rate was 25. Although the response rate may be considered low, the number of respondents was high and adequately represented working members, so the results can be considered reliable and generalisable. We selected the respondents with master's degrees engineering/technology, Master of Philosophy degrees in a similar field (science, mathematics, data processing) or postgraduate degrees (licentiate or doctorate) in these fields. The number of respondents was 10,671, of whom 77 % were men (n = 8,266) and 23 % were women (n = 2,405). The respondent's gender was derived from their personal identity code in TEK's membership register. As gender in personal identity codes in Finland is binary, we were unable to examine gender minorities with this data.

The data on discrimination, which remain the most wide-scale data available to TEK, consist of answers to the following questions:

a. *Unequal treatment or discrimination may occur in work life, for example in pay, recruitment, career advancement, access to education or dismissals. Have you experienced discrimination or unequal treatment in your work organisation (current or previous) during the last year on the basis of [criteria listed in the form]: Response options: yes/no/does not apply to me.*

b. *Please describe as briefly as possible, in one or two words, the situation to which the discrimination or unequal treatment was related (e.g., pay, recruitment, career advancement).*

c. *Please tell us about your experience in more detail if you wish.*

Discrimination against women and men on the basis of gender was combined as 'Gender-based discrimination' category.

Dataset 2: In 2020, a random sample of 6,268 people from the TEK member register (full members, Master's level students, and English-speaking members) was selected for the survey. A total of 621 people replied to the questionnaire (response rate 10%). Gender was elicited by offering four alternatives: male (64%), female (34%), other (0%), and rather not say (2%). The survey assessed equality at the workplace, the opportunities of different minority groups to express their identity, perceived discrimination, and sexual harassment. It also explored belonging to a sexual or racialised minority as a background variable. The respondents adequately represented TEK members in terms of age distribution and education, but women were overrepresented (34% of respondents and 23% of the sample), as were Swedish-speaking members (19% of respondents, estimated 5% of the sample). The overall response rate was interpreted as an indication that only some of the members were interested in equality. Moreover, discrimination is sometimes difficult to identify, which was also reflected in the open responses.

For this study, we selected 84 respondents who had indicated their gender and experienced discrimination (n=87). We were unable to study gender minorities because none of the respondents chose the ‘other’ category and only three did not want to indicate their gender. Discrimination against women and men on the basis of gender was combined as the ‘Gender-based discrimination’ category and, due to the low number of respondents, the age groups were combined into two categories (less than 45 years, and 45 years or more).

We analysed both datasets statistically (frequencies, cross tabulations), and applied thematic analysis to the qualitative data. From the 2015 member survey data, we selected the open responses (b and c) from the respondents who had experienced gender-based discrimination. We read the comments and divided the mentions into more detailed code categories, which we then combined into broader themes as the analysis progressed. If, for example, ‘pay’ was mentioned in (b) and discrimination based on pay was described in more detail in (c), we counted this as one mention of the ‘pay’ theme. If, on the other hand, another topic was described in (c), we counted these separately. However, the themes were not mutually exclusive: one mention could belong to several themes. From the 2020 sample survey, we analysed the comments of those who had experienced gender-based discrimination under ‘Tell us more about the realisation of equality in your work community’ and ‘If you wish, tell us more about discrimination or inappropriate treatment in your work community’. We compared these with the themes that arose from the member survey data.

For this article, I conducted both quantitative and qualitative analysis of the 2015 data and quantitative analysis of the 2020 data. We first submitted the article to Työelämän tutkimus in March 2021. We were required to make major revisions and consequently rewrote the literature and most of the analysis, which I did alone. The second revision (submitted in June 2021) was received more favourably, and the third revision with minor changes (submitted in September 2021) was accepted for publication. The article was published in December 2021. Since the article is in Finnish, it was submitted to a professional translator for an English translation to be part of this dissertation.

2.4 Article 4: Gender equality targets and recruitment to top management

The aim of the study was to understand how executives in technology companies relate to targets for gender equality of top management. The data for the study was based on nineteen semi-structured interviews of executives in ten technology companies[12] operating in Finland. Interviews were selected as the research method since the purpose is to gain understanding of how executives understand and reflect upon (increasing) gender equality in their companies.

In the sample, six interviewees were CEOs (=CEO), nine were HR managers/directors (=HR) and four were senior managers (=Manager). Ten interviewees were men and nine were women; of the CEOs, five were male and one was female whereas of the HR managers/directors, six were female and three were male. The four managers were two men and two women. The age of the interviewees ranged from 32 to 60 years, with most interviewees in their 40s and 50s. The nationality of the interviewees was not asked, but 18 interviewees were supposedly Finnish while one was Western European, and all interviewees were ‘white’.

The interviews were conducted in two separate rounds, with the first taking place in March - May 2019 (nine companies, 15 interviewees) and second in May 2021 (one company, four interviewees). In spring 2019, fourteen interviews were conducted face-to-face at the premises of the case companies and one by Skype. In 2021, all four interviews were conducted by Teams due to COVID-19 restrictions. The interviews lasted from 26 min. to 61 min. with an average of 47 minutes. Interview consent forms also included a permission to use the data for my doctoral dissertation. I conducted twelve of the interviews and observed three, whereas four interviews were conducted without me present.

12 The companies represent the following sectors within technology: industry/manufacturing (5 companies); planning and design (3 companies); IT consulting (1 company); ICT solutions provider (1 company). All companies are large or mid-size and five are listed in the Helsinki Stock Exchange.

All interviews were audio-recorded and most (13) interviews were transcribed verbatim (by a company with a confidentiality agreement). For six interviews conducted by me, the original interview notes based on the recordings were used instead. Eighteen interviews were conducted in Finnish and one in English. The quotes used in the article were translated from Finnish by me and they were anonymized to protect the interviewees.

The analysis method was (reflexive) thematic analysis (Braun & Clarke, 2020). I started the analysis process by submitting the transcripts (or interview notes for six interviews) into Atlas.ti 9 software. Since the interviews covered various topics, the first step was to identify relevant content which for this study were comments related to top management, their recruitment, and gender equality. The initial coding stage produced over 50 codes or categories, such as “top management”, “importance of gender equality”, “discrimination of men” and “challenges in recruitment”. Coded comments were then reread several times, checked, and merged into the eight main categories.

In the study, the focus was on the categories “Gender diversity of top management” and “Gender vs. competence (of top management)” although these overlapped with other categories. Drawing on the data as well as prior literature, the study identifies three ways in which the executives in technology companies relate to gender equality targets: endorsing, negotiating, and resisting.

This article, solo-authored by me, was submitted to the journal *Gender in Management: An International Journal* and has gone through the first round of peer review. The reviewers have recommended publication, and the paper is under the second round of peer review. The paper included in this dissertation is the first revision.

3 FINDINGS: SUMMARIES OF THE ARTICLES

3.1 Article 1: Application to STEM studies

As explained earlier, the gender gap in the STEM career pipeline in Finland already appears when men and women are applying to study STEM. Moreover, prior literature indicates that it is vital to differentiate between 'technology' and 'science'. In our study, the aim was to analyse gender differences among university-level STEM applicants in Finland by comparing applicants primarily wishing to study engineering/ technology (TECH) and applicants preferring biological or physical sciences, mathematics, or computer science (SCIMA). While the number of applicants selecting TECH and SCIMA as their first application choice was roughly similar (4,821 persons selected TECH whereas 4,283 persons selected SCIMA), gender differences were highly significant: of those selecting SCIMA studies as their first choice, 42.9 per cent were female, whereas the proportion of females among TECH applicants was 24.7 per cent. Thus, SCIMA studies clearly appeared more attractive to females than TECH studies, confirming the results by previous studies which had differentiated within STEM fields.

Next, we wanted to evaluate the degree of overlap between TECH and SCIMA applicants, that is, the proportion of applicants having both TECH and SCIMA programmes among their application choices. Therefore, we divided the applicants into two groups based on their first choice (TECH or SCIMA) and then recoded the remaining choice categories (2–6) either 0 (TECH for TECH applicants, and SCIMA for SCIMA applicants) or 1 (other than TECH or other than SCIMA). Then, a summary variable was computed to indicate only TECH/SCIMA choices or other than TECH/SCIMA choices. Furthermore, choices 2–6 of each applicant were grouped into TECH, SCIMA, and OTHER categories.

We found that male TECH applicants tended to be more restricted in their choices of field than females: 72.5 per cent of the men applying to engineering/technology programs did not apply to any other field. This means that although the applicants can select up to six study programs, which can be in any field, three of four men chose only engineering/ technology studies if their first choice was TECH. For women, the corresponding percentage was 58.6 per cent. Moreover, 71.7 per cent of the male and 65.7 per cent of the female TECH applicants selected another engineering/technology programme as their second choice

(Choice2). On the other hand, slightly over half of the SCIMA applicants (54.4% of the males and 52.5% of the females) opted only for SCIMA programmes, and less than half (41.5% of the males and 48.7% of the females) selected another SCIMA program as Choice2. Moreover, only 4.6 per cent of the female SCIMA applicants selected engineering/technology programs as Choice2, and only 7.6 per cent of the female TECH applicants selected SCIMA programs as their second choice.

Our main finding, therefore, was that engineering/technology (TECH) and natural sciences and mathematics (SCIMA) subjects were not perceived as alternative options by female applicants. Almost 60 per cent of all female TECH applicants and more than 50 per cent of the female SCIMA applicants only applied to their respective programs. Moreover, TECH applicants considering other options preferred other subjects to SCIMA, and vice versa. This means that even if successful, efforts to encourage more females to study ‘science’ are unlikely to impact the enduring gender gap in engineering/technology.

3.2 Article 2: Newly graduated engineers

In our comprehensive data of recent university graduates, women comprised 24 per cent of the respondents. While we were acutely aware of this gender gap and its potential ramifications, such as a more fragile professional identity as an engineer for women, we were interested in understanding whether, and how, it manifested in the views of the respondents. Thus, our study aimed to understand the professional identities of male and female engineers by analyzing their perceptions of the importance and development of professional engineering skills at the time of graduation. We found that in general, the gender differences in the perceptions of new graduates were small, particularly pertaining to the development of these skills.

We were, nonetheless, able to identify certain, statistically significant differences between the importance scores given by male and female respondents. Concerning individual items, the effect sizes indicated the greatest gender differences (Hedge’s g 0.3) in the importance of ethicality, knowledge in sustainable development, and written and oral communication skills. All of these were perceived more important by females than males. To a slightly lesser extent (Hedge’s g 0.2), we identified gender differences in the importance of self-knowledge and self-confidence, visual communication skills, skills in the practical application of theories, social skills, abilities to work independently, international skills, time management and prioritising, and career management capacities. Again, all of these were perceived as more important by women than by men.

The factor analysis showed that all the combined importance scores of women were higher than those of men and that these differences were statistically significant. The greatest gender difference was found in the importance score of Communication skills which was 5.28 for women and 5.10 for men. Although the effect size was moderate (Hedges g value = 0.3), it was still higher than for any other factor. The highest combined importance score for women was Working life skills (5.61), followed by Social skills (5.50). These were also the highest importance scores for males, although their scores were lower (5.50 and 5.39). Prior research gave us reason to anticipate a more significant difference between men and women pertaining to the importance of Social Skills but although the difference was significant (0.11 units), it was not greater than the other score differences.

Although the differences between men and women were small, and less significant than we anticipated, they suggest that the challenges for women identified in international literature also pertain to Finland. However, we note that caution is required in drawing conclusions. We venture to point out, nevertheless, that engineering education tends to emphasise the technical aspects of engineering while downplaying social and communication skills which women perceive more important. Hence, it may be challenging for female engineers to develop sufficient career-fit confidence during their studies, and they may be at greater risk of leaving engineering careers.

3.3 Article 3: Gender-based discrimination at the workplace

We evaluated prevalence of gender-based discrimination as well as how it was experienced by higher engineering graduate men and women in their workplaces. Previous (qualitative) studies have established that women keep encountering discrimination in technology studies and workplaces. Nonetheless, since wide-scale quantitative studies are lacking internationally, we do not know how common or widespread gender-based discrimination is in technology.

The results of the 2015 member survey show an enormous difference between men and women concerning experiences of gender-based discrimination: 30 % of women, and 2 % of men, reported such experiences. Women of all ages experienced gender-based discrimination far more often than men: the proportion of 'yes' responses ranged between 26% and 32%, compared to ranging from 1% to 4% among men. In the 2020 sample survey, 14 per cent of all respondents (21% of women and 10% of men) said they had experienced discrimination. Among these respondents, sixty per cent of women (n=45) and 21 per cent of men (n=39) said that it was due to their gender. All these gender differences were statistically significant. While the 2020 results cannot be compared directly with those of the 2015 survey, they show that women still commonly experience gender-based discrimination in technology workplaces.

The most common themes that emerged from women's comments were career development (137 mentions), pay and rewards (123 mentions), credibility as an expert (110 mentions) and treatment/behaviour (88 mentions). Importantly, while 'credibility as an expert' was the third most common theme for women, men did not mention this theme at all. We examined the comments regarding career development, credibility and unequal treatment or behaviour as part of the manifestation of a masculine culture. On the other hand, men's responses emphasised the favouring of women.

We found that the discrimination experienced by women was strongly linked to the workplace culture that intertwines technology, masculinity, and competence: in the open comments, women highlighted challenges to career advancement, doubting of competence, belittlement, inappropriate comments, and even sexual harassment. Although the men also described unequal treatment, none of them mentioned doubts about their credibility as experts in their own field. We argue that by challenging women's competence, the masculine culture supports the notion of men's (superior) competence.

We found that discrimination experienced by men is more often associated with age than gender, and men's experiences of gender-based discrimination also seem to be linked to older age. The discrimination experienced by men is specifically linked to actions that attempt to challenge the masculine culture. In their comments, men emphasised the favouring of women and highlighted their negative experiences of organisations' pursuit of gender equality. These comments reveal how, according to these respondents, women are favoured and (qualified) men are discriminated against. Dismantling masculine privilege feels like discrimination to some men, because they do not recognise nor acknowledge their own privileged status.

3.4 Article 4: Gender equality targets and recruitment to top management

The study identified three ways in which the executives in technology companies relate to gender equality targets: endorsing, negotiating, and resisting.

Four companies (A, B, C & D) out of ten had specified targets to increase the percentage share of women in the company and/or in management. Only the executives in Company A and one executive in Company B explicitly endorsed the targets. In Company A, Jari (male, CEO) mentioned hearing some criticism towards the targets but pointed out that it is necessary to have goals that drive taking gender equality into account in recruitment and other processes. Jari said that in the case of two equal candidates, he would probably select the women because of the target. This view was also echoed by Petri (male, HR). In Company B, Kati (female, manager) explained that increasing the number of women is beneficial for men as well. Further, Kati seemed to be willing to take on the role of an advocate, like the executives in Holgersson and Romani's (2020) study.

Several executives kept negotiating what the gender equality targets mean in practice. In Company B, other managers than Kati appeared to distance themselves from the publicly announced target. For example, Jukka (male, manager) discussed that it is important to have goals but there should be room for manoeuvre in how to get there, and Arto (male, manager) denied even knowing about the target. In Company C, although there have been targets to increase the percentage share of women in management, Sari (female, HR) wanted to have the option to select the man even if the candidates (man and woman) were equal. Similarly, CEO Jussi (male) discussed that it is challenging to get the right kind of candidates and pondered on prioritizing women. In Company D, the target set at the international Group level were not considered to be binding in any way.

The executives presented numerous comments that were interpreted as resistance to gender equality targets. Drawing on Galea and Chappel (2021), these comments were further classified into three groups: 1. denial of the need for any targets, 2. the competence-first approach, and 3. backlash; although all these are strongly intertwined.

Many of the respondents worried about even appearing to recruit women just to increase gender equality or diversity, since all agreed that recruitment and career progression to top management, as well as in the company overall, is – and should be – based only on merit or competence. For example, Olli (male, CEO) comments that: “[w]hen talking about career advancement or any such thing then it has to be based on meritocracy and nothing else matters.” Thus, while only Olli used the word ‘meritocracy’ to describe their company, all interviewees subscribed to the meritocratic ideal. While some executives in the study acknowledged that there may be bias against women, only few (women) seemed to recognize the opposite, the privileging of men. Even in companies with gender equality targets, policies that were seen to require deviating from the competence-first principle were considered troublesome.

Yet, several executives expressed reservations about the competence of women. Concerning quotas, for example, Vesa (male, CEO) commented: “Me, we are guided by competences and capabilities. It would be rather difficult for me to recruit the less competent one of two candidates just to fill in a female quota.” Thus, it is self-evident to Vesa that the “less competent” would be the female candidate and that quotas would mean having to hire incompetent women. All interviewees who mention quotas (except one female manager) resisted them for similar reasons. Nonetheless, it is interesting that the executives were not explicit about what ‘competence’ the women are supposed to lack. Resistance to quotas and worrying about the (potential) discrimination of men - in male-dominated technology companies – can be seen as an attempt to legitimize resistance against gender equality targets and initiatives.

The executives equated promoting gender equality with increasing the number/percentage of women, both in the companies (4) that had set gender equality targets and those (6) that had not. Understanding gender equality as the percentage of women can be considered rather narrow although it is not surprising, since the mainstream view is that the underrepresentation of women in technology or in STEM can be fixed by increasing the number of women. While other aspects of equality, such as reviewing the current culture or processes from a gender perspective were mentioned by (some) interviewees in Companies A, B and C, analysing male privilege was not mentioned at all.

3.5 Summary of the findings

Summary of key findings and contributions from the articles

Article	Key findings	Contribution
1	Studies in engineering/technology (TECH) and natural sciences and mathematics (SCIMA) are not perceived as alternative options by female applicants in Finland. Almost 60 % of all female TECH applicants and more than 50 % of the female SCIMA applicants apply only to their respective programs. Moreover, TECH applicants considering other options prefer other subjects to SCIMA and vice versa. Encouraging more girls to study STEM is not a sufficient solution for attracting more women to engineering. Instead of or in addition to encouraging girls to study science and mathematics in K-12 education, it is necessary to open the black box of technology and help young people better understand what engineering is about.	We use nationwide register data to elaborate on the differences between male and female applicants to TECH (engineering/technology) and SCIMA (natural sciences and mathematics) subjects in Finnish universities. Moreover, we highlight the gender differences between applicants at subgroup level. The study contributes to the literature by highlighting that 'STEM' is not considered a unified entity by applicants to university studies. Instead, TECH and SCIMA appeal to different applicants, respectively. Therefore, attracting women into 'science' will not solve the problem of women's underrepresentation within engineering/technology.
2	At the time of graduation, small yet significant gender differences exist between men and women engineers in Finland related to the perceived importance and development of professional skills. Most significant differences relate to perceived importance, as women consider communication skills, ethics and sustainability more important than men do. Moreover, our results suggest that the professional identity of female early-career engineers emphasises the heterogeneous and networked engineering practice more than does the professional identity of men, which relies more on the technical view of engineering. Overall, our results indicate that female Finnish early-career engineers may be under a greater risk of dropping out of the engineering career than their male counterparts.	We use comprehensive survey data to evaluate gender differences in the development of professional identity of newly graduated engineers, both male and female. Engineering education tends to emphasise the technical aspects of engineering while downplaying e.g., social and communication skills which are more important to women. Additionally, the inverted role hierarchy within engineering values technical roles over all others. Hence, it can be challenging for female engineers to develop sufficient career-fit confidence during their studies.

3 Men's and women's different experiences of working in the field of technology and of discrimination is verified in two ways: women's experiences of discrimination are more common and diverse, and the views of men and women on the nature and prevalence of discrimination differ considerably.

Our results show that discrimination against women is a major problem in the field of technology. In both 2015 and 2020, a notable proportion of women had experienced gender-based discrimination at their workplace during the previous year.

We show how women's experiences of discrimination are strongly linked to the masculine culture prevalent in the workplaces and compare these with men's experiences of women being favoured, which we also associate with the prevailing norm of masculinity in the field of technology.

We use quantitative and qualitative data, covering both men and women, from a large-scale survey conducted in 2015 and a sample survey conducted in 2020 by a union of higher engineering professionals. Previous studies in the field of technology have focused on discrimination towards women, rendering the experiences of men mostly invisible. Our results confirm discrimination experienced by women yet provide new insights about how it materializes in the workplaces. Moreover, we highlight the discrimination experienced by men which is often entangled with gender equality efforts.

Masculine culture is the main cause for discrimination against women in the field of technology while the dismantling of masculine privilege gives rise to experiences of discrimination among (some) men.

4 Executives in this study responded to gender equality targets in three ways - endorsing, negotiating, or resisting - but all these responses were constrained by their assumption that technology companies are meritocracies. In companies with defined targets, executives kept negotiating them and some even distanced themselves from the targets. In other companies, the executives' unwavering confidence in the functioning of the merit-based system renders gender equality targets unnecessary in their view.

The study argues that when executives do not actively support gender equality targets, they are perpetuating existing male privilege by reinforcing the status quo.

The findings also indicate that while setting and announcing targets is vital, it is not sufficient. Executives may resist gender equality targets if these are deemed to violate the principles of meritocracy.

Certain previous studies have explored managers' responses in case companies in Sweden and in the US but these can be considered ideal cases. This study presents findings based on interviews of 19 executives in ten technology companies operating in Finland.

The study shows that setting gender equality targets in technology companies causes a dilemma for the executives: if they promote gender equality, they may be violating the ingrained ideal of meritocracy.

The study shows how executives' narrow understanding of gender equality and reliance on the current systems, combined with underlying doubts about the competence of women, hinder the advancement of women to top management. Thus, the study helps executives understand how similar beliefs may thwart gender equality initiatives in their own companies.

4 DISCUSSION

> It is assumed that women need to be stimulated and inspired to choose science and technology, that they need to 'change themselves'. Such an approach is based on the assumption that it is enough to 'fix the women' to solve the problem of the gender-segregated labour market and render gender inequality and structural barriers invisible. (Jansson & Sand, 2021, p. 15.)

Why does the underrepresentation of women in STEM persist? Considering the literature and the findings of the articles, the question could be how the gender gap is not even wider.

The research questions of this study were:

- *RQ1. What kinds of explanations for the gender gap in STEM have been provided in the research literature?*
- *RQ2. In what way does the gender gap manifest in different stages of the STEM career pipeline in Finland?*
- *RQ3. Drawing from the data, what are the main factors contributing to the persistence of the gender gap in Finland?*

Next, I discuss my findings related to these questions.

4.1 Explanations for the gender gap in STEM

The mainstream literature keeps focusing on women in STEM, not gender and STEM. In most mainstream research, 'gender' is conceptualized (albeit without any discussion) as 'sex' or 'men' and 'women'; indicating two, distinct categories of people with innate and different, even opposing characteristics. The binary dichotomy of men/women and the essentialist construction of gender are prevalent features of mainstream studies. These have been criticized for masking similarities between men and women as well as differences among women and men (Barnard et al., 2010) and reinforcing traditional and essentialist notions of gender (Beddoes & Borrego, 2011; Phipps, 2007; Vera-Gajardo, 2021). The equation of gender with women is a persistent limitation within the mainstream literature, even in studies that seek to improve the situation of women, such as Kossek et al. (2017). Moreover, since gender is conceptualized as a clear-cut binary, men/women, hardly any room is left for bringing forward the existence and experiences of gender minorities (Cech & Rothwell, 2018; Leyva et al., 2016), including transgender and gender nonconforming persons (Haverkamp et al., 2021).

The focus on women within the (mainstream) literature means that men are conspicuously absent. Consequently, for example, "little is known about male software developers, how masculinities are constituted within the profession, how those masculinities are powerful enough to exclude women and how they may rely upon the exclusion of women for their constitution" (Tassabehji et al., 2021, p. 3). Therefore, Tassabehji et al. (2021), among others, highlight the need to focus on masculinity/ies as a much-needed corrective. Nonetheless, some (critical) studies have illuminated the differences among men and/or masculinities in STEM fields. For example, in their study of men in STEM academia in Ireland, O'Connor et al. (2015) identify four types of masculinity: Careerist, enterprising, pure scientific, and family-oriented breadwinning masculinity. O'Connor et al. (2015, p. 13) explain that their typology "challenges stereotypical constructions of masculinity and yet reveals the persistence of patriarchal privileging in individual men's lives".

Numerous mainstream studies have sought to evaluate the mathematical abilities of women and men to explain why women are underrepresented. However, as Cheryan et al. (2017) point out, there is no pure measure of intrinsic mathematics ability. Therefore, researchers have used performance on math tests and in math courses as a proxy for ability, though test performance is acknowledged to be shaped by situational factors such as academic preparation and stereotypes (Cheryan et al., 2017), leading to questions about their accuracy as indicators. Moreover, as already discussed, belief in one's ability seems to trump the importance of (demonstrated) math ability. For example, Perez-Felkner et al. (2017) found in the US that women who believed they had the ability to master challenging mathematical tasks in 12th grade (i.e., at age 17-18) were three times more likely to major in physical science, engineering, math, and computer science in college than women who did not believe they had that ability.

In the mainstream literature, most popular explanations for the gender gap tend to focus on interest in STEM. For example, in their influential article, Su and Rounds (2015) call for more attention to be paid on interests to understand the reasons for women's underrepresentation in STEM. The perception that 'men' are interested in 'things' – and, consequently, in 'STEM' - and 'women' in 'people' – hence, not in 'STEM' - appears to be widely shared among mainstream scholars and has also ingrained into public discourse on the topic. Nonetheless, critical literature has highlighted that interest and motivation to pursue studies and careers in STEM fields, or indeed in any field, are not formed in a vacuum – gendered societal norms, expectations, and stereotypes influence what an individual can and should be interested in (Cheryan et al., 2017; Wong, 2015; Petray et al., 2019). As Master and Meltzoff (2020) put it, motivation is malleable.

Studies focusing on the sense of belonging (e.g., Rainey et al., 2018; Sax et al., 2018; Wilson & VanAnterp, 2021; Wynn & Correll, 2017) find that persons in underrepresented groups are particularly vulnerable to feeling they do not belong in STEM. Since students' sense of belonging is a robust predictor of academic motivation, engagement, and achievement in STEM fields (Lewis et al., 2017; cf. Master & Meltzoff, 2020), these studies highlight that focusing only on interest in STEM is not sufficient. Master and Meltzoff (2020, p. 162) explain that the career aspirations of children start to form during elementary school, during which time children also become more familiar with stereotypes that involve both interest and ability: "Thus, as girls begin to form and express these early career choices, they are already aware that boys are associated with and widely believed to be better than girls at many STEM fields". Moreover, pervasive negative stereotypes and common social and environmental cues can signal to women and underrepresented minorities that they do not belong, which reduces their motivation to pursue these fields (Master & Meltzoff, 2020).

While the preference theory (e.g., Hakim, 2002) has gained popularity among certain STEM scholars (e.g., Ceci et al., 2014), others have pointed out that the focus on preferences may hide power imbalances and choice-based explanations can obscure underlying gender inequalities in the workplace (Glosenberg et al., 2022). Lewis and Simpson (2017, p. 129) highlight that preference theory constructs a particular reality through creating and sustaining of "a new choosing agentic feminine subject, who knowingly and deliberately makes choices around work, home and motherhood in a context of assumed equality of opportunity and the equivalence of choices". Hence, preference theory has enabled 'choosing' to gain legitimacy as a particular account of women's work–life experience, to the extent that other explanations have been ruled out (Lewis & Simpson, 2017). Cheryan et al. (2017, p. 22) point out that when majoring in a field is framed as a choice, the influence of contextual and cultural factors is concealed: "Students who see a poster that describes women who leave work to raise children as 'choosing to leave' are less likely to acknowledge that discrimination exists against women than those who see a poster that does not depict women leaving the workplace as a choice".

Mainstream explanations focusing on interests and preferences tend to disregard the complex dynamics of various factors. The interlinkages of masculine cultures, discrimination, and interest in STEM have only recently gained scholarly attention. Some mainstream studies find that the fear of being discriminated against in one's field reduces the appeal of STEM studies and careers (Cheryan et al., 2017; Ganley et al., 2018). Concerning both STEM and non-STEM majors, Ganley et al. (2018) found that concern over discrimination was a stronger predictor of the gender gap (i.e., underrepresentation of women within the major) than perceptions of the majors' orientation toward mathematics, (natural) science, creativity, making money, or helping people.

A major shortcoming in the mainstream research has been limited recognition of the impact of masculine cultures, underpinned by masculine privilege. While critical studies have provided ample evidence of masculine culture(s) and various forms of discrimination towards women in STEM fields, the mainstream literature tends to dismiss these as something belonging to past, if they are considered at all. Critical studies demonstrate that female STEM students and professionals need to deploy various coping mechanisms to fit in the masculine culture(s) of their study communities and workplaces (Alfrey & Twine, 2017; Barnard et al., 2010; Hatmaker, 2013; Lapan & Smith, 2022; Powell et al. 2009). Moreover, it may be that women have to choose between a 'gender-neutral' and 'gender-sensitive' approach. In a recent Finnish study, Vellamo (2022) finds that for female academics, gender-neutral approach allows for a stronger disciplinary identification with technical fields but leaves gendered practices unrecognised; whereas a gender-sensitive approach makes it more difficult to identify with the discipline and the former technical university while gendered practices in the organisation and the discipline are (to some extent) recognised.

To summarize: The mainstream literature has generally attributed the underrepresentation of women in STEM to: the women themselves (e.g., their abilities, ability beliefs, interest in STEM, career preferences), their treatment (e.g., stereotypes, bias, organizational climate) and their reaction to that treatment (e.g., stereotype threat). What has remained firmly out of critical attention is STEM itself – how science, technology, engineering, and mathematics are associated with masculinity, and how gender and technology are co-constructed. The mainstream literature and "we need more women" campaigns continue to view STEM as gender neutral, despite the mounting evidence to the contrary. As Faulkner

(2001, p. 79) has argued, “[t]he virtual failure of these initiatives indicates a failure to critically analyse the ways in which technology itself gets gendered in the eyes of would-be technologists”.

4.2 Gender(ed) gaps along the STEM career pipeline in Finland

The articles in this study cover four gender(ed) gaps along the pipeline of STEM careers: application to university STEM studies, graduation with Master’s in engineering/technology, gender-based discrimination in technology workplaces, and recruitment to top management in technology companies.

Article 1 sets the stage by describing the gender gap in applying to study STEM subjects at university level. Prior studies have established that Finnish girls are highly capable in science, mathematics, yet have only limited interest in studying technology. We contribute to the literature by using comprehensive, nation-level register data of actual application patterns and by elaborating on the differences at subgroup level for both TECH and SCIMA subjects, since many previous studies have emphasised the importance of analysing differences within STEM fields (e.g., Alegria & Branch, 2015; Cheryan et al., 2017; Kanny et al., 2014). We find that SCIMA subjects attracted far larger percentage of female applicants than TECH (43 % vs. 25 %). Furthermore, gender segregation within technology endures, as women favour for example architecture, environmental technology, and chemical engineering, and men opt for electrical, mechanical and automation engineering. Indeed, Vähäpesola (2009) points out that architecture and chemical engineering were deemed ‘appropriate’ fields for women in Finland already over 100 years ago. The data we used did not lend to identifying the causes of these differences. Nonetheless, we consider the explanations drawing on (mathematical) abilities and individual interests and preferences. We suggest that rather than focusing on interests, a culture change is required in engineering education.

Article 2 shifts the focus to newly graduated engineering/technology professionals. We find that at the time of graduation, small yet statistically significant gender differences exist between men and women related to the perceived importance and development of professional skills. A key concept in this article is engineering identity. Our results suggest that at the time of graduation, women emphasise the heterogeneous and networked engineering practice while men rely on the more technical understanding of engineering (cf. Faulkner, 2007;

Cech, 2015). As men perceive the development of their skills related to technical innovations to be better than women do, and women perceive both the importance and development of their managerial skills to be higher than men do, men are more likely to gravitate towards technical and women to managerial career paths. Thus, in the current engineering culture that values technical roles over others, women have a greater risk of being devalued as engineers (cf. Cardador, 2017¸ Cech, 2015). Overall, our results indicate that female Finnish early-career engineers may be under a greater risk of dropping out of the engineering career than their male counterparts, although caution is required in drawing conclusions from the data.

In article 3, we turn our gaze to technology workplaces. We show that discrimination against women is a major problem in the field of technology in Finland. Like prior (critical) studies, our results confirm discrimination experienced by women: in both 2015 and 2020, a notable proportion of women reported having experienced gender-based discrimination at their workplace. Nonetheless, our findings provide new insights about how gender-based discrimination materializes in the workplaces, and we also highlight the discrimination experienced by men. We show how women's experiences of discrimination are strongly linked to the masculine culture prevalent in the workplaces. Furthermore, we compare these with the experiences of men which are often entangled with gender equality efforts, as the dismantling of masculine privilege gives rise to experiences of discrimination among men.

Prior studies indicate that women typically respond to chilly climates in STEM workplaces in three ways: by downplaying their femininity, by neutralizing their difference through discursive positioning, or by leaving work in STEM fields (Alfrey & Twine, 2017). Women may also deny the impact of masculine cultures (e.g., Britton, 2017; Korvajärvi, 2021). For example, while some women in Rhoton's (2011) study reported experiences of discrimination, they stressed the importance of individual perseverance and motivation and downplayed the significance of discrimination as a structural problem (cf. Seron et al., 2018). Unlike these studies, the women in our study (article 3) widely reported their experiences of discrimination and many linked these to the masculine cultures in their workplaces, although the question remains how well they recognise the structural aspects of these experiences. On the other hand, some of the men in our study commented that gender equality has been achieved in Finland and thus there is no need for targets or activities (cf. Johansson et al., 2019 for similar discussion in Sweden).

Article 4 focuses on the gender gap in top management positions within technology companies, and how executives related to gender equality targets that attempt to bridge this gap. Prior studies indicate that the ideal of meritocracy is particularly entrenched in technology companies (Blair-Loy & Cech, 2022; Doerr et al., 2021; Nash & Moore, 2018; Seron et al., 2018). This study validates these results, finding that all the interviewed executives subscribed to the meritocratic ideal. The executives adamantly expressed that women need to earn recruitment/ promotion to top management by being 'competent' - only merit, skills, and willingness of the individual (should) count. Thus, the idea of hiring or promoting "only women" to increase gender equality was conceived as a blatant violation of meritocratic principles. Nonetheless, the executives may not realize that 'competence', 'merit' and similar concepts are subjective and socially constructed notions; for example, Blair-Loy and Cech (2022) illustrate how 'white' heterosexual men are most likely to be seen as embodying scientific excellence in STEM.

The gender imbalance was seen as a pipeline problem, and most executives were convinced that more women would progress in their company if there would be a larger number of 'competent' candidates. However, the executives did not appear to consider how their understanding of 'merit' and 'competence' impact who is seen to 'fit' in the pool. Moreover, while several respondents expressed doubts about the competence of women, it is not clear in what way the women are 'less competent'. Here, the executives could be referring to technological competence which often eludes women (e.g., Alegria, 2019; Faulkner, 2014; section 2.4) or certain leadership traits that are coded masculine, such as assertiveness (e.g., Blair-Loy & Cech, 2022). As discussed in previous sections, inequality regimes (Acker, 2006) in technology companies seem to favor men and gender-fluid women (Alfrey & Twine, 2017) and men have more options for performing the roles of competent technology professionals (Faulkner, 2007; O'Connor, O'Hagan & Brannen, 2015; Tassabehji et al., 2021).

Article 4 shows how executives navigate between targets for gender equality and adhering to current, presumably well-working systems of recruitment and career advancement. Executives responded to gender equality targets in three ways - endorsing, negotiating, or resisting - but all these responses were constrained by their assumption that technology companies are meritocracies. None of the executives in the study discussed attempts to challenge the prevailing culture or gender order, unlike in the study by Holgersson and Romani (2020). The findings also indicate that while setting and announcing targets is vital, it is not sufficient, since executives may resist gender equality targets if these are deemed to violate the principles of meritocracy. If technology companies are serious about improving gender equality in recruitment, retention, and career progression, they need to engage in thorough discussions of what are the required skills and how the competence/merit of applicants is defined and measured.

4.3 Main factors contributing to the persistence of the gender(ed) gap(s) in STEM in Finland

Mathematics is the bedrock of studies in STEM subjects. The perception and stereotype that males are 'naturally' more math-savvy endures despite numerous studies that have found no remarkable gender differences in mathematical abilities. Even mathematically talented women studying engineering may conform to this stereotype, believing that they are exceptional compared to other women (e.g., Seron et al., 2018). I argue that this stereotype is one of the main causes of the persistent gender(ed) inequalities in STEM in countries such as Finland. Indeed, some studies suggest that the stereotype associating mathematics to men is stronger in more egalitarian countries. Breda et al. (2020) argue that the 'educational gender-equality paradox' (Stoet & Geary, 2018; see section 2.2) can be explained by cross-country differences in gender norms regarding math aptitudes and appropriate occupational choices, showing that the gender essentialist norm "math is not for girls" is larger in more developed and more egalitarian countries.

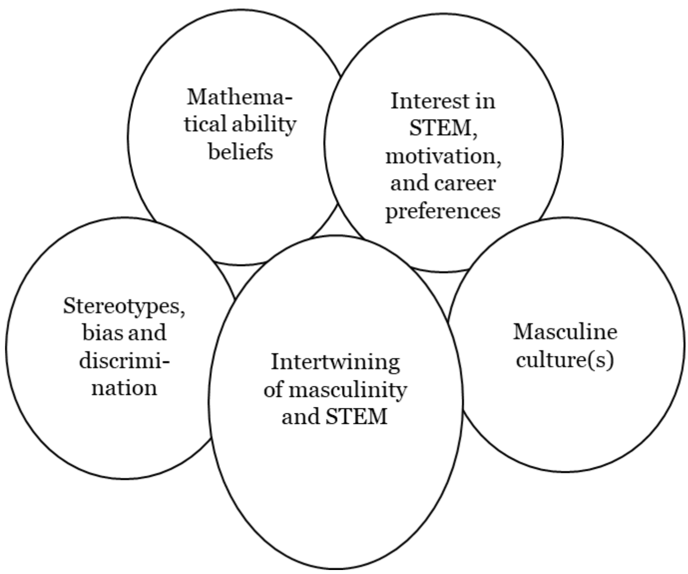
Several studies have demonstrated how the skills and competence of women pursuing careers in STEM in Finland have been questioned and even devalued, both in the past (e.g., Nitovuori, 2003; Vähäpesola, 2009) and the present (e.g., Anteroinen & Nikku, 2022; Kaukonen, 2020; Kupiainen, 2019). Privileged identity groups establish norms for accepted behaviours, have access to greater opportunities for success, and possess power over marginalized groups (Rodriguez & Lehman, 2018). As O'Connor et al. (2015) underline, one of the characteristics of hegemony is that those in dominant positions do not see the world in gendered terms. Galea and Chappel (2021, p.1) argue that masculine privilege in male-dominated (STEM) organizations occurs via three mechanisms: 1) a culture of denial; 2) perceptions that rules are neutral, legitimate, and applied objectively; and 3) through backlash and resistance to keep the gender status quo in place. While individuals and organizations proclaim values of equality and non-discrimination, masculine privilege still operates to maintain men's powerfulness (Galea & Chappel, 2021). Therefore, perhaps we should next turn our focus to the structures that perpetuate male domination and privilege in STEM organizations in Finland, as several critical researchers have proposed (e.g., Beddoes, 2021; Blair-Loy & Cech, 2022; Galea et al., 2020; O'Connor, 2020).

It is important to recognize that the framing of who is and is not underrepresented in STEM is itself political (Patrick et al., 2022). Rainey et al. (2018, p. 12) find that being demographically similar to others in the field positively impacts belonging, indicating that until STEM fields become more demographically diverse, "those in the majority group (generally white males) will remain privileged by the culture and organization of the discipline in ways that sustain their sense of belonging while undermining the sense of belonging of students from underrepresented groups". Several studies from the US indicate that alongside and intersecting with gender, nationality (e.g., Alegria & Branch, 2015) and/or 'race' (Alegria, 2019; Alfrey & Twine, 2017; Doerr et al., 2021; Rainey et al., 2018) significantly impact recruitment and retention in STEM studies and careers. Such studies are yet to be conducted in Finland (except Tanhua, 2022).

Concerning the ICT field, Lagesen, Pettersen and Berg (2021, p. 2) discuss what they call circles of exclusion and inclusion, summarizing that "a dominant narrative of a multitude of barriers in the form of resistance, gender stereotyping, a hostile and off-putting culture combined with an unattractive image of computer scientists has led to a negative circle of exclusion of women in ICT". In contrast, a (symbolic) link between masculinity, technology and ICT, as well as a culture permeated by gendered norms and ideologies together constitute what the authors call a positive circle of inclusion of men to ICT (Lagesen et al., 2021). Similar circles of inclusion (for men) and exclusion (for women) can be identified in other STEM fields as well, particularly within engineering/technology. As Seron et al. (2016, p. 207) describe: "At every point in professional socialization, these findings reveal why and how men enjoy the opportunity to cultivate increasing confidence that they belong in engineering whereas women confront obstacles and innuendos that leave them questioning whether engineering is the right field for them".

Overall, this study highlights the existence of numerous gender(ed) gaps within STEM instead of one 'gender gap'. By 'gendered gaps', I am referring to the various ways in which gender matters in STEM, leading to differing expectations, treatment, and experiences for men and women (and others)[13]. In this study, I argue that these gendered gaps persist due to the cumulated and compounded effects of masculine cultures favouring men and the stereotypes affirming male superiority in mathematics. These, in turn, are rooted in the strong and enduring linkages between masculinity and STEM (i.e., (physical) science, engineering, technology, and mathematics). These three are identified in this study as the most salient explanations for the enduring gender(ed) gaps in STEM in Finland, leading to lower ability beliefs[14] and less interest in STEM studies and careers as well as more fragile identities as STEM professionals for (many) women. This is not to claim that other factors, such as national, cultural, and organizational context and policies, for example regarding care responsibilities and parenting, do not have a role to play. Nonetheless, these are the explanations that most strongly emerge from the review of the literature and the data in this study.

Figure 3 illustrates my argument, showing how the three categories below form the basis of the explanations for the gender(ed) gaps, with the intertwining of masculinity and STEM at the centre, binding all the explanation categories together. Nevertheless, all the explanation categories overlap, and in more ways than can be depicted in Figure 3.

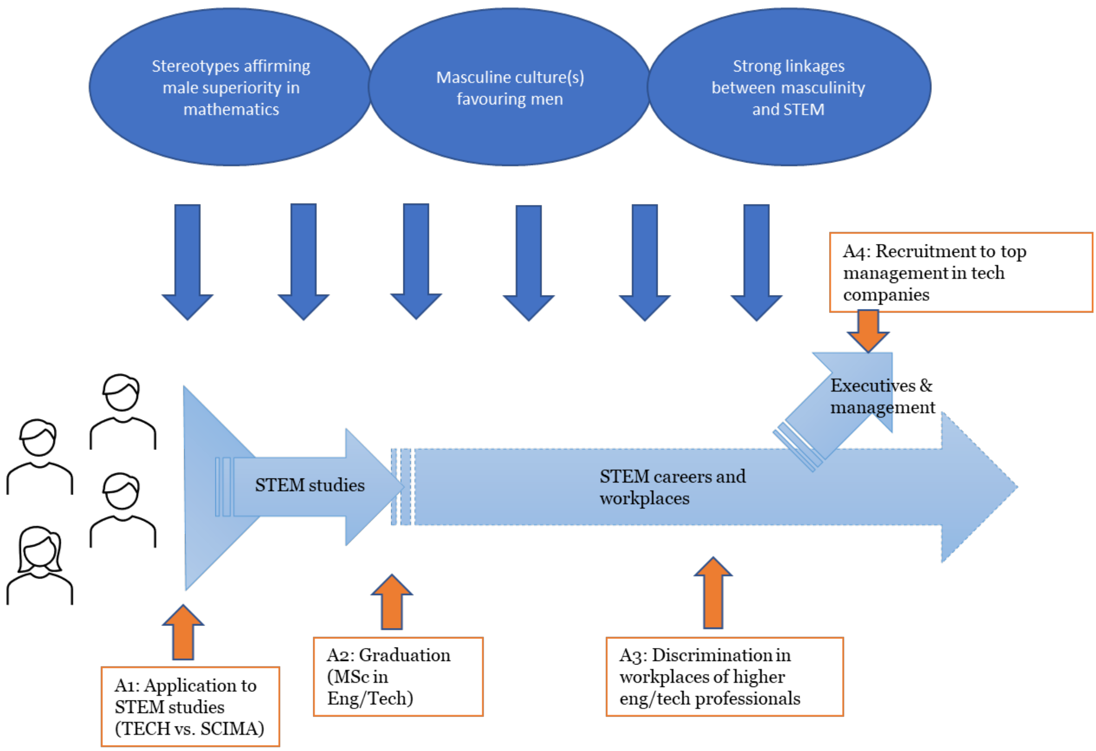


Revised model of the explanations for the gender(ed) gap(s) in STEM.

13 Research to date mostly focuses on men and women, but ‘gendered’ can – and should - also include gender minorities. I am using brackets for ‘others’ since the data in this study, unfortunately, did not lend to analysing their situation.

14 Since beliefs about mathematical ability have been found to impact more than (demonstrated) abilities, I have relabelled this explanation group accordingly.

Drawing from the findings, Figure 4 summarizes how the main factors identified in this study impact the gender(ed) gaps along the STEM career pipeline in Finland. The combination of the three interlinked factors - intertwining of masculinity and STEM, stereotypes about masculine superiority, and masculine cultures - acts like relentless rain corroding the STEM career pipeline for (most) women, causing leakages. In contrast, these factors have the opposite effect on (majority) men, strengthening the pipeline and smoothening their flow within it.



Gender(ed) gaps and their main explanations identified in this study.

4.4 Limitations and suggestions for further research

> We regret things we have done, said, and written. We also regret things we did not do, did not say, did not write—the lost opportunities to push ourselves and the field into the uncomfortable, vulnerable, and essential conversations we know we need to have. (Patrick et al., 2022, p. 5)

This study uses various kinds of data: register data (article 1), survey data (articles 2 and 3) and interview data (article 4) and deploys both quantitative methods (articles 1, 2 and 3) and qualitative methods (articles 3 and 4). Nonetheless, all these data are cross-sectional and can only provide a snapshot of the situation at the time when the data was gathered. To further assess gender differences in the STEM career pipeline, analysing longitudinal data would be highly illuminating (for such analysis of register data, see e.g., Riekhoff, Ojala & Pyöriä, 2021). This analysis could include comparison on what kind of jobs during studies do persons of different genders have, what kind of positions they obtain when starting their careers, and how their careers advance over time.

This study covers four gender(ed) gaps along the STEM career pipeline, but it does not argue that these are the only gaps. One single study cannot possibly address all the various ways in which gender (male, female, or other) makes a difference along the STEM career pipeline. For example, one important gap that is not covered in this study is the pay/income gap. Studies conducted by TEK, for example, indicate that women with engineering/technology degrees continue to earn less than men, and the pay gap is wider in management positions. This is an important area of further research.

Since the gender gap is construed as the ratio of women vs. men, it is binary by definition: no space is left for 'others'. This binary approach is entrenched in the mainstream literature, yet common in many critical studies as well. Therefore, fruitful avenues for further research are those that expand the discussion on gender in STEM beyond 'women'. These include studies on men and masculinities as well as gender minorities and sexual minorities. For example, TEK studies suggest that LGBTQI+ students worry about discrimination and experience harassment more often than their peers[15]. Moreover, intersectional studies about, for example, diversity and inclusion in technology education (e.g., Tanhua, 2022) and workplaces, and sense of belonging among various STEM

15 https://www.tek.fi/en/news-blogs/nearly-half-of-lgbtqi-students-fear-discrimination-in-their-career

professionals, could greatly enrich our understanding of gender in/and STEM. Alfrey and Twine's (2017, p. 30) concept 'gendered spectrum of belonging', which takes into account also sexual orientation, is an example of how this could be done.

A promising opening within mainstream research is the STEMO model developed by Master and Meltzoff (2020). The model draws on expectancy-value theory but highlights the importance of sense of belonging in fostering motivation for STEM and considers interest in STEM as an outcome rather than a predictor. Studies that analyse interest as an outcome, also with qualitative data, could provide important insights on what are the factors and contexts that enhance or reduce interest in STEM.

4.5 Implications for STEM education and organizations

> Initiatives to increase female participation in science at all levels have been notable for their lack of success in making any large and sustained impact on levels of recruitment in both education and the labour market. (White & Smith, 2021, p. 14)

To decrease the gender gaps in STEM education, particular attention should be paid to attracting more women (and others) to study those fields where the gender gaps are widest, that is, most fields of technology, including ICT. It is worth noting that more gender-balanced programmes are more attractive to men as well as women (Lagesen et al., 2021). Achieving this requires critical evaluation of engineering/technology education, including the following aspects that have been identified as gendered: 1) assumptions about students' experiences, values, and backgrounds, 2) aims and objectives of engineering programs, 3) forms of assessment, 4) course content, 5) teaching and learning methods, 6) teaching practices, and 7) the learning environment (Mills, Ayre & Gill, 2010). As Anteroinen and Nikku (2022) point out, equal treatment and support during studies enhance female students' engagement in male-dominated technical fields in Finland. Finnish universities can also take lessons from other countries on how to enhance inclusion, sense of belonging and engagement of women and minorities (e.g., Lagesen et al , 2021; Rover et al., 2020).

Among engineering educators, engineering knowledge and processes are widely considered gender-neutral (e.g., Beddoes & Borrego, 2011) and engineering knowledge is valued for its alleged objectivity (Seron et al., 2016). Research deploying critical perspectives, such as those discussed in this study, can assist in understanding how these views may be problematic (cf. Beddoes & Borrego, 2011). Engineering education also in Finland tends to emphasise the traditional, technical aspects of engineering while downplaying for example social and communication skills which are more important to women than to men. To attract a wider range of applicants, it is necessary to better articulate what engineering and the development of technology are about, and to be open to potentially transforming these (e.g., Riley et al., 2009). Moreover, to achieve the required cultural change, engineering as a discipline needs to discuss and communicate the added value of attracting more women and other non-traditional groups.

Increasing the number of women will not automatically alter the current masculine culture(s). When persons encounter limiting structures, such as organizational culture and processes, it more likely that they will adapt than that the structures will bend. Articles 3 and 4 demonstrate that while many technology companies and organisations publicly espouse the importance of diversity, equity, and inclusion (DEI), they still have considerable challenges in turning these values into day-to-day reality. Article 4 finds that like prior studies conducted in, for example, Australia (Galea & Chappel, 2021) and the US (Blair-Loy & Cech, 2022), executives in Finnish technology companies tend to perpetuate masculine privileges despite the declared values of gender equality and non-discrimination. It is important to acknowledge that while men have a vital role to play in promoting gender equality in the field of technology, the challenge is that the pursuit of equality (often) requires men to change.

Organisations need to recognise that while setting and announcing targets is vital, it is not sufficient. Successful gender equality initiatives require guidelines, processes, and shared understanding of the importance of striving towards the targets. For example, Lapan and Smith (2022, p. 12) highlight that even when large-scale equality initiatives are in place in organizations, it is the “microclimate” – interpersonal interactions with colleagues, supervisors, and teams – that matters most. Critical scholars illustrate how the culture(s) of STEM organizations directly and indirectly advantage men while they devalue, isolate, marginalize and exclude (many) women (O’Connor, 2020; also Blair-Loy & Cech, 2022; Galea et al., 2020; Wilson & VanAntwerp, 2021). In a culture that questions women’s competence, even equal treatment of women may be seen as unjustified favouring of women. Additionally, prior research (e.g., Doerr et al., 2021) indicates that it can be particularly challenging for persons belonging to several minorities, such as women belonging to racialised minorities, to develop the identity of a competent professional and experience inclusion in engineering/technology studies and workplaces.

Overall, this study recommends that executives critically evaluate how the main factors contributing to the persisting gender(ed) gaps identified in this study - the intertwining of masculinity and STEM, masculine cultures, and stereotypes affirming male superiority - manifest in their own organizations. Awareness and understanding of the prevailing and persistent gender(ed) inequalities would be highly beneficial within STEM organizations in Finland (cf. Wynn, 2020). Moreover, acknowledging gender differences in understandings about equality and discrimination is a prerequisite for successful culture change towards an inclusive culture that values diversity.

5 CONCLUSIONS

Women continue to be underrepresented in STEM education and careers, particularly within many fields of engineering/technology. In this study, the vast scholarly literature on women/gender and STEM is classified into two broad groups which are labelled ‘mainstream’ and ‘critical’. Instead of trying to explain ‘the gender gap’ and its endurance with a single overarching theory, this study classifies and discusses various explanations from both camps, thus seeking to bring clarity to the abundant literature on women/gender and STEM.

This study argues that instead of ‘the gender gap’ – the underrepresentation of women - numerous gender(ed) gaps exist within STEM, manifesting in different yet often subtle ways across various contexts. By ‘gendered gaps’, I am referring to the various ways in which gender matters in STEM, leading to differing expectations, treatment, and experiences for men, women, and others. The articles in this study cover four gender(ed) gaps along the pipeline of STEM careers in Finland: application to university STEM studies, graduation with Master’s in engineering/technology, gender-based discrimination in technology workplaces, and recruitment to top management in technology companies. The study deploys a mixed methods approach, combining both quantitative and qualitative data and methods.

The study critiques the mainstream approaches and draws on critical feminist theorizing to explain the persistence of the gender(ed) gaps. While (lacking) interest in STEM is among the most popular explanations in the mainstream literature, critical studies underline that interest in studies and careers in STEM fields - or indeed, in any field - are not formed in a vacuum as gendered societal norms, expectations, and stereotypes influence what an individual can be interested in. Furthermore, the intertwining of masculinity and STEM, and its linkages to stereotypes and understandings of 'natural' male superiority in STEM, has received hardly any attention from mainstream scholars. Additionally, mainstream studies have not sufficiently addressed the impact of masculine culture(s).

This study argues that the gender(ed) gap(s) in STEM in Finland persist due to the cumulated and compounded effects of masculine cultures favouring men as well as stereotypes affirming male superiority in mathematics, stemming from the strong linkages between masculinity with (physical sciences), mathematics, engineering, and technology. Consequently, for (many) women, these lead to lower ability beliefs and less interest in STEM studies and careers as well as a more fragile identity as STEM professionals.

To conclude, I argue that the (low) number or percentage of women in STEM is not the central problem. Rather, the problem is the persistent gender(ed) inequality. The low number/percentage of women is the symptom or manifestation of this problem and instead of focusing on the symptom, we need to address the underlying problem: the intertwining of masculinity and STEM, masculine cultures underpinned by male privilege, and stereotypes affirming male superiority in mathematics. Addressing these is the key to successfully attracting and retaining a more diverse STEM workforce, required for developing better technology for us all. Due to the climate crisis, this is now more urgent than ever.

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6 APPENDICES

Article 1: Naukkarinen, JK and Bairoh, S. (2020). STEM: A help or a hinderance in attracting more girls to engineering? *Journal of Engineering Education* 2020; 109: 177– 193. https://doi.org/10.1002/jee.20320

Article 2: Naukkarinen, JK and Bairoh, S. (2021). Gender differences in professional identities and development of engineering skills among early career engineers in Finland. *European Journal of Engineering Education* 2021, DOI: 10.1080/03043797.2021.1929851

Article 3: Bairoh, S. and Putila, S. Pätevät naiset eivät etene" vai "naisia suositaan"? Sukupuoleen perustuvan syrjinnän ristiriitaiset kokemukset tekniikan korkeakoulutettujen työpaikoilla. *Työelämän tutkimus* 19 (4) 2021, pp. 595– 619. https://doi.org/10.37455/tt.112502
["Qualified women are not promoted" or "women are favoured"? Contradictory experiences of gender-based discrimination in the workplaces of higher engineering graduates]

Article 4: "Do we hire only women then?" Executives navigating gender equality targets and meritocracy in technology companies. Under second round of review in: *Gender in Management: An International Journal*

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ORIGINAL ARTICLE

STEM: A help or a hinderance in attracting more girls to engineering?

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Abstract

Background: Research on gender differences and practical initiatives to attract girls to engineering are often carried out at the macro level where science, technology, engineering, and mathematics are aggregated into an entity called STEM.

Purpose/Hypothesis: This article challenges the aggregated approach, analyzes gender differences among science and engineering applicants in Finland, and discusses the implications of the findings for engineering education and intervention initiatives.

Design/Method: The data consist of the application choices of all applicants to Bachelor studies in Finland in 2016 (151,369 individuals), from which two groups were selected: persons whose first application choice was engineering/technology and persons whose first choice was natural sciences or mathematics. The application choices of these individuals (in total 9,104) are statistically described and analyzed.

Results: Engineering/technology (TECH) and natural sciences and mathematics (SCIMA) subjects are not perceived as alternative options by female applicants. Almost 60% of all female TECH applicants and more than 50% of the female SCIMA applicants apply only to their respective programs. Moreover, TECH applicants considering other options prefer other subjects to SCIMA and vice versa.

Conclusions: Encouraging more girls to study STEM is not a sufficient solution for attracting more women to engineering. Instead of or in addition to encouraging girls to study science and mathematics in K-12 education, it is necessary to open the black box of technology and help young people better understand what engineering is about.

KEYWORDS

gender diversity, higher education, identity, STEM

1 | INTRODUCTION

The underrepresentation of women studying Science, Technology, Engineering, and Mathematics (STEM) subjects and, consequently, the gender gap among professionals in these fields have attracted attention from educators, researchers, and policy makers since the 1970s. Over the last 10 years, scholars have started to question the validity of prevalent explanations for the gender gap (e.g., Mann & DiPrete, 2013; Stoet & Geary, 2018) and to highlight the importance of evaluating change over time (e.g., Kanny, Sax, & Riggers-Piehl, 2014). Furthermore, many researchers now acknowledge that conducting research on the gender gap at the aggregate level of STEM appears insufficient and even problematic. Even the main concept, STEM, is somewhat ambiguous and used inconsistently (Manly, Wells, & Kommers, 2018).

The gender gap in STEM has often been explained by differing cognitive abilities, girls' lack of academic preparation, or their lack of interest in STEM subjects (Blickenstaff, 2005). According to several international studies measuring proficiency in natural sciences and mathematics, Finnish girls have been outperforming boys both in mathematics and natural sciences since 2015 (Vettenranta, Välijärvi, et al., 2016; Vettenranta, Hiltunen, Nissinen, Puhakka, & Rautopuro, 2016). On the other hand, Finnish girls are far less interested in engineering and technology as study fields than boys (Stoet & Geary, 2018; Teräsaho & Keski-Petäjä, 2016). Current intervention efforts and projects in Finland assume that enhancing girls' interest in natural sciences and mathematics will also lead to an increasing interest in technology and engineering. However, these efforts have not had a significant impact on the underrepresentation of women in engineering/technology.

Although there are extensive data available on students and education in Finland, data on the application choices of individuals are not publicly available, and thus, we do not know whether engineering/technology or natural sciences and mathematics attract the same applicants or whether these fields appeal to different applicant pools. If distinct pools exist, this has important implications for engineering education and initiatives aimed at attracting more girls to study engineering.

There were approximately 51,000 students studying for STEM degrees in Finnish universities in 2018 when STEM is defined to include natural sciences (i.e., biological or physical sciences), mathematics, computer science, engineering, and technology. Thirty percent of these students were women although the percentage varies considerably depending on the discipline. For example, the percentage of female students was 69% in biology, 26% in physics, and 14% in electrical engineering and energy technology. The proportion of women among new students in engineering/technology fluctuated around 25% between 2005 and 2017 (Vipunen, n.d.).

In this article, we examine the choice patterns and identify gender differences in these patterns among STEM applicants in Finland based on data containing all applicants to university-level Bachelor studies in Finland in 2016. Along with increasing understanding of the applicants' interests, we assess and challenge current recommendations for decreasing gender segregation in STEM, especially in engineering. We also discuss broader implications for engineering education and intervention initiatives.

2 | THE GENDER GAP IN SCIENCE AND TECHNOLOGY

The gender gap in technology and related fields has been studied extensively since the 1980s. The studies have employed a wide variety of theoretical approaches and focused on different levels of the gender gap (see, e.g., meta studies by Blickenstaff, 2005; Kanny et al., 2014). A considerable amount of this research is conducted at the macro level where science, technology, engineering, and mathematics are aggregated into an entity called STEM. Consequently, many of the practical initiatives for attracting girls have been undertaken at this level, such as "Girls into STEM" in the United Kingdom and "Komm, mach MINT" in Germany (Hutchinson, 2014).

Recently, several studies have critically assessed the validity of the various explanations for the gender gap. Kanny et al. (2014) present a review of 40 years of literature on the gender gap in college STEM majors and highlight the importance of evaluating change over time. They conclude that researchers should not focus on a single explanation and that they should also be mindful of the evolving nature of the field, meaning that the reasons behind underrepresentation may have changed over time. Ceci, Ginther, Kahn, and Williams (2014) argue that the number of women in science at all levels has increased so dramatically over the past 40 years that research based on data prior to the 1990s may have little bearing on the current circumstances women encounter. Furthermore, some scholars argue that new perspectives are required because "conventional narratives explain little of the continuing (and, in some ways, worsening) gender gap" (Mann & DiPrete, 2013, p. 1536).

Researching the gender gap at the aggregate level of STEM is troublesome in many ways. First, the concept of STEM is somewhat ambiguous and used inconsistently, with different researchers and organizations having their own definitions of STEM. For example, STEM may or may not include social and behavioral sciences, and many studies do not explicitly define which disciplines are considered STEM (Manly et al., 2018). Manly et al. (2018) recently emphasized that "given the prevalence of inconsistent and/or unreported STEM definitions, we posit that literature on gender and STEM currently requires excessive assumption and interpretation" (p. 1). They warn that the lack of transparency in the literature is likely to lead to confusion or error and recommend that educators and researchers interpreting findings on gender and STEM need to understand that STEM is not defined uniformly in the literature.

Secondly, considering all STEM fields as if they have similar characteristics obscures differences between and within them. Smith (2011) has pointed out that even though women are studying many science subjects in higher numbers, recruitment to physics and engineering remains stagnant. Kanny et al. (2014) emphasize that the lack of subfield research has done a disservice in addressing the gender gap because of the presumption that explanations for the underrepresentation of women are the same for different subfields. Likewise, Su and Rounds (2015) stress that gender differences across STEM fields are not identical and that overlapping yet different mechanisms in different fields and subdisciplines contribute to gender disparities. Alegria and Branch (2015) illustrate the contrasting development of gender profiles in computing and life sciences, highlighting the intersections of gender, race, nationality, and field-specific factors. We can, thus, conclude that conducting research at the aggregate level means that we can only find general solutions and explanations, and addressing subject-specific challenges is rendered practically impossible.

Emerging discipline-specific research has accentuated the concerns pertaining to aggregate STEM-level studies. Studies by Sax et al. (2016), Sax et al. (2017), and Sax, Lehman, Barthelemy, and Lim (2016) show that the predictors of study interests in different STEM disciplines such as engineering, physics, and computer science not only vary with respect to the discipline and gender but also change over time. Furthermore, the variables that most explain the gender gap depend on the discipline, although engineering and computer science are alike in this respect. For example, commitment to social activism continues to result in limited interest in majoring in these disciplines, while women's lower self-rating of their mathematical ability and lack of interest in making a theoretical contribution to science carry less weight than they did before (Sax et al., 2017; Sax, Kanny, et al., 2016) On the other hand, women planning to major in physics appear quite different from women in other STEM fields as they, for example, tend to be confident in their mathematical abilities (Sax, Lehman, et al., 2016).

Studies on the gendered perceptions of college majors are also emerging. As Ganley, George, Cimpian, and Makowski (2018) point out, it is important to study perceptions because these are what students base their decisions on when full, accurate, and timely information on various options is not necessarily available. Ganley et al. (2018) compare 20 categories of U.S. college majors to investigate how students' perceptions of these majors differ and what differences in perceptions best explain the gender gap. They conclude that perception of potential gender discrimination is the dominant predictor in the gender gap in both STEM and non-STEM fields rather than perceptions of majors' orientation toward math, science, creativity, making money, or helping people. Moreover, "the majors that were perceived as having the greatest potential for future income were more likely to be highly math focused and also had the *highest levels of perceived gender bias (e.g. engineering, physical sciences, computer science)*" (Ganley et al., 2018, p. 476; italics added). Focusing specifically on engineering, Kelley and Bryan (2018) show how gender impacts the choices students make about the type of engineering they want to study. They find that women consider typical engineers to be more masculine than men do but that these perceptions may not impact their choice of specialty as much as expected.

Since the level of and reasons behind the gender disparity vary in different STEM fields, the aggregated actions cannot guarantee positive development in engineering. As Cheryan, Ziegler, Montoya, and Jiang (2017) point out: "Reinforcing the importance of these fields to boys and girls may be a useful strategy to recruit more students into STEM but will likely do less to close gender gaps in participation. Moreover, based on current trends, raising the math performance of girls in high school may result in more women entering the social and health sciences over computer science, engineering, and physics" (p. 22). Hence, knowing more about the female engineering/technology (TECH) applicants' preferences is crucial for devising actions to increase their number. The Finnish application system offers an interesting opportunity for scrutinizing the choices of the same applicant and the overlap between interest in different disciplines.

3 | ENGINEERING AS PART OF STEM

The relationship between natural science and engineering is an intriguing one. From certain angles it is hard to tell the difference, whereas in other respects the distinction is very clear. Until quite recently, engineering was considered an applied science, thus sharing the same basic philosophy with the natural sciences (Meijers, 2009). In the past couple of decades, there has been a growing interest in recognizing and understanding the nature of engineering and engineering sciences as an endeavor of its own (see, e.g., Hendricks, Jakobsen, & Pedersen, 2000; Meijers, 2009; Naukkarinen, 2015). Although science and mathematics still have a strong presence in engineering curricula and engineering practice, the design practices and activities in particular are receiving more attention as something typical for engineering.

In the Finnish discourse, the role of technology and engineering as part of STEM is ambiguous and somewhat invisible. This invisibility is manifested in the acronym "LUMA," which comes from the first two letters of "**lu**onnontieteet," the Finnish word for natural sciences, and "**ma**thematics" (LUMA Centre Finland, n.d.) omitting technology and engineering altogether. Although the official aim of LUMA is to inspire and motivate children and youth about mathematics, science, and technology, in practice the activities lean more toward science education than technology education as the people involved in these activities predominantly have a background in natural sciences or mathematics. Antink-Meyer and Meyer (2016) noticed that in the U.S. science teachers typically have no experience in engineering and may have quite fundamental misconceptions of it. This situation is also likely to be the case in Finland, where science teachers receive no training in engineering subjects. A solution frequently offered to the problem of encouraging more girls to study engineering is to provide them with more experiences related to natural sciences and mathematics. The effectiveness of this approach is rarely questioned.

In Finland, technology education is not taught as a separate subject, but instruction on technology-related topics comes within various subjects like crafts, a compulsory basic education subject in Finland that includes both soft and hard materials like woodwork and metalwork (Niiranen, 2016). School curricula are expected to follow the national framework curriculum (NFC), which is revised in 10- to 15-year cycles. In the 2004 NFC, technology obtained a place in the Finnish curriculum for the first time when the topic "Human Beings and Technology" was one of the seven cross-curricular themes introduced alongside the specific study subjects. However, no specific time was allocated for cross-curricular themes, nor was there any pedagogical training offered to the teachers for implementing the themes (Järvinen & Rasinen, 2015). In the 2014 NFC, the theme was replaced by "Information and Communications Technology (ICT) Competences" (Opetushallitus, 2014). This may lead to narrowing the focus of technology education only to ICT, but so far no studies have been conducted on the impact of this change.

Although the Finnish cross-curricular teaching of technology has met its objectives regarding the development of technological knowledge and attitudes toward technology, the development of technological ideas has not been implemented in teaching, and pupils have not been given opportunities to develop technological applications nor to study the lifespan of artifacts. Young people also seem to have a narrow understanding of what counts as technology and primarily see it as subject matter connected to ICT (Järvinen & Rasinen, 2015). In subjects like physics and chemistry, theoretical constructs easily overshadow practical applications, whereas in crafts and metalwork and woodwork education practical applications overshadow the theoretical aspects. Technological concepts are also rarely discussed in broader environmental, ecological, or social contexts. (Autio, 2015). Hence, it is likely that Finnish pupils' perceptions of technology and engineering remain narrow (ICT overemphasized), and their awareness of the related skills is limited (no understanding of what engineering is nor what an engineer does).

Henwood and Miller (2001) have argued that in the research addressing gender and education, sciences, technology, and mathematics are often perceived as immutable and autonomous. They suggest that this perception is due to black boxing, where the social and cultural practices constituting the disciplines are not acknowledged and the formation and essence of gender are likewise considered given. This results in practices aimed at changing women's attitudes, knowledge, and interests without addressing the structural and cultural matters that originally push women away from the science and technology communities (e.g., Phipps, 2007). From the perspective of engineering, it seems important that the epistemological features of the discipline are acknowledged and taken into consideration when gender issues are researched or practically tackled as they also provide means to distinguish between engineering and other STEM fields. Moreover, seeing gender and technology as continuously coproduced (see, e.g., Faulkner, 2001) can help all of us to understand and communicate that better technology requires a better balance between genders.

4 | FINNISH GIRLS AND STEM EDUCATION

The topic of the gender gap has been addressed in a myriad of studies, many of which focus on the United States. Nevertheless, it is challenging to evaluate to what extent the previous findings and suggestions are applicable to other countries. Therefore, studying the gender gap in divergent educational systems not only increases our understanding of the situation in that culture but also advances our knowledge of the phenomenon in general.

The Finnish educational system consists of 9 years of basic education followed by 3 years of either general upper secondary education or vocational upper secondary education. Entering higher education is possible through either path of secondary education (OECD, n.d.). When applying for a Bachelor's Degree program in a university, the study right is usually also granted for the Master-level program for the same discipline in the same university, meaning that students can continue in the respective Master-level studies directly after completing their Bachelor's Degree without any admissions or application procedures required.

The degree programs that the students apply for are quite specific from the start and changing majors is possible within certain limits, although not easy nor common. Thus, the application choices also strongly direct the possible career paths of the graduates. In mathematics and natural sciences, applicants typically choose between degree programs in mathematics, statistics, physics, chemistry, biology, geology, and environmental science. In engineering, applicants also have to choose a more specific subfield such as electrical, mechanical, civil, or industrial engineering at the application stage. Universities and universities of applied sciences (UAP) offer degrees in similar fields but the nature of the degrees is different: The university degrees have a more scientific focus and the UAP degrees, a more practical one. In engineering, the difference in profile resembles somewhat the difference between the U.S. Bachelor's Degree in engineering and the Bachelor's Degree in engineering technology.

From the start of the international research co-operation in year 2000, Finnish elementary school pupils performed extremely well in the Organization for Economic Co-operation and Development's (OECD) Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMMS) measuring proficiency in natural sciences and mathematics (Vettenranta, Hiltunen, et al., 2016; Vettenranta, Välijärvi, et al., 2016). In recent years, the results have declined especially for boys, which has resulted in Finnish girls outperforming boys both in mathematics and natural sciences. In PISA 2015, Finnish pupils' science proficiency was the second highest among the OECD countries, and confidence in their skills the same as the OECD average. Concerning collaborative problem solving, Finnish pupils were fifth among the OECD countries, with Finnish girls outperforming boys by the largest margin among all the countries (Vettenranta, Välijärvi, et al., 2016).

At the same time, educational segregation at the secondary and tertiary levels remains very strong, and girls opt out especially of technology and engineering. According to the PISA 2015 results, only 1%of Finnish ninth-grade girls are interested in a profession in science and technology. Together with Indonesian girls, this is the lowest percentage of all nations in the study (Vettenranta, Välijärvi, et al., 2016). In a national survey for high school students, 37% of the boys but only 9% of the girls stated they would like to study engineering. For natural sciences, the respective figures were 37% for boys and 30% for girls (Taloudellinen tiedotustoimisto TAT, 2016). Of all the respondents expressing interest in working in natural sciences, 62% were male and 38% were female. For engineering, the respective figures were 83% for men and 17% for women (Teräsaho & Keski-Petäjä, 2016). The proportion of women starting engineering education in Finland is also among the smallest in the OECD countries and the lowest among the Nordic countries. In Finland, only 18% of the starting engineering students are female. In Sweden the proportion is 29%, in Denmark 30%, and in Norway 24% (Keski-Petäjä & Witting, 2018).

Stoet and Geary (2018) discuss a phenomenon they call the educational gender-equality paradox, meaning that countries with a high profile in gender equality have large STEM gaps in secondary and tertiary education. They suggest that this paradox can be explained both by the life quality pressures in countries with a lower profile promoting girls' engagement with STEM subjects in a hope for better future income, and by the role and perception of individuals' academic strengths in career choices. Although in Finland girls generally outperform boys in science, their intraindividual strengths still favor reading, meaning that they are even better at reading. Stoet and Geary (2018) suggest that especially in gender-equal nations, such as Finland, the liberal conventions and smaller financial costs of foregoing STEM paths amplify the influence of intraindividual strengths and direct the educational interests of different genders more readily toward fields that seem to favor the respective strengths. This along with the lack of interest Finnish girls have in engineering indicates that engineering is not perceived as a field where reading-related skills are highly valued or needed.

Previous research has, thus, demonstrated that Finnish girls are highly capable in science, mathematics, and problem solving, but have little interest in studying technology and engineering. Although girls recognize the relevance of STEM subjects to their lives and futures (Microsoft, 2017) and have average confidence in their knowledge and skills, they still prefer to study something else. Within the STEM subjects, girls have a far greater interest in studying natural sciences than engineering. Many of the girls perceive themselves as equal to boys, and a great majority see gender equality as desirable (Kiianmaa, 2012; Teräsaho & Keski-Petäjä, 2016); yet gender segregation of professions in Finland is among the most prominent in Europe (Keski-Petäjä & Witting, 2018).

Stoet and Geary (2018) propose using knowledge of intraindividual differences to better take into account and target STEM-related interventions especially for high-achieving girls whose personal academic strength lies in science or mathematics. From the engineering perspective, this seems viable and sufficient *if* we assume that mathematically oriented girls are equally likely to be interested in engineering and other STEM subjects, and *if* we expect that only the mathematically oriented can have a meaningful career in engineering. We will next empirically investigate the former of these assumptions.

5 | RESEARCH QUESTIONS, DATA, AND METHODS

In this article, we analyze gender differences among university-level STEM applicants in Finland by comparing applicants primarily wishing to study TECH as opposed to applicants preferring biological or physical sciences, mathematics, or computer science (SCIMA). Thus, our definition follows that of the U.S. National Center for Education Statistics but excludes agricultural sciences (Manly et al., 2018). To obtain a more nuanced understanding of this phenomenon, we seek to identify the choice patterns of these two groups of applicants and how these choice patterns are gendered.

Our research questions are:

Research Question 1: *What kinds of choice patterns can be identified among applicants who primarily wish to study engineering/technology (TECH) and applicants who primarily wish to study biological or physical sciences, mathematics, or computer science (SCIMA)?*

Research Question 2: *How are these choice patterns gendered, that is, how do the patterns differ between males and females?*

The data used in the study are derived from the Studyinfo.fi application portal and database (Finnish National Agency for Education, n.d.), which contains the information about all study programs leading to a degree in Finland. The portal is maintained by the Finnish National Agency for Education (EDUFI), and it has been used in all admissions to Bachelor-level studies since 2015. Application to all institutions of higher education, that is, universities or UAP (also known as polytechnics), is completed through the portal. The database is maintained by the national Board of Education, which may grant access to the data for scientific purposes. We requested the data for the year 2016 from the Board of Education in May 2017 and obtained the information on September 21, 2017. The original data contained all applicants to Bachelor-level studies for the year 2016 (151,369 individuals) and their application choices. Application choices appear in the database as six-digit codes according to the national classification (Statistics Finland, n.d.). This classification is based on the Unesco International Standard Classification of Education 2011 (UNESCO Institute for Statistics, 2012).

Each individual can choose up to six study programs, and these are provided in a ranking order (Choice1, Choice2, and so on). This order is binding, and the applicants are offered only the study place located highest on their preference list to which they have enough points to be accepted. For the purposes of this study, two groups were identified and selected for further analysis based on their primary application choice (Choice1) as follows:

- TECH: Applicants whose first application choice (Choice1) is engineering/technology studies at a university (B.Sc.).
- SCIMA: Applicants whose first application choice (Choice1) is biological or physical sciences (biology, chemistry, physics, and related subjects), mathematics, or computer science at a university (B.Sc.).

The data also contain certain background information on the applicants (gender, nationality, language, home country). Since we are interested in the Finnish education system, we used this information to omit applicants who do not reside in Finland. In total, the application choices of 9,104 individuals (of whom 98.7% are Finnish citizens) are included in the study. After selecting the target groups, all application choices were checked and unified so that each choice category contained only one six-digit code. In some cases, more than one code appeared per choice category in the original data. In such cases, the first one was selected as the primary application choice within that choice category. All six application choice categories were recoded for analysis purposes.

Moreover, the first application choices (Choice1) of the TECH applicants were recoded into 10 categories for further analysis. In a similar way, the first application choices (Choice1) of SCIMA applicants were recoded into 10 categories. These categories are presented in the Findings section. The analysis methods applied in this exploratory study are mainly descriptive (percentages, cross-tabs). The main background criterion used in the study is the gender (male/female) of the applicant.

6 | EMPIRICAL FINDINGS

In total, 4,821 persons selected TECH as their first application choice (Choice1) while 4,283 persons selected SCIMA. We started the analysis of the results by assessing the percentage of females in both groups. As expected, gender differences are significant: of those selecting SCIMA studies as their first choice, 42.9% are female, whereas the proportion of females among TECH applicants is 24.7% as seen in Table 1. Thus, SCIMA studies appear more attractive to females than TECH studies. To verify the statistical significance of our findings, we cross-tabulated gender and Choice1 (TECH/SCIMA) and conducted a Pearson's Chi-square test, which confirmed that gender differences among Choice1 applicants are statistically highly significant (Pearson's Chi-square: $p < .000$, two-tailed test, $df = 1$, $n = 9{,}104$).

Next, we evaluated the degree of overlap between TECH and SCIMA applicants, that is, the proportion of applicants having both TECH and SCIMA programs among their application choices. To conduct this analysis, we divided the applicants into two groups based on their first choice (TECH or SCIMA) and then recoded the remaining choice categories (2–6) either 0 (TECH for TECH applicants, and SCIMA for SCIMA applicants) or 1 (other than TECH or other than SCIMA). Then, a summary variable was computed to indicate only TECH/SCIMA choices or other than TECH/SCIMA choices in these choice categories. The percentage shares of applicants with choices only in the same field as their first choice are presented in the right-hand column of Table 1.

Another way to investigate the overlap is to analyze the subsequent choices of the applicants. Therefore, Choices 2–6 of each applicant were grouped into TECH, SCIMA, and OTHER categories. The analysis reveals a similar pattern for all three groups: The relative proportions of the categories remain similar, and the total number of applicants decreases by 15–20% when moving from Choice2 to Choice3, and so on. The pattern indicates that the analysis of the second choice (Choice2) provides a reliable enough estimate of the applicants' interest in other disciplines. Therefore, detailed information about Choices 3–6 is omitted from this article.

We found that male TECH applicants tend to be more constricted in their choices of field than females: 72.5% of the men applying to engineering/technology programs did not apply to any other field. This means that although the applicants can select up to six study programs, which can be in any field, three of four men chose only engineering/technology studies if their first choice was in this area. For women, the corresponding percentage is 58.6%. Moreover, 71.7% of the male and 65.7% of the female TECH applicants selected another engineering/technology program as their second choice (Choice2). On the other hand, slightly over half of the SCIMA applicants, 54.4% of the males and 52.5% of the females, opted only for SCIMA programs, and less than half (41.5% of the males and 48.7% of the females) selected

TABLE 1 Results by applicant group (TECH/SCIMA): Number of applicants, percent of females, percent of secondary choice as compared to first choice, and percent of applicants with all choices in the same field

	Applicants by their first choice		Applicants' secondary choice in comparison with their first choice[a]			Applicants' choices 2–6[a]
Field	Total number of applicants (n)	Percent of females (%)	Same field (%)	Complementing field (%)[b]	Any other field (%)[c]	All choices in the same field (%)
TECH	4,821	24.7	Males: 71.7 Females: 65.7	Males: 6.3 Females: 7.6	Males: 5.6 Females: 11.1	Males: 72.5 Females: 58.6
SCIMA	4,283	42.9	Males: 41.5 Females: 48.7	Males: 11.3 Females: 4.6	Males: 19.5 Females: 25.1	Males: 54.4 Females: 52.5

Abbreviations: SCIMA, natural sciences and mathematics; TECH, engineering and technology.
[a]Applicants could choose up to six study programs, provided in a binding ranking order.
[b]Complementing field: SCIMA for TECH applicants, TECH for SCIMA applicants.
[c]Any other field: all the study options outside the SCIMA and TECH programs.

another SCIMA program as Choice2. In general, SCIMA applicants, thus, have more variation in their application choices than TECH applicants.

Based on our findings, the applicant group with the most interest in a complementing discipline (TECH for SCIMA applicants, and vice versa) was male SCIMA applicants, of whom 11.3% selected an engineering/technology program as a second choice. However, even in this group, other study programs seem more appealing than TECH studies to applicants as almost 20% selected some other program as Choice2. Additionally, only 4.6% of the female SCIMA applicants selected engineering/technology programs as Choice2 while 25% selected some other program. On the other hand, TECH applicants did not show high interest in SCIMA studies, as only 6.3% of the males and 7.6% of the females selected SCIMA programs as their second choice. With the exception of male TECH applicants, all groups had a program in some other field as a second choice more often than in the complementing field. We can, thus, conclude that the overlap between TECH and SCIMA applicants is limited.

We also conducted a more detailed analysis of engineering/technology applicants. We categorized the original six-digit codes of Choice1 thematically into 10 subgroups, based on the similarity of the program content as well as the gender profile, that is, the male/female ratio. A degree program-level analysis was conducted to ensure that this grouping does not hide anything crucial from the gender perspective. Because the within-group gender profiles are quite similar, we are convinced that the subgroups provide detailed enough information.

Categorization of the engineering/technology programs (TECH) resulted in 10 subgroups:

- Electrical engineering and energy technology
- Mechanical and automation engineering
- Information and communications technology
- Industrial engineering and knowledge management
- Engineering sciences and technical physics
- Civil engineering and geoinformatics

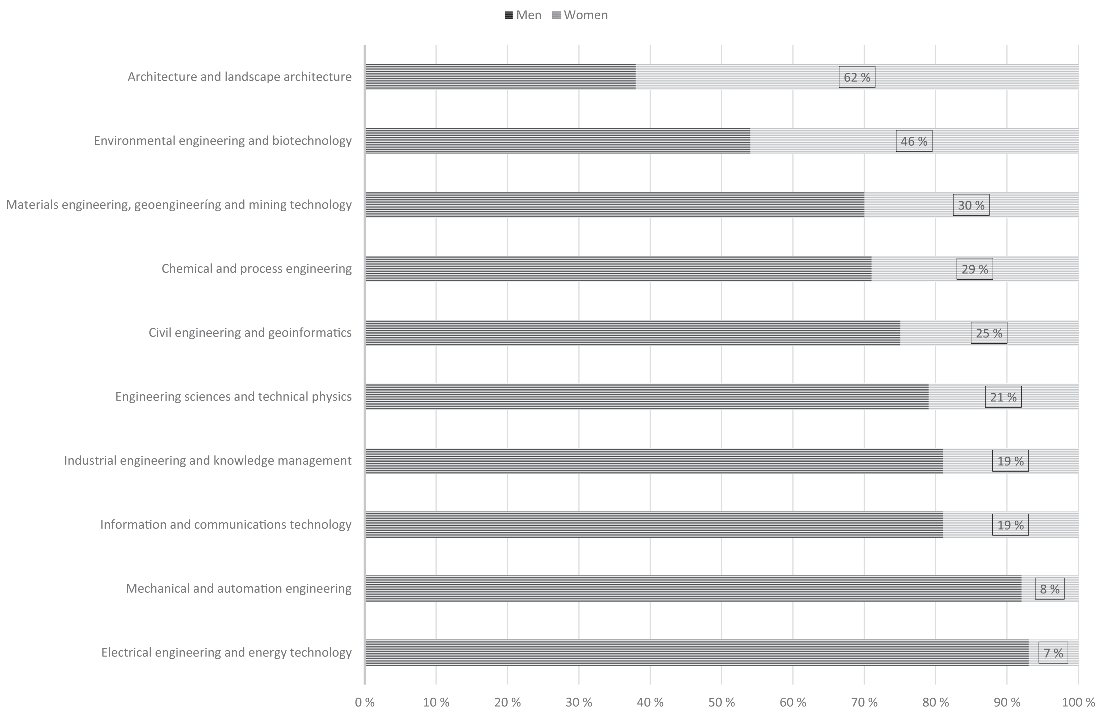

FIGURE 1 Gender distribution of first choice (Choice1) of TECH applicants by disciplinary subgroups

- Chemical and process engineering
- Materials engineering, geoengineering, and mining technology
- Environmental engineering and biotechnology
- Architecture and landscape architecture

Because there is no uniform way of naming the degree programs, the subgroups and their names are our own.

Assessment of the number of applicants reveals that one in three (34%) of all female applicants in the engineering/technology programs wish to study architecture or landscape architecture (n = 405). By absolute numbers, the next most popular groups are industrial engineering and knowledge management (n = 164), information and communications technology (n = 163), and environmental engineering and biotechnology (n = 113). These three together make up another 37% of all the female applicants. However, owing to the different preferences of their male counterparts, gender profiles vary considerably among the subgroups (see Figure 1). These gender differences are also statistically highly significant (Pearson's Chi-square: $p < .000$, two-tailed test, $df = 9$, $n = 4{,}821$).

Figure 1 illustrates the differences in the gender distribution of TECH applicants among different subgroups, ranging from fewer than 10% of the female applicants in electrical engineering and energy technology as well as in mechanical and automation engineering, to close to half in environmental engineering and biotechnology, and more than half in architecture and landscape architecture. Figure 1 also reveals that despite the relatively large proportion of female applicants opting for industrial engineering and knowledge management as well as information and communications technology, approximately one-fifth of all the applicants in these subgroups are women. In general, the programs with a relatively large proportion of female applicants are those with fewer applicants (and study places), and the programs with a relatively small proportion of female applicants are the ones accepting the most students. These results highlight significant gender segregation when engineering is viewed in its totality.

A comparison of our results with publicly available admissions data reveals that the patterns among applicants are very similar to the patterns among admitted students. For example, in 2016, there were 15,228 primary applicants to

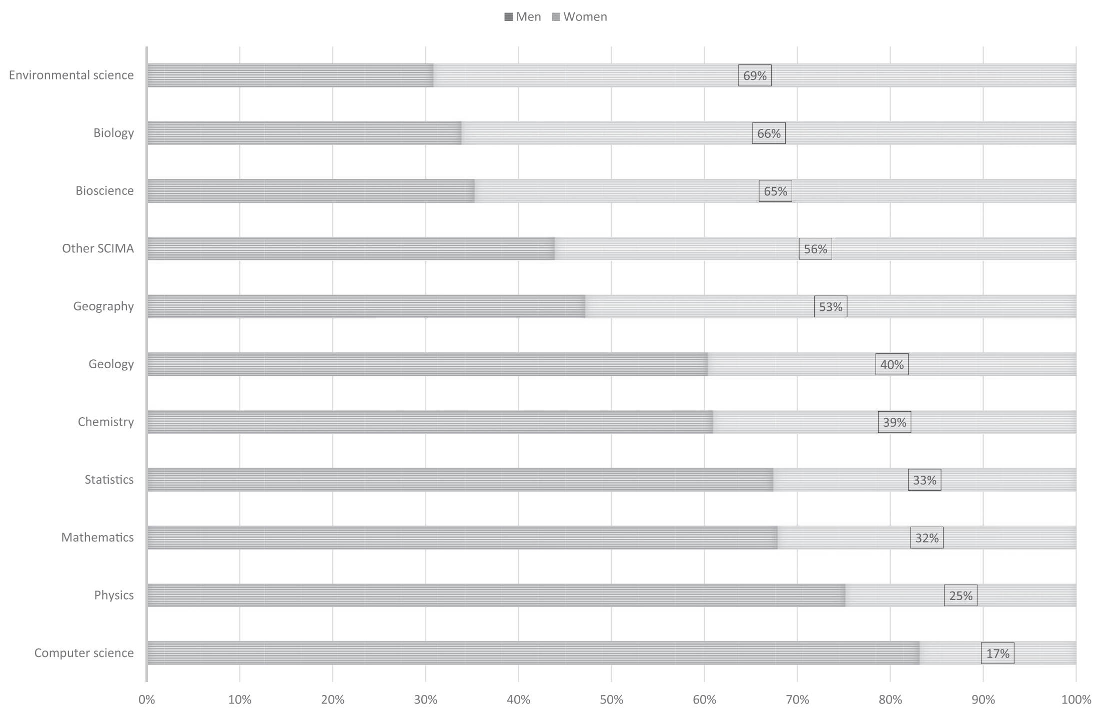

FIGURE 2 Gender distribution of first choice (Choice1) of SCIMA applicants by disciplinary subgroups

TECH and SCIMA university studies, a total of 9,387 persons were offered a place in a university, and 8,256 persons accepted the place offered. Thirty-three percent of those accepting the offered study place were women, but their percentage varied considerably depending on the program (e.g., 72% in biology, 55% in architecture, 50% in chemistry, and 14% in electrical engineering and energy technology) (Vipunen, n.d.).

As among TECH applicants, the gender distribution of SCIMA first choice applicants differs markedly depending on the discipline, as can be seen in Figure 2. Over or nearly two-thirds of the applicants in environmental science, biology, and bioscience are female, whereas in statistics, mathematics, physics, and computer science, more than two-thirds of the applicants are male. The subgroup "Other SCIMA" consists of several small programs with few primary applicants each and includes, for example, biomedical sciences, aquatic sciences, and nutritional science.

The analysis of the second choices (Choice2) of female TECH applicants by subgroups reveals interesting differences, which are illustrated in Figure 3. (Note that here the categories of TECH and SCIMA also include the programs in universities of applied sciences.) A strong preference for engineering/technology is evident, with over or nearly half of the second choices in all subgroups representing engineering/technology subjects. Yet, there are clear differences among the subgroups. In some subgroups, TECH female applicants have very little interest in disciplines other than TECH and practically no interest in SCIMA. This applies to electrical engineering and energy technology, mechanical and automation engineering, materials engineering, geoengineering and mining technology, and architecture and landscape architecture. In the last case, the second choice for most applicants (67%) is also a program in the same subgroup as the first choice.

There are, however, subgroups where natural sciences and mathematics (SCIMA) are clearly options for the applicants. These include engineering sciences and technical physics, chemical and process engineering, information and communications technology, and environmental engineering and biotechnology. The engineering programs in these subgroups are the ones that seem to have a "sibling program" among SCIMA programs (i.e., physics, chemistry, computer science, environmental science, biochemistry). Furthermore, the only engineering degree program that includes teacher training (Engineering Science at Tampere University of Technology) belongs to one of these subgroups.

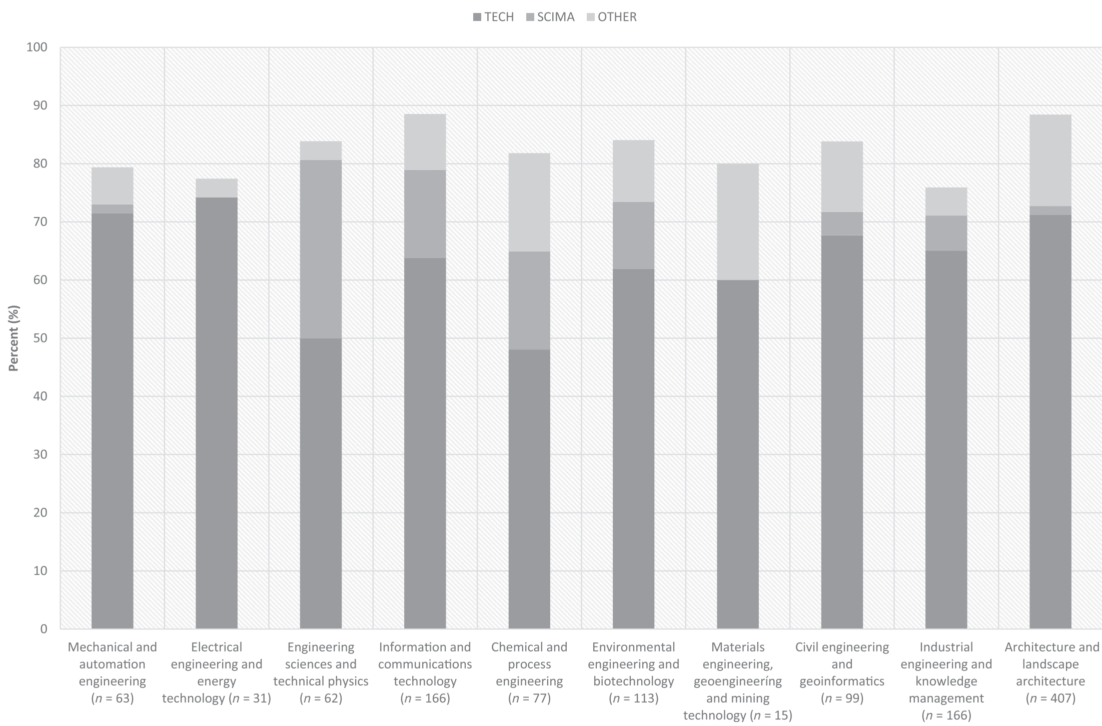

FIGURE 3 The analysis of second choices (Choice2) of female TECH applicants by disciplinary subgroups of their first choice (Choice1)

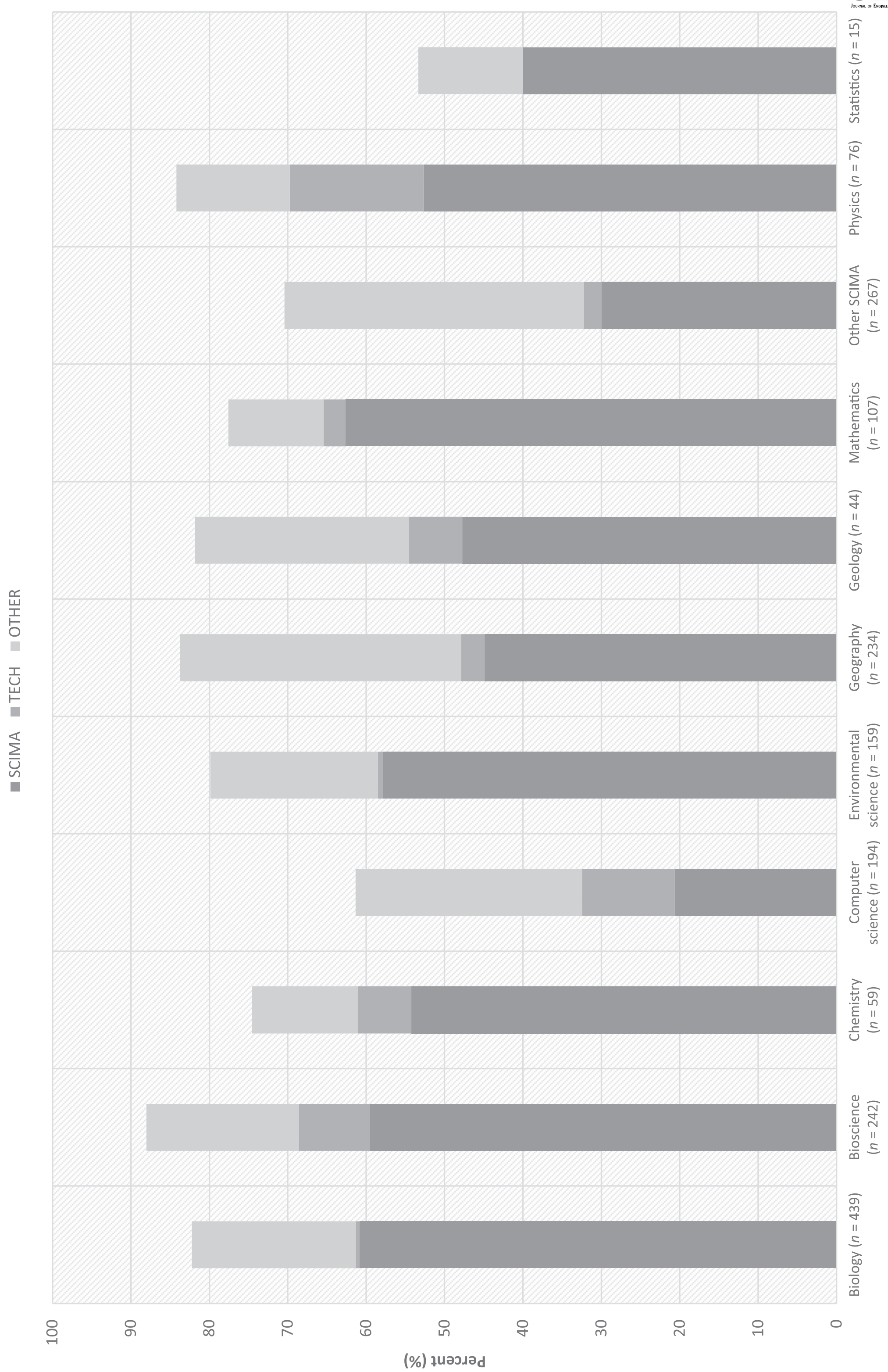

FIGURE 4 The analysis of second choices (Choice2) of female SCIMA applicants by disciplinary subgroups of their first choice (Choice1)

Choice1 applicants in the remaining subgroups (industrial engineering and knowledge management; civil engineering and geoinformatics) appear to have a strong interest in technology but also some interest in SCIMA. Yet, other programs seem to be an equally or even more viable option than SCIMA as Choice2. This also applies to applicants in chemical and process engineering, and environmental engineering and biotechnology.

Similar patterns also emerge when analyzing the secondary choices of male TECH applicants. Therefore, it can be concluded that among engineering/technology applicants, preferences range from a rather strong interest in natural sciences and mathematics (i.e., considerable overlap between TECH and SCIMA) to zero interest (no overlap). Moreover, the areas of no overlap seem to be located either in the area of architecture or in the mechanical, electrical, and automation engineering programs.

The second choices of female SCIMA applicants illustrated in Figure 4 show that these applicants are not quite as committed to SCIMA subjects as the female TECH applicants are to TECH programs. This is also illustrated by the percentage of applicants applying only to TECH or only to SCIMA (see Table 1). In general, SCIMA applicants show only limited interest in TECH programs. The greatest interest can be seen in the "sibling programs," namely physics, computer science, bioscience, and chemistry, which attracted the most attention from the TECH applicants. Geology applicants also seem to have some interest in TECH programs. However, although environmental engineering and biotechnology applicants show some inclination toward SCIMA programs, environmental science applicants do not seem to be attracted to TECH programs, including environmental technology. This result is intriguing as one would expect the environmentally minded applicants to consider both options.

7 | DISCUSSION

Our findings reveal that the overlap between the SCIMA and TECH applicants is surprisingly small: Over 70% of the TECH applicants and more than 50% of the SCIMA applicants apply only to their respective programs, and only a small minority select the complementary field (SCIMA for TECH and TECH for SCIMA) among their further application choices.

However, exploring the results in more detail reveals some interesting gender differences. Female engineering applicants tend to be slightly more open to other options than their male counterparts, and among the female engineering applicants, there are subgroups with considerable interest in SCIMA subjects as well as subgroups with virtually no interest. Because different engineering subdisciplines have different gender distributions of applicants, there is most likely some correlation between the TECH versus SCIMA interest patterns of different genders and different subdisciplines. This possibility appears to support the suggestion by Mann and DiPrete (2013) that a greater curricular flexibility and the possibility to pursue coursework in other fields of interest enhances women's interest in a discipline, and on the other hand, diverts them from fields of engineering lacking curricular flexibility.

If the applicants are really interested in *either* engineering *or* science, is there a point in trying to sell them both as one "STEM package"? Even worse, is there a danger that emphasizing the unity of science and engineering deters some potential applicants? In her study of successful Swedish students, Engström (2016) found two profiles among male students who, despite their interest in technology, did not find mathematics and science particularly easy, interesting, or enjoyable. This kind of practical technology interest was not found among the female students. Earlier research also suggests that female applicants do not even apply for engineering if they have doubts about their academic success or interest in science subjects (e.g., Du, 2006). This makes us wonder whether women with a more practice-oriented mindset could be successful in engineering in the same way as men.

For many years, chemistry, physics, and mathematics courses were placed at the beginning of the Finnish engineering curricula, with the assumption that students had to master these topics to be able to apply them in their later engineering courses. A similar principle seems to be reflected in the idea that the elementary school technology education naturally emerges from science classes where pupils learn about phenomena so that they can later apply them for practical purposes. This "theory first" approach was challenged in an experiment delivering integrated science, technology, and engineering education focused on real-world practice. The integrated approach was noted to significantly improve both the knowledge of science, technology, and engineering content and pupils' aspirations for engineering (Yoon, Lucietto, Capobianco, Dyehouse, & Diefes-Dux, 2014). Using the engineering design process as a teaching framework for physics and biology was also found to increase female students' interests in physical sciences in particular (Ward, Lyden, Fitzallen, & de la Barra, 2015).

There are currently ongoing attempts to profile young people according to their interests in STEM subjects and careers (Motivaction & YoungWorks, 2010; Teknikföretagen, 2017). The profiles discovered clearly illustrate different reason that people have for being interested in STEM subjects both separately and as a group. Some are equally interested in science and technology or theory and practice. They want not only to understand principles but also to be able to put them into practice. Some people are driven by practice, and the more theoretical knowledge is interesting only when it clearly serves a practical purpose. Others are theorists to whom practice does not necessarily appeal at all. Moreover, there are those who are the most interested in using instead of producing technologies. Interestingly, there are also secondary education pupils, typically more girls than boys, choosing STEM subjects who are not interested in them but opt for them to keep their options open (Yazilitas, Saharso, de Vries, & Svensson, 2017).

One viable option for addressing the interests of the practically minded potential applicants already in their basic education could be the integrated science, technology, and engineering education suggested by Yoon et al. (2014). As their approach did not weaken the academic results at the expense of improving practical knowledge and aspirations, it is likely that it would not put the pupils interested in science in a worse position but could benefit the science learning and the identity formation of the pupils interested in "only technology." In essence, this integrated approach is a way of increasing the visibility of engineering design and the creative side of engineering work, which is often weakly acknowledged by K-12 pupils (Capobianco, Diefes-Dux, Mena, & Weller, 2011). Seeing the creative side of engineering can be a substantially appealing factor for young people with an inventive mind and/or practical mindset who may not find the mathematics or science attractive in themselves.

There are notable differences among the technological subdisciplines with respect to both the gender distribution of the applicants and the applicants' interests in other STEM disciplines. There are several plausible explanations for this difference: Some subdisciplines appear more feminine in nature than others because of their emphasis on social imperatives or their interdisciplinary content or methods (Barnard, Hassan, Bagilhole, & Dainty, 2012; Brawner, Camacho, Lord, Long, & Ohland, 2012; Foor & Walden, 2009; Mann & DiPrete, 2013); the influence of socializers such as parents, teachers, and friends (Ikonen, Leinonen, Asikainen, & Hirvonen, 2017); and different personal motives linking with different subdisciplines (Engström, 2016). Kelley and Bryan (2018) show that female students in the subdisciplines with the greatest proportion of females have the most masculine perceptions of engineering in general. They suggest that females would, therefore, seek specialty areas with more females to increase their level of comfort. Another explanation for this is that although women perceive a typical engineer as masculine, they may perceive their choices as atypical and, hence, more appealing. Ganley et al. (2018) argue that in addition to perceived gender representation, the perceived gender discrimination is an important factor behind the gender differences in choice of major.

Different subdisciplines appear to attract somewhat different applicants although women interested in technology and engineering have been found to be a more homogeneous group than men (Engström, 2016). Engström (2016) identified one profile among the Swedish engineering students that was present among the female students but had no counterpart among the male. Students in this profile emphasized their willingness to do something good for society and humanity. A similar observation was made by Shealy et al. (2015), who discovered that females interested in civil engineering were more likely to wish to address societal issues, such as poverty or distribution of wealth and resources, than males interested in civil engineering or both females and males interested in other fields of engineering. These kinds of more general motives could provide a better starting point for the understanding of choice patterns in totality instead of explaining the applicants' behavior through the first choice only. From this viewpoint, it was particularly interesting to note that practically none of the female applicants for environmental sciences applied to environmental engineering or any other engineering program as their second choice. This suggests that many young, environmentally minded women with possible altruistic study motives do not perceive engineering as a discipline that allows them to help society and environment. This, however, is a topic that calls for further study.

As our results also show, different engineering subdisciplines attract women to varying degrees. Nonetheless, as Cheryan et al. (2017) argue, even if women are interested in other fields, it does not mean that they could not be equally interested in engineering if the culture of the discipline signaled to them that they belong there. Therefore, instead of or in addition to encouraging more Finnish girls to study science and mathematics in K-12 education, it is also necessary to open up the black box of technology (Henwood & Miller, 2001) and help girls as well as boys to better understand what engineering and development of technology are about. This, however, is not primarily a question of giving young people information but rather a question of creating and presenting a wider disciplinary self-understanding. This requires a cultural change and critical contemplation of values as suggested by Ulriksen, Møller Madsen, and Holmegaard (2010).

As a part of the cultural change required, engineering as a discipline needs to discuss and better communicate the added value of women and other nontraditional groups for the field. This, on the other hand, may call for more discussion about both the disciplinary nature of engineering and the purpose of engineering for society—both topics not very often discussed within the engineering community. This means changes in both academic and managerial engineering discourse as well as in the liberal education discourse in the engineering education institutions (Stonyer, 2002). The altruistic and humanitarian aspects of technology have been noted to be more important to women than men (Engström, 2016; Motivaction & YoungWorks, 2010), and the women's stronger commitment to social activism is one of the variables that most explain the gender gap in engineering (Sax, Kanny, et al., 2016). Thus, emphasizing the opportunities to serve society in engineering has the potential to attract more women to the field. Yet, the dualistic discourse of the discipline often devalues these aspects and considers them less essential (Faulkner, 2000) or “imaginary engineering” (Foor & Walden, 2009, p. 41).

8 | LIMITATIONS

The data on the application choices used in this study were derived from the Studyinfo portal (Finnish National Agency for Education, n.d.). We had to define which data were necessary for conducting this study very early in the application process and limit our investigation only to that data. As this is the first study of the kind (to our knowledge) to be conducted using the Studyinfo data, we decided that a descriptive approach would best suit our objectives. Since we were interested in the choice patterns of applicants and how these choice patterns are (potentially) gendered, we selected the application choices (1 to 6) and the gender of the applicant as our main focus. Gender in the database is a binary variable (male/female) and, therefore, does not allow variety of gender identities to be taken into account. Further studies could analyze the importance of other demographics not contained in our data set, such as the age of the applicants (although the majority of applicants to Bachelor studies in Finland are between the ages of 18 and 19).

The results reflect the Finnish educational system, and the applicability of our findings naturally depends on similarities and differences between systems. In the Finnish system, the choice of degree program is much more tightly connected to the future career than, for example, in the United States, where one can more easily change their major during college or continue to Master-level education or professional education from several different Bachelor's degrees. Thus, the decisions made in application to tertiary education have different consequences in different educational systems and may also be influenced by different factors.

9 | CONCLUSIONS

The findings presented in this article show that, as expected, studies in engineering or technology (TECH) and studies in biological or physical sciences, mathematics, or computer science (SCIMA) attract men and women to varying degrees. Our results also reveal that TECH and SCIMA subjects are not perceived as alternative options by male or female applicants. Over 70% of the TECH applicants and more than 50% of the SCIMA applicants apply only to their respective programs, and the TECH applicants considering other options prefer other subjects to SCIMA, and vice versa. Indeed, considering the tendency to perceive science, technology, engineering, and mathematics as one entity (STEM) and to emphasize the strong relationship between science and technology, the overlap between SCIMA and TECH applicants is surprisingly small. Applicants to TECH and SCIMA Bachelor studies in Finnish universities have clearly decided on which discipline they are interested in.

Our findings also reveal notable differences between the technological subdisciplines with respect to both the gender distribution of the applicants and the applicants' interests in other STEM disciplines. For almost two-thirds of the female engineering applicants, the second choice was also engineering/technology, but this percentage varied from 48% for chemical and process engineering applicants to 74% for electrical engineering applicants. Additionally, the applicants' interests in science and mathematics varied from no interest at all to more than 30% of the applicants applying for SCIMA disciplines as their second choice. These differences cannot be explained by the perceived representation or perceived gender discrimination of the first choice as previous studies have suggested.

As this and several earlier studies have pointed out, conducting research at the aggregate level yields only general solutions and explanations. Moreover, when practical initiatives are based on explanations provided by aggregate research, addressing subject-specific challenges is rendered practically impossible. Our findings indicate that although emphasizing the importance of finding means for attracting more women to study STEM may be necessary, it is not a sufficient solution to attract more women into engineering. Thus, it is necessary to better articulate what engineering and the development of technology are about—for both girls and boys. To achieve the required cultural change, engineering as a discipline needs to discuss and better communicate the added value of women and other non-traditional groups for engineering and technological development.

Engineering has several subdisciplines, some of which attract women more than others. Nevertheless, engineering design and human–technology interface are central aspects in any field of engineering. Thus, the ideas described earlier could and should be taken into account consistently throughout the field instead of using them to create "female-friendly" subdisciplines, which easily become devalued and perceived as softer or "imaginary" engineering and actually work to maintain the status quo of engineering as masculine as it has hitherto been.

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Gender differences in professional identities and development of engineering skills among early career engineers in Finland

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ABSTRACT
Formation of professional identity is a process where individuals attempt to bring together the social expectations set for them as professionals and their own interests and values. The cultural landscape of engineering is masculine in various ways, which can be challenging especially for female engineers who need to match the cultural expectations with their personal identities. So far, few studies have compared the professional identities of early-career men and women engineers. This study aims to understand the professional identities of newly graduated Finnish male and female engineers by analysing their perceptions of the importance and development of professional engineering skills. An analysis of cross-sectional survey data of more than 4000 early-career engineers suggests some gender differences related to professional identities and indicates that the observed differences in values and perceived skills can put women at a greater risk of dropping out of an engineering career.

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Engineering identity; professional skills; gender difference

Introduction

Development of professional skills and identity is a central part of engineering education (Johri and Olds 2011). While learning the skills, an engineering student also builds up perceptions and understanding of the use and value of those skills. In the process of professional identity formation, individuals attempt to bring together the social expectations for them as professionals and their own interests and values (Tonso 2014).

The cultural landscape of engineering has been noted to be masculine in various ways, reflected for example in different valuations of ‘hard’ and ‘soft’ skills, or the strong linkage of engineering identity and male norms (e.g. Faulkner 2007; Holth 2015). Yet among engineering educators, engineering knowledge and processes are widely thought to be gender-neutral (Beddoes and Borrego 2011; Godfrey and Parker 2010). This contradictory situation can be challenging especially for female engineers, who need to match these expectations with their personal identities. Cultural climate has been noted to drive female graduate engineers away from the workforce in many countries (Singh and Peers 2019), and female engineering students have been discovered to employ enculturation and professionalisation strategies that fail to value femaleness and can lead to ‘undoing gender’ while ‘doing engineering’ (Powell, Bagilhole, and Dainty 2009).

Engineering competencies and identities are inseparably linked and shape each other simultaneously (Tonso 2014). Hence, the professional identity of engineers is not a straightforward result of acquiring certain competences or skills, nor can the competencies be simply derived

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from the identity. Both the engineering identity and the engineering competencies are situated in terms of time and place and shaped by circumstances and changes outside the profession. Tonso (2014) suggests that claims about engineering identity and valuing some sorts of engineers ahead of others do not depend only on the past practices but also affect the future identity norms in engineering. When explicitly recognised, this provides engineering education powerful means to steer the course of the discipline.

This study assumes that the importance individuals attach to various skills reflects their perceptions of engineering identity and also steer further development of those skills. Moreover, we are convinced that the development of engineering identity and skills as well as the perception of them is contextual. Buckley et al. (2021) illustrate how the prototypical definition of an intelligent engineer is influenced by the cultural context and gender and suggest that the cultural context of participants may mediate people's interests and associated gender differences. Hence, we believe that gaining a better understanding of the Finnish cultural context not only benefits the actions in the Finnish engineering education but also enriches the general understanding around gendered practices in engineering education.

Engineering identity

Tonso (2014) identifies two strands of sociocultural engineering identity research that contribute to the understanding of how professional identities in engineering are gendered. The research on technical/social dualism illustrates how engineers have two types of stories of what is considered proper engineering and, hence, two kinds of professional identities, one relying on a highly technical view of engineering and the other emphasising the more heterogeneous and networked engineering practice (Faulkner 2007; Faulkner 2011). The research on campus cultures in engineering reveals what kinds of norms and power relations the hidden curricula conveys and thus produces gendered order and influences the identity production (Tonso 2014).

The technical/social dualism shows in various ways in engineering work and education. According to Trevelyan and Williams (2019), the literature indicates that technological innovation is the principle site of value creation in engineering, even though the majority of engineers are not innovating. Trevelyan (2010) discovered that engineers relegate a peripheral status to the social aspects of their work and therefore fail to recognise many central aspects of their work. Human performance and social interactions are viewed as management issues and not as relevant constraints of design and problem-solving. The work related to technical functioning of a system is privileged over the work related to usability or the human interface of a system even when the work in essence is similar (e.g. coding software) (Trevelyan 2010). Framing engineering work through this dualism is not restricted to workplaces but is, in fact, even stronger among engineering students and faculty (Lagesen and Sørensen 2009).

The technical/social dualism is inherently gendered given the common association of sociality with femininity and technicality with masculinity. According to Faulkner (2007), 'technicist engineering identities persist in part because they converge with (and perform) available masculinities, and that women's (perceived and felt) membership as 'real' engineers is likely to be more fragile than men's' (Faulkner 2007, p. 331). The tinkering orientation of engineering can undermine many women's confidence and sense of belonging in engineering especially at the beginning of engineering studies, but the challenges for balancing the personal and professional identities often continue throughout the career. Although transferring from technical to managerial roles, often through promotion, means giving up some technical aspects of work, for male engineers it does not mean giving up their credentials as a man, but rather changes from one type of masculinity (the one of science and technology) to another (the one of corporate authority and business). For a female engineer moving toward a more heterogeneous role, which may feel more gender authentic, can bring a greater risk of losing her identity as 'real engineer' than for the male colleagues (Faulkner 2007; Holth 2015).

Campus culture and educational practices are the interfaces through which the engineering students become socialised to the engineering culture and values. Seven facets of engineering curriculum and pedagogy have been identified as gendered: (1) assumptions about students' experiences, values, and backgrounds, (2) aims and objectives of engineering programmes, (3) forms of assessment, (4) course content, (5) teaching and learning methods, (6) teaching practices, and (7) the learning environment (Mills, Ayre, and Gill 2010). The campus cultures in engineering education are known to be pervasively masculine. The male dominance shows in the physical surroundings (Du 2006), social interactions (Tonso 2006), as well as in the engineering way of thinking, doing and being (Godfrey and Parker 2010). Although female students can integrate into these environments by adapting to the prevalent thinking and finding a socially supportive niche, they often leave the traditions and culture intact (Godfrey 2007). The epistemic culture of engineering mitigates students' public welfare interests over the course of their education (Cech 2014). This devaluation of the social and altruistic aspects of engineering can bring along challenges to the professional identity development especially to women, who more often than men enter the discipline with socially conscious motives (Seron et al. 2016).

Cech et al. (2011) suggest that professional role confidence consists of two dimensions; expertise confidence and career-fit confidence. Expertise confidence, that is, the confidence in one's ability to master the needed professional skills and competencies, was discovered to matter for persistence in an engineering major, whereas the career-fit confidence, that is, the confidence that a career path in profession meets one's interests and values, mattered for intentions to work in engineering after graduation. Men were discovered to have significantly more professional role confidence along both dimensions than women (Cech et al. 2011). Gender differences are also manifested in how well-suited women and men consider themselves for careers in engineering and technology. Powell, Dainty, and Bagilhole (2012) found that women engineering/technology students maintained contradictory viewpoints, at times upholding gendered stereotypes about women's suitability for 'masculine' work such as engineering but also subscribing to an ideal that the sector is accessible to all who want to work in it. By upholding gendered stereotypes, for example, that men are more talented in mathematics and therefore more suited for a career in engineering, and at the same time distinguishing themselves from other women, the women studying engineering and technology seemed to align themselves with (male) engineers rather than other women (Powell, Dainty, and Bagilhole 2012). Considering oneself the exception rather than the rule, as a woman in engineering, comes across also in other studies (e.g. Seron et al. 2018).

The ways female students interpret the negative encounters with their male peers in collaborative projects and teamwork reflects the discipline's deep beliefs in the individualism and meritocracy. In collaboration settings, female students are often allocated tasks that are less technical or otherwise perceived as less important. Yet women do not see this as a cultural feature, but, as a personal responsibility to develop their own strategies (Seron et al. 2016). The ethos of success through individual merits combined with illusions of gender-neutrality can lead female students to refrain from certain support measures in a fear of being perceived to take advantage of their gender (e.g. Seron et al. 2018). The stigmatisation of support functions and organisations happens despite the fact that female students report occurrences of sexism and implicit bias both in academic and workplace settings (Smith and Gayles 2018).

Engineering skills

Engineering identity and engineering knowledge are tightly linked to each other, but also to the culture and history of the national environment where the engineers are educated (Downey and Lucena 2004). Hence, it would be surprising to find a unified set of engineering skills adopted by all engineers. The historical differences in the development of national engineering education systems and cultures result in variance in understanding the concept of theory, the relationship between theory and practice, the measures of progress, and the status of the profession, to name a few examples (Downey and Lucena 2004). Yet, there are also many similarities between local views on appropriate engineering skills. In their extensive review study, Passow and Passow (2017) managed to identify 16 generically important competencies for engineering practices across the disciplines, practice areas and countries. The competencies were grouped to reflect four different realms of capabilities: applying technical foundations, collaborating with different stakeholders, engineering with constraints, and managing one's own performance (Passow and Passow 2017).

Many engineering societies and accreditation agencies regularly discuss the nature of engineering skills and competencies and thus set the stage for the production of professional identity of individual engineers (Tonso 2014). Although the skills repertoire represented for example in the accreditation criteria of the Accreditation Board for Technology and Engineering (ABET) in North America (ABET n.d.). and The European Network for Accreditation of Engineering Education (ENAEE n.d.) is wide and multifaceted, in practice some skills are valued over others. Trevelyan (2019) argues that in engineering education 'money is usually seen as a topic of marginal importance' (Trevelyan 2019, p. 826), written communication is preferred over face-to-face interactions, listening skills are overlooked, individual efforts are valued over collaboration, and emotions and beliefs are absent from the curricula. Although engineers identify a set of coordination and communication skills as the most important skills in their work, they still perceive technical problem-solving as the essence of 'real' engineering work and uphold the technical/social dualism in the conceptualisation of their work (Anderson et al. 2010).

Cech (2014) points to the precipitous decline in students' beliefs about the importance of understanding the consequences of technology and understanding how people use machines during engineering education. When comparing engineering and business students' perceptions of generic skills, Chan and Fong (2018) found that engineering students perceived self-management skills, interpersonal and communication skills, and community and citizenship knowledge less important than business students. Of all the listed generic skills, engineering students perceived the awareness of political, social, economic and environmental issues as the least important to their future career (Chan and Fong 2018). These findings suggest that engineering education places greater value on applying technical foundations on practical problem-solving over consideration of nontechnical constraints or communication and collaboration. This is consistent with the technical/social dualism discussed above.

Career expectations and workplace experiences

Do men and women have similar or different expectations of their careers in engineering? Some studies indicate that aspirations and motivation for careers in engineering/technology may differ between men and women (Kossek, Su, and Wu 2017). For example, VanAntwerp and Wilson (2018) discover gender differences in the expressed intrinsic and introjected motivation for engineering work by early-career engineers. They suggest that the non-technology-focused intrinsic motivation, more common among women, leads to a weaker commitment to an engineering career than the technology-focused intrinsic motivation commonly held by men. VanAntwerp and Wilson (2018) also conclude that women may be more vulnerable to engineering career exits because of the stronger connection between their self-esteem and the introjected motivation for engineering. Moreover, certain studies demonstrate that the career paths of women and men differ. Holth (2015) shows how women in Sweden, less often than men, end up in positions that do not match their educational level or qualifications while Xu (2017) presents similar findings from the United States: gender inequality pertaining to salary and employment status in STEM occupations is significant from the very beginning of post-baccalaureate employment.

The masculine, even hostile, culture of engineering workplaces and academia may be an important explanation for the lack and withdrawal of women. For example, Miner et al. (2019) find that junior women faculty in STEM experience an interpersonally chillier climate compared with junior men faculty in STEM and that working in such a climate has consequences for junior women's well-being especially when they have chilly interpersonal experiences with male colleagues. Mallette (2017) describes in detail how numerous factors along with the culture that excluded communication from the engineering work made a competent female engineer to leave engineering. Hatmaker (2013) further illustrates how women engineers need to engage in at times extensive identity work and agency-building efforts to be recognised and becoming an accepted member; work that men do not necessarily need to do. Not gaining respect, not fitting in, and balancing between work and family are the main challenges identified by late-career and retired female engineers in the United States (Ettinger, Conroy, and Barr II 2019).

Combining family responsibilities with careers in engineering seems to be problematic even in varying national contexts. Cech and Blair-Loy (2019) show that in the United States, up to 43% of women leave fulltime STEM employment after their first child. New mothers are more likely than new fathers to leave STEM, to switch to part-time work, and to exit the labour force. On the other hand, combining STEM work with caregiving responsibilities appears problematic also for fathers, since 23% of new fathers leave STEM after their first child (Cech and Blair-Loy 2019). In Sweden, Holth (2015) found that in contrast to men, women working in IT rejected both management and consultant roles in favour of duties and positions, normally project and team leaders, where their availability for family life could be prioritised to a greater degree. These positions of project leader and team leader, however, lead the women away from the organisation's technical core business, entailing the loss of women's technical skills in the long term (Holth 2015). Even the significant efforts to advance women's careers in engineering by actively promoting them to managerial positions can have countereffective consequences, as the inverted role hierarchy in engineering favouring the status of technical over managerial roles can make female managers question their status and identity as engineers and hence increase the risk of exiting the profession at some point of their career (Cardador 2017).

The persistence of women in the engineering profession appears to be connected to steps women have taken to ensure that their work environment matches their expectations of interesting, challenging, and enjoyable work in a supportive and inclusive culture (Ayre, Mills, and Gill 2013). Ayre, Mills, and Gill (2013) point out that while the interviewed women had all entered the profession strongly believing in themselves as engineers, and this belief had endured despite the difficulties they encountered, many of these women had experienced being isolated, overlooked, and marginalised in the prevailing masculine culture of engineering workplaces (Ayre, Mills, and Gill 2013). O'Connor, O'Hagan, and Gray (2018), who identify four types of femininities within STEM (careerist, individualissed, vocational, and family-oriented femininity) underline that all of these are constituted in relation to the meanings attached to the masculinist STEM career, which performatively render women outsiders. The most common orientation (career orientation) involves adopting characteristics associated with masculinity – although experienced and read as feminine – and requires remaining silent about sexism and making constant and creative efforts to 'blend in' (O'Connor, O'Hagan, and Gray 2018).

Identity, skills, and gender differences among Finnish engineers

Finnish technical universities and faculties and the Finnish Association of Academic Engineers and Architects TEK have conducted a joint feedback survey for Master's level engineering graduates since 2011 (Hyötynen, Kokko, and Teini 2015). Among many other things, the survey asks about graduates' perceptions of the importance of different professional skills in working life as well as the development of these skills in education and work experience during studies. Pyrhönen, Niiranen, and Pajarre (2019) amended the graduate survey data with data of academics' and employers' perceptions of the importance of different engineering skills. Their findings suggest that graduates' perceptions of the most important skills resemble those of employers' but differ from the respective perceptions of academics. However, the learning outcomes seem to follow the academic valuation of skills as the skills perceived most important by academics are also those which graduates perceive to develop most during the studies. Pyrhönen, Niiranen, and Pajarre (2019) point out that this happens even when the graduates find the skill to be among the least important ones. Graduates and employers value the more general and practical skills, such as time management and team working, whereas academics value the more theoretical skills, such as knowledge in mathematics and natural sciences (Pyrhönen, Niiranen, and Pajarre 2019).

Even though Finnish engineering students highly appreciate preserving and enhancing the welfare of the people (Teini, Mursu, and Piri 2018), ethics and sustainable development are among the skills perceived to be least important by graduates (Pyrhönen, Niiranen, and Pajarre 2019). This suggests that the culture of disengagement discovered by Cech (2014) in the US engineering education may be present also in the Finnish engineering education. The suggestion is also supported by the fact that sustainable development was among the skills perceived least important also by academics. Other less important skills in academics' eyes were the practical application of theories, management skills, leadership, and creativity. The practical application of theories was considered very important by graduates, and thus highlights again the difference between the graduate and academic views (Pyrhönen, Niiranen, and Pajarre 2019).

Both the results of the graduate survey and a workshop for various different stakeholders manifest the growing importance of interpersonal skills (Hyötynen, Kokko, and Teini 2015). In the study by Pyrhönen, Niiranen, and Pajarre (2019), employers mentioned team work, social skills, self-knowledge, and self-confidence as skills that are most often lacking among graduates. Finnish female engineering students have been noted to value social and interdisciplinary teaching and benefit from that (Paloheimo 2015). However, especially academics' perceptions of the skills needed in engineering seem to emphasise the theoretical and technical aspects of engineering so heavily that the social and human aspects may not appear very visible in the Finnish engineering education.

Like in many other countries, also in Finland the early career in engineering is a rockier road for women than for men (Paloheimo 2015; Vuorinen-Lampila 2016). Paloheimo (2015) noted that at the time of graduation men had better employment and were more often permanently employed than women. During the first five years of their career women had more unemployment periods and more and longer family leave periods, and they achieved fewer managerial positions than their male peers (Paloheimo 2015). These findings were confirmed by Vuorinen-Lampila (2016), who also discovered that during the first three years of their career 'men have been more successful in the labour market irrespective of whether they have graduated from male-dominated, female-dominated, or gender-balanced study fields' (Vuorinen-Lampila 2016, p. 300).

Research questions, data and methods

Hardly any studies have compared the professional identities of early-career men and women engineers, especially with large data sets covering several educational institutions (Rodriguez, Lu, and Bartlett 2018). The objective of this study is to understand the professional identities of newly graduated engineers in Finland by analysing their perceptions of professional skills. Based on previous studies, we anticipate that gender has an impact on how early-career engineers perceive the importance and development of professional skills. On the other hand, the field of engineering may also have a significant impact. Therefore, we ask:

Q1. How do the perceived importance and development of professional skills differ between early-career female and male engineers?

Q2. Can the gender differences in Q1 be explained by different gender distributions in various fields of engineering education?

The study uses cross-sectional survey data from the TEK Graduate Survey, collected between January 2018 and December 2019. The TEK Graduate Survey is a joint process organised together by TEK (Academic Engineers and Architects in Finland) and all Finnish universities awarding Master's level university degrees in Engineering and Architecture. All these universities share a process where feedback related to academic study is collected from every student at the time of their graduation. Approximately 80% of all graduates within the scope of the TEK Graduate Survey answer it (in 2018, 83% and in 2019, 76%). The data have not been previously studied extensively with respect to gender differences. In the survey, the respondents can identify their gender as male, female, or other. However, only ten persons identified themselves as 'other' in our data, and thus, their responses were excluded from our analysis.

Information on respondents is presented in Table 1; 76% of the respondents are male and 78.5% are Finnish nationals. The majority were 27–28 years of age at the time of responding to the Graduate Survey. The most common fields of education are IT and Telecom, Electrical and Automation, and Mechanical and Energy Technology.[1] The percentage of female graduates differs considerably between the fields, from 13.9% in Mechanical & Energy to 45.6% in Process & Materials Engineering.

In Finland, university graduates in engineering/technology have gained approximately 1–2 years of relevant work experience during their studies by working alongside experts in companies, with similar tasks and roles but with a lower salary. Typically, students in the master's phase (i.e. with 180 study points or after three years of higher engineering studies) work fulltime during the summer (May–August) and part-time during the semester (September–April), often for the same employer. Thus, the respondents can be considered early-career engineers although they had just received their Master's degree at the time of answering the survey. Nearly 80% of respondents (79% of males and 76% of females) were employed at the time of graduation, with further 2% working as entrepreneurs or freelancers. Furthermore, the respondents on average have 19 months of work experience during their studies of which 13 months are related to their field of study. Interestingly, women on average have two months less work experience compared to men at the time of graduation.

The respondents were asked to rate 29 professional skills items on a Likert scale of 1–6 (1 = Not at all, 6 = Very much) on three aspects: (a) the importance of these items, (b) their development in studies, and (c) their development at work during the studies. The average ratings of the three aspects of the 29 items by gender are presented in Figure 1. In order to assess differences between male and female respondents, Mann–Whitney *U* tests were conducted to identify statistically significant differences. Hedges' *g* values were calculated to estimate the effect size as Hedges' *g* instead of Cohen's *d* is recommended when the groups to be compared are different in size (e.g. Ellis 2010). Pooled standard deviation required for calculating Hedges *g* values was derived from Glen (2020). The results of the Mann–Whitney *U* tests and the Hedges *g* values for all the 29 items are presented in Table 3.

Since our analysis revealed that the difference between male and female respondents is most significant in relation to the *importance* of the 29 items, we conducted a factor analysis (principal components analysis) of the importance scores. Our aim was to identify a more limited number of factors for comparison purposes as well as highlight potential gender differences at a more general level. To

Table 1. Background information of respondents.

	Number (*n*)			Percent (%)		
	Male	Female	Total	Male	Female	Total
Respondents	3133	971	4104	76.3	23.7	100.0
Nationality: Finnish	2488	733	3221	77.2	22.8	100.0
Other EU/ETA country	103	30	133	77.4	22.6	100.0
Country outside of EU/ETA	542	208	750	72.3	27.7	100.0
Year of Birth: Mean	1990	1990	1990			
Median	1991	1992	1992			
Field of Education (Eng./Tech.)						
Mechanical & Energy	617	100	717	86.1	13.9	100.0
Electrical & Automation	735	124	859	85.6	14.4	100.0
IT & Telecom	710	178	888	80.0	20.0	100.0
Process & Materials	318	267	585	54.4	45.6	100.0
Construction & Surveying	296	134	430	68.8	31.2	100.0
Industrial Management	454	165	619	73.3	26.7	100.0

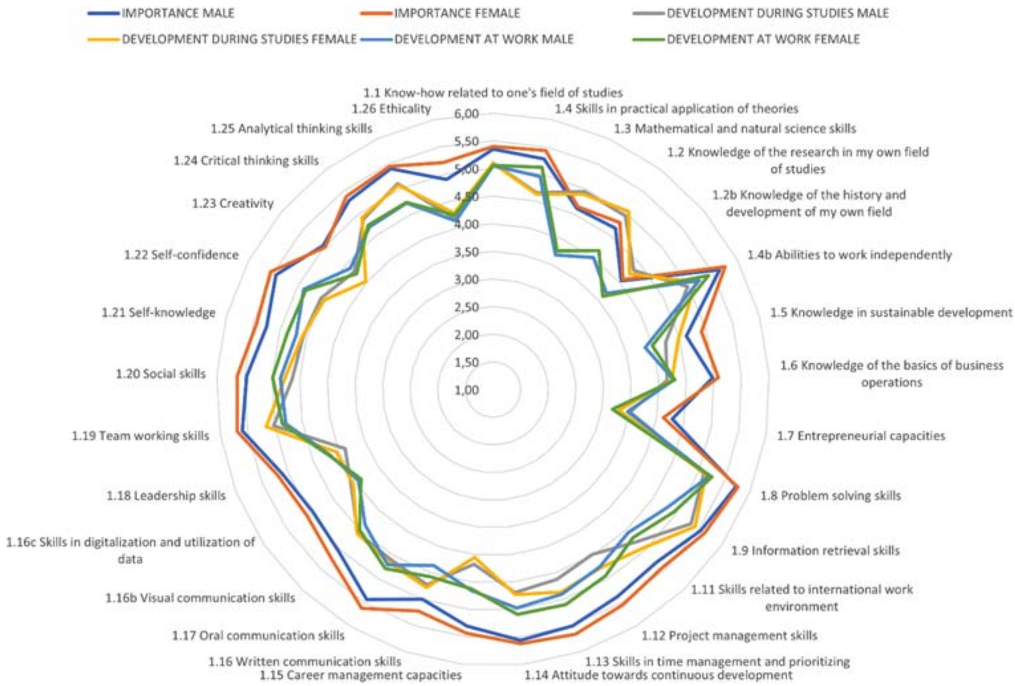

Figure 1. Average of respondents' ratings of the survey items with respect to the three aspects of interest (importance, development in studies, and development at work) by gender.

analyse the suitability of the data for exploratory factor analysis, a correlation matrix of all 29 variables (importance scores) was produced. The level of correlation considered adequate was $r \geq 0.3$ at least with one other variable. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was 0.936 (marvelous), all the KMO measures were higher than 0.9, and Bartlett's test of sphericity was significant ($p < .0005$), and thus, the PCA analysis was deemed appropriate.

The principal components analysis with varimax rotation revealed five components that had eigenvalues greater than one (Model F1). These five components explained 51.4% of the total variance and adding a sixth component increased this to 54.8%. The scree plot showed an inflection point at component 5. However, the rotated component matrix revealed that several variables had high factor loadings on more than one component (cross-loadings). Therefore, another factor analysis (Model F2) was conducted with a fixed number of factors increased to six. The rotated component matrix still showed several cross-loadings. Another factor analysis (Model F3) was then conducted with a fixed number of factors (six) and with a different rotation method (Oblimin). In this model, the variables fitted sufficiently well into the six components. Therefore, we decided to proceed with F3, although the variance explained (55%) is somewhat lower than recommended in the literature (<60%, see, for example, HairJr et al. 2014), and the sixth component has an eigenvalue lower than 1 (0.98).

To evaluate the internal consistency of the identified six factors, Cronbach's *alpha* was used. The Cronbach's *alpha* values range from 0.65 to 0.84, and thus, the internal consistency of the factors was considered adequate. Results of the factor analysis are presented in Table 2. Four items could have been deleted since their loadings are below the 0.5 threshold (as instructed e.g. by HairJr et al. 2014), but we decided to retain them, mainly to keep more items in the analysis. For each factor, we then summated the item scores and divided them by the number of items within the factor to calculate combined means on the original scale (1–6).

To examine the effect of the field of engineering on gender differences, we conducted regression analysis (first, ordinal logistic regression and then, multinomial logistic regression) on the combined

Table 2. Factors (see Appendix for full factor loadings of items).

Factor name	Eigenvalue	% of Variance	Cronbach's alpha
Working life skills	8.75	30.17	0.84
Business and management	2.11	7.29	0.65
Expertise and substance knowledge	1.69	5.69	0.69
Analytical skills	1.32	4.56	0.80
Communication skills	1.07	3.67	0.70
Social skills	0.98	3.38	0.73

mean score for the importance of communication skills, that is, the skills area with greatest gender differences. However, we discovered that the dependent variable did not sufficiently lend itself to a regression analysis and concluded that this is mainly due to its distribution. The respondents gave scores of 1–6 to each item, and there are four items in the factor; thus, the combined means can only gain values of .00, .25, .50, or .75. The cumulated mean scores for the importance of Communication

Table 3. Statistical difference (Mann–Whitney *U* test) and effect size (Hedge's *g*) of the difference between the responses of female and male respondents.

	Importance		Development in studies		Development at work	
Factors and items	M–W sig.	Hedge's g	M–W sig.	Hedge's *g*	M–W sig.	Hedge's g
Analytical Skills	**0.00**	**0.2**	0.37	0.0	0.56	0.0
Self-knowledge	**0.00**	**0.2**	0.39	0.0	**0.00**	0.1
Self-confidence	**0.00**	**0.2**	0.19	−0.1	0.23	0.0
Creativity	**0.00**	−0.1	**0.00**	**−0.2**	**0.00**	−0.1
Critical thinking skills	**0.00**	0.1	0.45	0.0	0.58	0.0
Analytical thinking skills	0.20	0.1	0.43	0.0	0.87	0.0
Ethicality	**0.00**	***0.3***	0.03	0.1	0.06	0.1
Business and management skills	**0.01**	0.1	0.44	0.0	0.28	0.0
Knowledge in sustainable development	**0.00**	***0.3***	**0.00**	**0.2**	0.02	0.1
Knowledge of the basics of business operations	0.88	0.1	0.12	0.1	0.54	0.0
Entrepreneurial capacities	0.65	−0.1	**0.00**	−0.1	**0.00**	**−0.2**
Communication skills	**0.00**	***0.3***	0.27	0.0	0.05	0.1
Written communication skills	**0.00**	***0.3***	0.16	0.0	**0.00**	**0.2**
Oral communication skills	**0.00**	***0.3***	0.10	0.1	0.16	0.1
Visual communication skills	**0.00**	**0.2**	0.37	0.0	**0.01**	0.1
Skills in digitalisation and utilisation of data	0.94	0.1	0.48	0.0	0.23	0.0
Expertise And Substance Knowledge	**0.00**	0.1	0.65	0.0	0.39	0.1
Know-how related to my own field of studies	**0.00**	0.1	0.74	0.0	0.76	0.0
Skills in practical application of theories	**0.00**	**0.2**	0.40	0.0	**0.00**	0.1
Mathematical and natural science skills	**0.00**	0.0	0.42	−0.1	0.17	0.1
Knowledge of the research in my own field of studies	**0.00**	0.1	**0.00**	0.1	**0.01**	0.1
Knowledge of the history and development of my own field	**0.00**	0.0	0.05	−0.1	0.11	−0.1
Social skills	**0.00**	**0.2**	**0.00**	**0.2**	0.08	0.1
Leadership skills	0.03	0.1	**0.00**	0.1	0.91	0.0
Team working skills	**0.00**	0.1	**0.00**	0.1	0.23	0.1
Social skills	**0.00**	**0.2**	**0.00**	0.1	**0.00**	0.1
Working life skills	**0.00**	**0.2**	**0.00**	**0.2**	0.00	**0.2**
Abilities to work independently	**0.00**	**0.2**	**0.00**	**0.2**	**0.00**	**0.2**
Problem-solving skills	0.07	0.1	0.12	0.0	0.54	0.0
Information retrieval skills	**0.00**	0.1	**0.00**	0.1	**0.00**	0.1
Skills related to international work environment	**0.00**	**0.2**	**0.00**	0.1	**0.01**	0.1
Project management skills	**0.00**	**0.2**	**0.00**	***0.3***	**0.00**	**0.2**
Skills in time management and prioritising tasks	**0.00**	**0.2**	**0.00**	**0.2**	**0.00**	**0.2**
Attitude toward developing one's skills in working life	**0.00**	0.1	0.19	0.0	**0.01**	0.1
Career management capacities	**0.00**	**0.2**	0.02	−0.1	0.46	0.0

Note: Statistically significant differences and effect sizes equal to or greater than 0.2 are given in bold. The effect sizes equal to or greater than 0.3 are also italicised.

Skills are far from evenly distributed (the range is 1.75–6.00) and cluster around the high end: almost 20% of women and 13% of men give the highest score (6) to all four items in this factor, as their combined mean score is 6.00.

The regression analysis indicated that besides gender, the field of engineering may have an impact on the importance scores of Communication Skills. We thus analysed the combined mean scores for the importance of Communication Skills by cross-tabulating them by field of engineering and furthermore by gender for selected fields (discussed further in the Results section).

Results

The average of respondents' ratings of the survey items with respect to the three aspects of interest (importance, development in studies, development at work) by gender are illustrated in Figure 1, and the statistical significance and effect size of the difference are presented in Table 3. Figure 1 shows that, in general, the gender differences in the perceptions of graduates are small. With most of the items, the perception of the development of the respective skill both during the studies and the employment is rated lower than the perceived importance. The only exceptions to this are the items Mathematical and natural science skills, Knowledge of the research in my own field of studies, and Knowledge of the history and development of my own field, where the development during the studies was rated higher than or equal to the perceived importance. This applied to both female and male respondents.

Our analysis revealed that the difference between male and female respondents is most significantly related to the importance of the 29 items. The statistically significant differences between female and male respondents are indicated in bold in Table 3. The factor analysis (PCA) of the importance scores identified six factors as explained in the Methods section. The combined means of the identified factors are presented in Table 4.

The effect sizes indicate that the greatest gender differences (Hedge's *g* 0.3) lie in the perception of the importance of ethicality, knowledge in sustainable development, and the written and oral communication skills. All of these are perceived more important by females than males. To a slightly lesser extent (Hedge's *g* 0.2) we can see gender differences in the importance of self-knowledge and self-confidence, visual communication skills, skills in the practical application of theories, social skills, abilities to work independently, international skills, time management and prioritising, and career management capacities. All of these were perceived as more important by women than men. Women graduates perceive their project and time management skills, knowledge in sustainable development, and independent working abilities to have developed better during the studies than men do, whereas men see that the studies have developed their creativity more often than women do. Working life seems to support the development of men's entrepreneurial capacities and women's writing skills as well as women's ability to work independently and manage projects and time.

The factorised results presented in Table 4 show that all the combined *importance* scores of women are higher than those of men and that these differences are statistically significant. The

Table 4. Results of factor analysis: Combined means (scale: 1–6).

	Importance		Development during studies		Development at work	
	Male	Female	Male	Female	Male	Female
Communication skills	**5.10**	**5.28**	4.49	4.52	4.33	4.44
Social skills	**5.39**	**5.50**	**4.51**	**4.65**	4.60	4.68
Business and management	**4.63**	**4.72**	3.98	4.02	3.87	3.83
Expertise and substance knowledge	**4.79**	**4.87**	4.79	4.78	4.27	4.32
Working life skills	**5.50**	**5.61**	**4.78**	**4.90**	**4.88**	**5.01**
Analytical skills	**5.23**	**5.35**	4.60	4.57	4.58	4.62

Note: Statistically significant differences (according to the Mann–Whitney *U* tests) are given in bold.

highest combined importance score for females is Working life skills (5.61), followed by Social skills (5.50). These are also the highest importance scores for males, although their scores are lower (5.50 and 5.39). Based on previous studies, we anticipated even a more significant difference between men and women pertaining to the importance of Social Skills. Although the difference is significant (0.11 units), it is similar to the difference between other scores, which mostly range between 0.9 and 0.12 units. Nonetheless, our analysis reveals that the difference between women and men in the importance score of Communication skills (women 5.28 and men 5.10), though moderate (Hedges g value = 0.3), is still higher than for any other factor.

The combined scores for *development of skills during studies* differ less than the importance scores. While for most factors the scores for men and women are very close, the scores for Social Skills and Working Life Skills show a clear difference between men and women, which is also statistically significant. On the other hand, the combined scores for *the development of skills at work* reveal that women experience more strongly than men that their Working Life Skills have developed while working (women 5.01, men 4.88). The scores for females are clearly higher also for Communications skills (women 4.44, men 4.33) and Social skills (women 4.69, men 4.60), indicating that women more often consider that these skills have developed while working.

To examine the effect of the field of engineering/education on the observed gender differences, we analysed the combined mean scores for the importance of Communication Skills by cross-tabulating them by field of education. This analysis revealed that the results of those graduating from Industrial Management differ most from the others. Therefore, we further cross-tabulated these results by gender and selected the field with most females (Process and Materials Engineering) for comparison purposes. Our aim is to shed light on whether gender or field of education impacts the importance scores of Communication Skills more.

The cross-tabulation of the combined mean scores for the importance of Communication Skills by field of education and gender reveals interesting differences, as shown in Figure 2. Women who have graduated from Industrial Management consider Communications Skills clearly more important than men in the same field or women graduating from Process and Materials Engineering, and far more important than men graduating from Process and Materials Engineering. This difference is

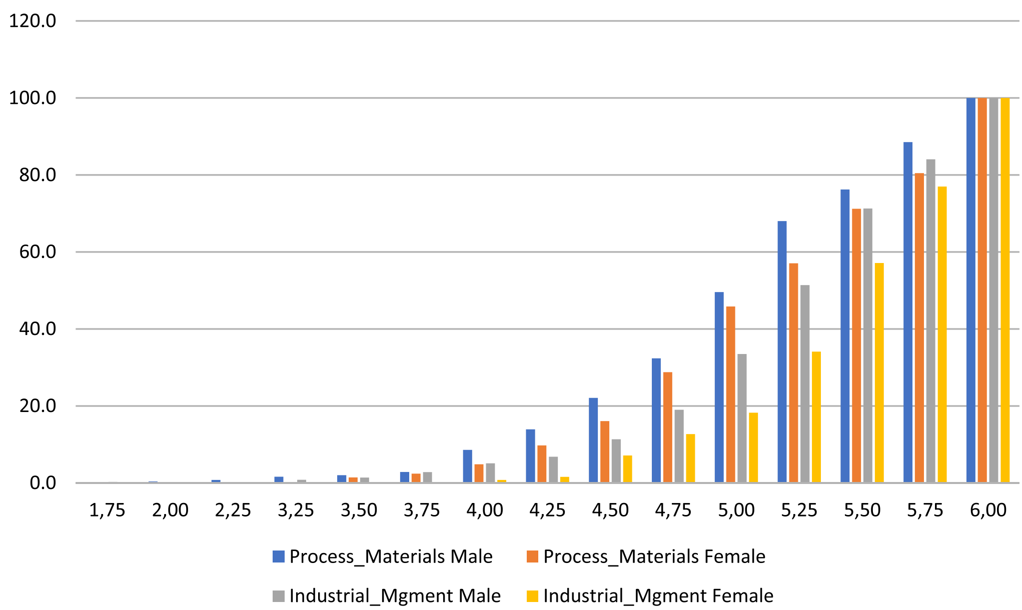

Figure 2. Combined mean scores (cumulative) for importance of Communication Skills by gender and field of education (Process & Materials Engineering and Industrial Management).

particularly stark for importance scores between 4.75 and 5.25 but evens out when reaching the highest scores (5.75 and 6.00).

Discussion

Although the gender differences, in general, were smaller than we anticipated, the noted differences fit quite well the observations and explanations in international literature suggesting that the challenges related to the professional identity development of female engineers in Finland are rather similar to experiences of female engineers elsewhere in the world. However, the actual gender differences in the data as well as the effect sizes of the statistically significant differences were relatively small, and therefore, caution is required in drawing conclusions from this analysis.

The major difference is found in perceived importance related to communication skills, which women more than men felt to be important in engineering. Gender differences in perception of the role of written communication in engineering work have been suggested to contribute to the attrition of women from engineering careers (Mallette 2017). Moreover, if engineering work is framed through a technical/social dualism, communication is often considered a management issue and thus not relevant or central for 'real' engineering (Trevelyan 2010) as the more heterogeneous and networked engineering identity is overpowered by the highly technical view of the profession (Faulkner 2007; Faulkner 2009). At the end of their studies, women perceive the value of social and altruistic aspects, such as ethicality and sustainability, higher than men. These aspects, however, are not considered that important by academics (Pyrhönen, Niiranen, and Pajarre 2019), which may result in a culture of disengagement (Cech 2014). All of this is likely to weaken female students' development of career-fit confidence (Cech et al. 2011) during their studies.

Women also perceive the management skills, such as project management and time management skills, and self-management skills, such as self-knowledge and self-confidence, more important than men do and report more frequently than men that both the studies and the work experience have developed their management skills. Cech (2015, 69) discovered that engineers whose 'professional identities emphasize managerial/communication skills are more likely to intend to seek out different professional paths'. Cardador (2017) explains this phenomenon with the inverted role hierarchy in engineering, which makes female engineers in managerial roles question their status as engineers. This could mean that the risk of exiting the engineering career path is greater for women than for men also in Finland. Parallel to the managerial skills, female graduates also rate the importance and development of independent working abilities higher than male graduates. This suggests that also in Finland the women's role in team and project work during the studies may often end up being more administrative than technical, and women's response to the situation is not to attempt to change the situation or the dynamics but to develop their own skills and strategies accordingly (Seron et al. 2016). However, the emphasis put on abilities to work independently may also signal devaluation of teamwork and thus diminish the valuation of management and social skills in the professional image of engineering. This can affect both the expertise confidence and career-fit confidence of female graduates.

Perhaps somewhat surprisingly, women also perceive the skills in practical application of theories more important than men. In previous literature, tinkering experiences and interests have been noted to be closely connected to boys and their motives to enter engineering (see, e.g. Du 2006), whereas girls' lack of practical experiences has been identified as one of the great challenges of women studying engineering (Godfrey 2007). It is plausible that the lack of tinkering skills and experiences prior to engineering studies, and the difficulties resulting from it, cause the women to appreciate and emphasise these skills more than men. At the same time, there is no difference in the perception of the development of these skills. Hence, the gap between the perceived importance and development is larger for females than males, which may result in weaker career-fit confidence.

The gender differences regarding the development of different skills are even smaller than the differences in perceived importance, and most of the differences are statistically not significant or have a very small effect size. Nevertheless, some differences arise. In addition to the previously noted development of independent working abilities and management skills, women also perceived the development of their social skills during the studies, knowledge in sustainable development, and the development of their written communication skills at work to be better than men did. Men, on the other hand, felt more than women that the studies had enhanced their creativity and that the work experience improved their entrepreneurial capacities. In the light of Trevelyan and Williams (2019) observation about technological innovations being seen as the principle site of value creation in engineering and Trevelyan's (2010) explication of social aspects considered peripheral by engineers, it seems that the studies and working life help men to develop better the skills considered central for engineering, whereas the skills women develop more may not be seen professionally so important. This again illustrates potential challenges facing female engineers in terms of career-fit confidence.

A closer look at the communication skills shows that there are differences in the perceived importance between different fields of engineering. However, comparing women and men within the same field reveals that the gender differences remain similar and women perceive the communication skills more important than men. This indicates that even if some of the difference could be explained by the field of engineering, it does not explain the whole difference. Nonetheless, our data and methods did not yield sufficient proof of interactions between gender, field of engineering, and aspects of professional identity, and the issue needs to be studied further.

Conclusions

We conclude that small gender differences exist related to the perceived importance and development of professional skills between early-career women and men engineers in Finland. The observed differences are greater with respect to perceived importance than perceived skill development. Early-career women perceive the importance of social and altruistic aspects, such as communication, ethics, and sustainability, as greater than men do. Yet, earlier studies suggest that even in Finland the engineering education emphasises the technical aspects and downplays the human interface of engineering work. This can be suspected to pose a challenge especially to the development of female engineering students' career-fit confidence.

Our results suggest that the professional identity of female early-career engineers emphasises the heterogeneous and networked engineering practice more than does the professional identity of men, which relies more on the technical view of engineering. As men perceive the development of their skills related to technical innovations, such as creativity and entrepreneurial capacities, to be better than women do, and women perceive both the importance and development of their managerial skills to be higher than men do, the career paths are more likely to take men into more technical and women to more managerial roles. Hence, in the current engineering working culture, women have a greater risk of being devalued as engineers during their career if they choose to follow their personal interests.

Although the field of engineering may have some effect on the perception of needed and acquired skills, our research indicates that the observed gender differences cannot be fully explained by the different gender distribution in various fields of engineering. All this together implies that female Finnish early-career engineers may be under a greater risk of dropping out of the engineering career than their male counterparts. This is an alarming possibility, which warrants further investigation.

Note

1. Note that graduates majoring in Architecture were excluded from this study although they participate in the Graduate Survey.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix

Table A1. Factor analysis results: Factors, included items and full factor loadings.

	Name of factor (eigenvalue, % of variance, Cronbach's alpha)					
	Working Life Skills (8.75, 30.17, 0.84)	Business and Management (2.11, 7.29, 0.65)	Expertise and Substance Knowledge (1.65, 5.69, 0.69)	Analytical Skills (1.32, 4.56, 0.80)	Communication Skills (1.07, 3.67, 0.70)	Social Skills (0.98, 3.38, 0.73)
1.8 Problem-solving skills	**0.765**	−0.089	0.110	−0.005	−0.010	0.007
1.13 Skills in time management and of prioritising tasks	**0.631**	0.055	0.027	−0.024	0.098	0.140
1.9 Information retrieval skills	**0.618**	−0.002	0.076	−0.137	0.030	−0.115
1.4b Abilities to work independently	**0.612**	−0.071	0.143	0.013	−0.006	−0.001
1.14 Attitude towards developing own skills in working life	**0.586**	0.078	−0.015	−0.188	−0.019	0.088
1.12 Project management skills	**0.552**	0.235	0.003	0.075	0.054	0.209
1.11 Skills related to international work environment (including language skills)	**0.454**	0.205	−0.077	−0.069	0.182	−0.049
1.15 Career management capacities	**0.448**	0.147	−0.001	−0.136	0.057	0.201
1.5 Knowledge in sustainable development	−0.009	**0.645**	0.166	−0.212	−0.078	−0.008
1.7 Entrepreneurial capacities	0.126	**0.637**	−0.090	0.100	0.220	0.025
1.6 Knowledge of the basics of business operations	0.352	**0.587**	−0.129	0.116	0.003	0.245
1.2b Knowledge of the history and development of my own field	−0.121	0.449	**0.445**	−0.125	0.019	−0.106
1.1 Know-how related to my own field of studies	0.104	−0.067	**0.743**	0.057	−0.022	0.182
1.4 Skills in practical application of theories	0.266	−0.106	**0.695**	0.069	−0.017	0.068
1.2 Knowledge of the research in my own field of studies	−0.180	0.221	**0.538**	−0.160	0.203	−0.137
1.3 Mathematical and natural science skills	0.103	0.126	**0.447**	−0.092	0.137	−0.280
1.24 Critical thinking skills	0.103	−0.078	0.043	**−0.723**	0.058	−0.013
1.25 Analytical thinking skills	0.291	−0.192	−0.024	**−0.633**	0.143	−0.147
1.21 Self-knowledge	0.066	0.125	−0.014	**−0.628**	−0.055	0.278
1.23 Creativity	−0.079	0.068	−0.011	**−0.575**	0.257	0.034
1.26 Ethicality	−0.048	0.355	0.057	**−0.529**	0.014	0.035
1.22 Self-confidence	0.104	0.017	0.054	**−0.520**	−0.032	0.418
1.16b Visual communication skills	−0.070	−0.048	0.045	−0.083	**0.748**	0.159
1.16 Written communication skills	−0.046	0.029	0.125	−0.088	**0.637**	0.044
1.16c Skills in digitalisation and utilisation of data	0.213	0.057	−0.098	−0.001	**0.634**	−0.181
1.17 Oral communication skills	0.062	−0.073	0.086	−0.005	**0.559**	0.449
1.20 Social skills	0.118	0.050	0.005	−0.192	0.060	**0.659**
1.19 Team working skills	0.237	−0.076	0.101	−0.130	0.099	**0.555**
1.18 Leadership skills	−0.006	0.274	0.011	−0.003	0.247	**0.544**

Note: Extraction Method: Principal Component Analysis. Rotation Method: Oblimin with Kaiser Normalization.

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Susanna Bairoh & Sanna Putila

”Pätevät naiset eivät etene” vai ”naisia suositaan”? Sukupuoleen perustuvan syrjinnän ristiriitaiset kokemukset tekniikan korkeakoulutettujen työpaikoilla

Tiivistelmä

Tarkastelemme artikkelissamme naisten ja miesten kokemuksia sukupuoleen perustuvasta syrjinnästä tekniikan korkeakoulutettujen työpaikoilla. Aiemmat tutkimukset tekniikan alalla ovat selvittäneet naisten kokemaa syrjintää, mutta miesten kokemukset ovat jääneet pitkälti näkymättömiksi. Aineistomme koostuu syrjintää koskevista kysymyksistä tekniikan alan ammattiliiton toteuttamissa kahdessa selvityksessä: vuonna 2015 toteutetussa laajassa jäsentutkimuksessa sekä vuonna 2020 toteutetussa otostutkimuksessa. Tuloksemme todentavat aikaisempien tutkimusten mukaisesti naisten tekniikan alalla kohtaaman syrjinnän mutta tuottavat uutta tietoa sen yleisyydestä ja ilmenemismuodoista. Aineistomme osoittaa, että naisten kokema syrjintä liittyy vahvasti työpaikoilla vallitsevaan maskuliiniseen kulttuuriin. Rinnalle nousevat miesten kokemukset naisten suosimisesta, jotka myös liitämme tekniikan alalla vallitsevaan maskuliinisuusnormiin. Johtopäätöksenä esitämme, että maskuliinisuuden ensisijaisuus tekniikan alalla aiheuttaa naisten syrjintää ja toisaalta maskuliinisen etuoikeuden purkaminen synnyttää miehissä syrjinnän kokemuksia. Tarvittavan kulttuurimuutoksen onnistumisen edellytys on tasa-arvoon ja syrjintään liittyvien sukupuolten välisten näkemyserojen tunnistaminen ja tunnustaminen.

Johdanto

Suomessa tekniikan alalla työskentelevistä noin joka viides on nainen. Sukupuolten eroa tekniikan koulutukseen ja työpaikkoihin hakeutumisessa on selvitetty lukuisissa kansainvälisissä tutkimuksissa viime vuosikymmeninä, mutta miesenemmistöisyys on säilynyt sitkeästi (esimerkiksi Blickenstaff 2005; Jansson & Sand 2021; Kanny ym. 2014). Suomessa insinöörikoulutukseen hakeutuvien naisten osuus on OECD-maiden ja Pohjoismaiden alhaisimpia: vain 18 prosenttia aloittavista insinööriopiskelijoista on naisia, kun Norjassa osuus on 24, Ruotsissa 29 ja Tanskassa 30 prosenttia (Keski-Petäjä & Witting 2018).

Maskuliininen kulttuuri on todettu merkittäväksi esteeksi sukupuolten tasa-arvon toteutumiselle tekniikan alalla (Faulkner 2011; Jansson & Sand 2021; Powell & Sang 2015). Maskuliinisen kulttuurin piirteiksi on aikaisemmassa tutkimuksessa tunnistettu naisiin liitetyt (kielteiset) stereotypiat, alalle kuulumisen kyseenalaistaminen, osaamisen epäileminen ja urakehityksen haasteet (Cheryan ym. 2017). Vaikka tekniikan alalla tuntuisi olevan tilaa monenlaisille miehille (Faulkner 2009), alan kulttuuri näyttää noudattavan melko kapeaa maskuliinista normia, joka uusintaa sukupuolten hierarkiaa ja osaamisen eriarvoisuutta sekä heikentää naisten viihtyvyyttä (esim. Faulkner 2009; Jansson & Sand 2021; Kaukonen 2020).

Suomessakin naisten määrän lisäämiseen tekniikan alalla tähtäävät kampanjat ja hankkeet, kuten WomenInTechFi ja MimmitKoodaa, ovat suosittuja alan yrityksissä. Voidaan kuitenkin kysyä, missä määrin niissä tartutaan sukupuolieron juurisyihin (vrt. Jansson & Sand 2021). Sukupuolten tasa-arvoa lisäävät toimet eivät myöskään saa varauksetonta kannatusta. Esimerkiksi kun IT-yhtiö TietoEVRY maaliskuussa 2021 ilmoitti tavoittelevansa naisten osuuden kasvattamista 50 prosenttiin henkilöstöstään, nostettiin Kauppalehdessä esiin huoli miehiin kohdistuvasta syrjinnästä (Vehkaoja 2021).

Tutkimuksessamme tarkastelemme sukupuoleen perustuvaa syrjintää suomalaisilla tekniikan korkeakoulutettujen työpaikoilla. Sukupuolen merkitystä tekniikan alalla käsittelevissä tutkimuksissa on harvoin tarkasteltu syrjinnän yleisyyttä työpaikoilla; miesten kokemaa syrjintää ei ole tutkittu juuri lainkaan. Tällä tutkimuksella pyrimme osaltamme paikkaamaan tätä aukkoa.

Luomme aluksi katsauksen sukupuolisyrjintää käsittelevään aikaisempaan tutkimukseen. Sitten käsittelemme erityisesti kriittiseen perinteeseen pohjaavaa teoriaa maskuliinisesta kulttuurista tekniikan alalla. Sen jälkeen esittelemme aineistomme ja siihen pohjautuvat tulokset. Aineistomme perustuu Tekniikan akateemiset TEKin[1] vuonna 2015 ja 2020 toteuttamiin selvityksiin. Hyödynnämme sekä tilastollista että laadullista analyysiä. Keskustelussa pohdimme, mitä tulokset kertovat tekniikan alalla vallitsevasta maskuliinisesta kulttuurista ja sen vaikutuksista syrjinnän kokemuksiin.

Sukupuolittunut syrjintä työelämässä

Suomessa kuten useimmissa muissakin maissa syrjintä on kielletty lailla. Etenkin naisiin ja alle 30-vuotiaisiin kohdistuva syrjintä työelämässä näyttää kuitenkin olevan Suomessa yleisempää kuin monessa muussa Euroopan maassa (Pietiläinen ym. 2018). Pietiläinen ja kumppanit (2018) ovat osoittaneet, että tyypillisimpiä syrjinnän syitä suomalaisilla työpaikoilla ovat suosikkijärjestelmät, työsopimuksen tyyppi, sukupuoli (kohdistuen naisiin) ja ikä. Neljä prosenttia naisista mutta vain 0,4 prosenttia miehistä raportoi sukupuoleen perustuvaa syrjintää työpaikallaan vuonna 2013 (emt.). Työpaikoilla tapahtuva syrjintä on muutoinkin sukupuolittunutta: naiset kokevat ja havaitsevat syrjintää useammin kuin miehet ja raportoivat enemmän syrjinnän kokemuksia kaikissa tilanteissa (Koivunen ym. 2017; Pietiläinen ym. 2018).

Naiset kokevat Koivusen ja kumppaneiden (2017) mukaan Suomessa enemmän syrjintää miesenemmistöisillä kuin naisenemmistöisillä tai tasatyöpaikoilla ja kaikentyyppisillä työpaikoilla enemmän kuin miehet. Myös Kauhanen ja Riukula (2019) ovat todenneet, että naiset kokevat haasteita sukupuolensa takia etenkin miesenemmistöisillä työpaikoilla ja yksityisellä sektorilla niin palkkauksessa, uralla etenemisessä kuin ammattitaidon arvostuksessakin. Lisäksi perhe haittaa yhä naisten työmarkkinatilannetta enemmän kuin miesten. Koivusen ja kumppaneiden (2017) mukaan miesenemmistöisillä työpaikoilla naisia ja heidän tekemäänsä työtä saatetaan pitää vähemmän tärkeänä, mikä voi johtaa syrjintään ja eriarvoisuuteen.

1 TEK on diplomi-insinöörien, arkkitehtien ja vastaavan tekniikan tai luonnontieteen yliopistokoulutuksen saaneiden etu- ja palvelujärjestö. Katso lisää: www.tek.fi

Miesenemmistöisillä työpaikoilla korostuu Kupiaisen (2019) mukaan puhetavoissa sukupuolen merkityksen vähättely, mutta osaajia ja osaamista käsitteleviä puhetapoja sävyttää vahva miesnormatiiviisuus. Kupiaisen (2019, 166–167) sanoin: ”Jos sukupuolistuneet oletukset ja käsitykset jäävät tiedostamatta ja käytäntöinä paikantamatta, ammatillisen osaamisen relevanttiudesta joudutaan neuvottelemaan sekä tilanteisesti että pitkällä ajanjaksolla, ehkä koko työuran, jos osaaminen ei sovi vakiintuneeseen käsitykseen työn ja alan asiantuntijasta.” Kauhasen ja Riukulan (2019) mukaan tiedostamattomat asenteet ja uskomukset vaikuttavat esimerkiksi naisten työsuoritusten arviointiin, mikä osaltaan selittää naisten kokemusta työpanoksen vähemmästä arvostuksesta.

Naisia tekniikan ja luonnontieteen aloilla käsittelevissä valtavirran tutkimuksissa on esitetty, että syrjintä ei enää selitä naisten aliedustusta (esim. Ceci ym. 2014). Toisten tutkimusten mukaan taas naisiin kohdistuva syrjintä on laajaa ja ilmeistä (Cheryan ym. 2017). Cheryanin ja kumppaneiden (2017) tarkastelemissa tutkimuksissa syrjinnän todetaan aiheuttavan naisille esteitä, joita heidän mieskollegansa eivät kohtaa. Viitteitä naisten ja miesten eriarvoisesta kohtelusta löytyykin myös määrällisistä tutkimuksista. Vuorinen-Lampila (2016) on osoittanut uralla etenemisessä merkittäviä sukupuoleen perustuvia eroja tekniikan ja kaupan alalta valmistuneiden joukossa, miesten hyväksi: kolme vuotta valmistumisen jälkeen miehillä oli naisia useammin kokoaikainen vakituinen työ, ja he olivat edenneet organisaatioissaan korkeampiin asemiin. Holth ja kumppanit (2013) ovat esittäneet vastaavia tuloksia Ruotsista: IT-alalta valmistuneet työllistyivät yhtä hyvin heti valmistumisen jälkeen, mutta miehet etenivät naisia useammin korkeampiin asemiin. Naisten teknisen osaamisen alihyödyntämistä voidaan pitää rakenteellisen syrjinnän muotona, ja se sisältää myös riskin miesten ja teknologian ja erityisesti miesten ja tietoteknisen osaamisen vahvan yhteyden uusintamisesta (emt.).

Maskuliininen insinöörikulttuuri

Kriittisiä feministisiä näkökulmia hyödyntävät tutkijat ovat todenneet, että maskuliininen kulttuuri muodostaa merkittävän esteen sukupuolten tasa-arvon toteutumiselle tekniikan alalla (esim. Faulkner 2011; Jansson & Sand 2021). Maskuliinisen kulttuurin piirteisiin kuuluvat naisiin liitetyt (kielteiset) stereotypiat, naisten alalle kuulumisen kyseenalaistaminen ja osaamisen epäileminen sekä näihin liittyvät haasteet urakehityksessä (Cheryan ym. 2017). Cheryan ja Markus (2020) puhuvat miesenemmistöisillä aloilla vallitsevista maskuliinisuusoletuksista (*masculine defaults*): näitä piirteitä on kulttuureissa, jotka arvostavat, palkitsevat tai pitävät normaaleina, neutraaleina tai tarpeellisina miehiin yhdistettyjä luonteenpiirteitä tai käytöstapoja. Koska maskuliinisuusoletukset perustuvat ”valkoisiin” heteroseksuaalisiin miehiin, ne rajoittavat myös etnisiin vähemmistöihin tai seksuaalivähemmistöihin kuuluvia miehiä (emt).

Insinöörikulttuuri perustuu maskuliinisuuden ja teknologian vahvaan kytkökseen, jota uusinnetaan eri tavoin (esim. Jansson & Sand 2021). Faulkner (2000) kuvaa tätä muun muassa käsitteellä ”teknisyyden/sosiaalisuuden dualismi”: teknisyys ja sosiaalisuus käsitetään toisensa poissulkevina, miehiä ja naisia pidetään erilaisina ja sosiaalisuus liitetään naisiin ja feminiinisyyteen, joten ”tekninen nainen” on käsitteenä kummajainen (myös Tassabehji ym. 2021). Naisten ja miesten erilaisuutta korostava kulttuuri heijastuu myös mahdollisuuksiin toimia sukupuolelle sopivalla tavalla (*gender in/authenticity*) (Faulkner 2011). Insinöörinä työskentely ja innostuminen teknologiasta nähdään sopivana (maskuliinisille) miehille mutta epäsopivana naisille (Faulkner 2011) sekä sukupuoli- ja seksuaalivähemmistöille (Leyva ym. 2016).

Tekniikan alan maskuliinista kulttuuria on kuvattu hyytäväksi tai jopa naisille vihamieliseksi. Wynnin ja Correllin (2018) mukaan hyytävän kulttuurin piirteitä ovat muun muassa avoimen seksuaaliset viitteet, stereotyyppiset kuvastot, miesten ja maskuliinisuuden korostaminen, naisten poissulkeminen tai vähätteleminen ja naisten vähäinen määrä. Osoittaakseen kuuluvansa maskuliinisuuden leimaamille työpaikoille naisten täytyy usein kontrolloida feminiinisyyttään (Johansson ym. 2020) ja soveltaa erilaisia sopeutumisstrategioita, joita ovat esimerkiksi esiintyminen ”yhtenä jätkistä” ja sukupuoleen perustuvan syrjinnän hyväksyminen (esim. Powell ym. 2009). Myös alalla työskentelevät naiset omaksuvat insinöörikulttuurin, jota leimaa vahvasti individualismi ja usko meritokratiaan (Seron ym. 2018). Aikaisempien tutkimusten mukaan naiset yrittävät jättää syrjinnän ja kielteiset asenteet taakseen osoittamalla pätevyytensä insinööreinä ja uskovat, että lopulta heidän sukupuolensa menettää merkityksensä (esim. Powell ym. 2009; Powell & Sang 2015). Insinöörin ammatti-identiteetin omaksuminen laimentaa Seronin ja kumppaneiden (2018) mukaan jopa omat, tunnistetut syrjinnän kokemukset ja ulkopuolisuuden tunteen.

Miesten on helpompaa kokea tekniikan ala omakseen, eikä heidän osaamistaan jatkuvasti kyseenalaisteta. Faulkner (2009) esittää, että insinöörien työpaikoilla on tilaa monenlaisille maskuliinisuuksille ja että ne näin ollen sopivat valtaosalle miehistä, vaikka "hegemonista maskuliinisuutta" ilmentävät miehet sopivatkin helpoimmin joukkoon. Galean ja Chappelin (2021) mukaan miesenemmistöisillä aloilla vallitseva maskuliininen kulttuuri tuottaa miehille etuoikeutetun aseman. Etuoikeuden olemukseen kuuluu, ettei sitä tunnisteta eikä sitä tuottavia järjestelmiä kyseenalaisteta, joten etuoikeuden kyseenalaistaminen johtaa useimmiten vastustukseen (emt.). Maskuliinisen kulttuurin vaikutuksia miehiin – varsinkin enemmistöön kuuluviin miehiin – on kuitenkin tekniikan alalla tutkittu melko vähän. Tassabehji ja kumppanit (2021) tunnistivat ohjelmistokehittäjien puheesta kaksi maskuliinisuuden ilmentymää, koodaajat ja ideaalit ohjelmistokehittäjät, ja yhden feminiinisyyden ilmentymän: ihmisen. Maskuliinisuus on useimmiten näkymätöntä (Johansson ym. 2019), ja miehet esiintyvät tutkimuksissa epäsuorasti, viitteinä naisten kommenteissa (Tassabehji ym. 2021).

Aineisto ja menetelmät

Tarkastelemme tutkimuksessamme sukupuoleen perustuvaa syrjintää suomalaisilla tekniikan korkeakoulutettujen työpaikoilla. Selvitämme syrjinnän yleisyyttä sekä miesten ja naisten kokemuksia. Erityisesti meitä kiinnostaa se, miten insinöörikulttuurin maskuliinisuus ilmenee naisten ja miesten syrjinnän kokemuksissa.

Tutkimuskysymyksemme ovat seuraavat:

1. Kuinka yleistä on sukupuoleen perustuva syrjintä tekniikan korkeakoulutettujen työpaikoilla?
2. Millaisia sukupuoleen perustuvan syrjinnän kokemuksia tekniikan korkeakoulutetuilla on, ja miten kokemukset eroavat sukupuolen mukaan?
3. Miten tekniikan alan maskuliininen kulttuuri näyttäytyy syrjinnän kokemuksissa?

Tutkimuksen aineisto perustuu kahteen Tekniikan akateemiset TEKin toteuttamaan selvitykseen, jotka sisältävät sekä määrällistä (numeerista) että laadullista (avoimet kommentit) aineistoa. Avoimia kommentteja annettiin molemmissa kyselyissä kolmella kielellä (suomi, ruotsi, englanti). Olemme kääntäneet kaikki artikkelissa esitettävät kommentit suomeksi.

Aineisto 1: Tekniikan akateemisten jäsenkysely toteutetaan vuosittain web-kyselynä. Vuonna 2015 kysyttiin useiden muiden teemojen lisäksi jäsenten kokemasta syrjinnästä. Kyselyn linkki lähetettiin kaikille työssäkäyville jäsenille (noin 40 000 henkilöä) loka–marraskuussa 2015, ja vastausprosentti oli 25. Vaikka vastausprosenttia voidaan pitää alhaisena, on kyselyn vastaajamäärä suuri ja työssäkäyviä jäseniä hyvin edustava, joten tuloksia voidaan pitää luotettavina ja yleistettävinä. Valitsimme mukaan vastaajat, joilla oli tekniikan alan maisterin tutkinto, filosofian maisterin tutkinto vastaavilta aloilta (luonnontieteet, matematiikka, tietojenkäsittely) tai jatkotutkinto (lisensiaatti tai tohtori) näiltä aloilta. Vastaajia oli 10 671, ja heistä miehiä oli 77 prosenttia (n = 8 266) ja naisia 23 prosenttia (n = 2 405). Vastaajan sukupuoli määräytyi henkilötunnuksen perusteella ammattiliiton jäsenrekisterin tiedoista. Koska henkilötunnuksessa sukupuoli on binäärinen, aineistossa ei ole mahdollista tarkastella sukupuolivähemmistöjä.

Syrjintää koskeva aineisto, joka on edelleen laajin käytettävissä oleva, koostuu vastauksista seuraaviin kysymyksiin:

a) ”Työelämässä voi ilmetä eriarvoista kohtelua tai syrjintää esimerkiksi palkkauksessa, työhönotossa, uralla etenemisessä, koulutukseen pääsyssä tai irtisanomistilanteissa. Oletko kokenut omassa työorganisaatiossasi (nykyisessä tai aikaisemmassa) viimeisen vuoden aikana syrjintää tai eriarvoista kohtelua, joka perustuu [lomakkeessa lueteltuihin perusteisiin]:” Vastausvaihtoehdot: kyllä / en / ei koske minua. Syrjintäperusteet ja kyllä-vastausten osuudet näkyvät liitteessä 1.
b) ”Kerro mahdollisimman lyhyesti yhdellä tai kahdella sanalla, mihin tilanteeseen syrjintä tai eriarvoinen kohtelu on liittynyt (esim. palkkaus, työhönotto, uralla eteneminen jne.).”
c) ”Kerro halutessasi tarkemmin kokemuksestasi”.

Naisiin ja miehiin sukupuolen perusteella kohdistuva syrjintä yhdistettiin kategoriaksi ”sukupuoleen perustuva syrjintä”. Tarkastelun selkiyttämiseksi ei-omaan sukupuoleen kohdistuvaa syrjintää raportoineet vastaajat (miehistä 201 ja naisista 6) jätettiin pois analyysistä. Lisäksi jätettiin pois vaihtoehdon ” ei koske minua” valinneet sekä puuttuvat vastaukset. Yhdistetyn kategorian mukaiset vastaukset näkyvät ikäluokittain taulukossa 1.

Aineisto 2: Vuonna 2020 toteutettiin otostutkimus, jossa kyselyyn poimittiin 6 268 henkilön satunnaisotos TEKin jäsenrekisteristä (täysjäsenet, opintojen loppupuolella olevat opiskelijat sekä englanninkieliset jäsenet). Kyselyyn vastasi 621 henkilöä (vastausprosentti 10). Sukupuoli kysyttiin vastausvaihtoehdoilla mies (64 %), nainen (34 %), muu (0 %) ja en halua sanoa (2 %). Kyselyllä selvitettiin yhdenvertaisuuden toteutumista työpaikalla, eri vähemmistöryhmien mahdollisuuksia ilmaista identiteettiään, koettua syrjintää, seksuaalista häirintää sekä seksuaali- tai rodullistettuun vähemmistöön kuulumista. Ikäjakaumaltaan ja koulutukseltaan vastaajat edustivat hyvin otosta, mutta naiset olivat yliedustettuja (vastaajista 34 % ja otoksessa 23 %), samoin ruotsinkieliset (vastaajista 19 %, otoksessa arviolta 5 %). Heikko vastausprosentti tulkittiin osoituksena siitä, että tasa-arvo ja yhdenvertaisuus kiinnostavat vain osaa jäsenkunnasta. Lisäksi syrjintää on välillä vaikea tunnistaa, mikä heijastuu myös avoimissa kommenteissa.

Tähän tutkimukseen poimittiin mukaan syrjintää kokeneista vastaajista (n = 87) sukupuolensa kertoneet 84 vastaajaa. Sukupuolivähemmistöjä emme pysty tarkastelemaan, koska kategoriaa ”muu” ei valinnut kukaan vastaajista ja vain kolme ei halunnut ilmoittaa sukupuoltaan. Naisiin ja miehiin sukupuolen perusteella kohdistuva syrjintä yhdistettiin kategoriaksi ”sukupuoleen perustuva syrjintä” ja ikäluokat yhdistettiin vastaajien vähäisen määrän vuoksi kahdeksi luokaksi taulukossa 2 esitetyllä tavalla.

Analysoimme molempia aineistoja tilastollisesti (frekvenssit, ristiintaulukoinnit), ja laadulliseen aineistoon sovellamme lisäksi temaattista analyysiä. Vuoden 2015 jäsenkyselyn datasta poimimme avoimet kommentit (kysymykset b ja c) vastaajilta, jotka olivat kokeneet sukupuoleen perustuvaa syrjintää. Luimme kommentit ja luokittelimme maininnat ensin yksityiskohtaisempiin luokkiin, jotka yhdistimme analyysin edetessä laajemmiksi teemoiksi. Luokittelimme maininnat suhteessa toisiinsa siten, että jos kohdassa b esimerkiksi mainittiin ”palkkaus” ja kohdassa c kuvailtiin tarkemmin palkkaukseen liittyvää syrjintää, laskimme tämän yhdeksi teeman ”palkkaus” maininnaksi. Jos taas kohdassa c kuvailtiin jotakin muuta aihetta, laskimme nämä erikseen. Teemat eivät kuitenkaan ole toisensa poissulkevia, vaan yksi maininta voi kuulua useampaan teemaan. Vuoden 2020 otostutkimuksesta analysoimme sukupuoleen perustuvaa syrjintää kokeneiden kommentit kohtiin

”Kerro halutessasi lisää yhdenvertaisuuden toteutumisesta työyhteisössäsi” sekä ”Kerro halutessasi lisää syrjinnästä tai epäasiallisesta kohtelusta työyhteisössäsi”. Vertailimme näitä jäsenkyselyn aineistosta nousseisiin teemoihin.

Tulokset

Tässä osiossa luomme ensin katsauksen sukupuoleen perustuvan syrjinnän esiintymiseen eri ryhmissä aineistossamme. Sen jälkeen syvennymme sukupuoleen perustuvaa syrjintää raportoineiden avoimiin vastauksiin ja peilaamme niitä teoriassa esitettyihin maskuliinisuusoletuksiin.

Sukupuoleen perustuvan syrjinnän yleisyys

Jäsentutkimuksen 2015 tulokset osoittavat suorastaan valtavan eron miesten ja naisten välillä sukupuoleen perustuvan syrjinnän kokemuksissa. Kaikenikäiset naiset kokevat sukupuoleen perustuvaa syrjintää enemmän kuin miehet: kyllä-vastausten osuudet vaihtelevat 26 ja 32 prosentin välillä, kun miehillä vaihteluväli on 1–4 prosenttia (ks. taulukko 1). Korkea asema työpaikalla ei suojaa syrjinnältä, sillä johtotehtävissä työskentelevistä naisista 28 prosenttia ja keskijohdossa peräti 36 prosenttia raportoi kokeneensa syrjintää. Sektoreiden välillä on kuitenkin selviä eroja: teollisuudessa työskentelevillä naisilla syrjintää kokevien osuus on korkein (36 %) ja yliopistoissa matalin (19 %), kun taas miehet kokevat syrjintää harvimmin teollisuudessa (1 %) ja useimmin valtiosektorilla (6 %). Kaikkien vastaajien osalta sukupuolten ero kyllä-vastauksissa on tilastollisesti erittäin merkitsevä (Pearsonin khiin neliö: $p < .0005$, kaksisuuntainen testi, $df = 1$, $n = 10\,260$).

Taulukko 1. Sukupuoleen perustuvan syrjinnän ja epäasiallisen käytöksen kokemukset sukupuolen mukaan taustamuuttujittain, Jäsentutkimus 2015

		Kyllä-vastausten osuus		Vastaajamäärä (n)	
	Kokenut sukupuoleen perustuvaa syrjintää	**Mies**	**Nainen**	**Mies**	**Nainen**
Ikäluokka	Alle 30 v.	1 %	29 %	701	357
	30–39 v.	1 %	31 %	2968	903
	40–49 v.	2 %	32 %	2407	578
	50–59 v.	3 %	26 %	1674	370
	60 v. tai enemmän	4 %	28 %	541	105
Toimiasema	Johto	2 %	28 %	885	127
	Keskijohto	1 %	36 %	1690	397
	Asiantuntija	2 %	28 %	4496	1489
	Muu	1 %	32 %	177	106
Sektori	Teollisuus	1 %	36 %	3330	690
	Muu yksityinen sektori	2 %	28 %	2874	887
	Yliopisto	4 %	19 %	389	177
	Valtio	6 %	22 %	376	164
	Kunta	3 %	33 %	325	215
Kaikki	*Yhteensä*	*2 %*	*30 %*	*7931*	*2313*

Otostutkimuksessa 2020 syrjintää kertoi kokeneensa 14 prosenttia kaikista vastaajista, 21 prosenttia naisista ja 10 prosenttia miehistä. Syrjintää kokeneilta kysyttiin syrjinnän perusteita. Syrjintää kokeneista naisista 60 prosenttia (n = 45) ja miehistä 21 prosenttia (n = 39) kertoi syrjinnän perustuvan sukupuoleen (ks. taulukko 2). Sukupuolten ero on tilastollisesti erittäin merkitsevä (Pearsonin khiin neliö: $p < .0005$, kaksisuuntainen testi, df = 1, n = 84). Alle 45-vuotiaista syrjintää kokeneista naisista 67 prosentilla ja 45 vuotta täyttäneistä 50 prosentilla syrjintä oli perustunut sukupuoleen, kun miehillä vastaavat osuudet ovat 10 ja 32. Tuloksia ei voida suoraan vertailla vuoden 2015 jäsentutkimuksen kanssa, koska kyseessä on otostutkimus, kysymyksenasettelu on jossain määrin erilainen ja vastaajamäärä on huomattavasti pienempi. Tulokset osoittavat kuitenkin, että naiset kokevat edelleen varsin yleisesti sukupuoleen perustuvaa syrjintää tekniikan työpaikoilla. Toisaalta miesten kokemukset sukupuoleen perustuvasta syrjinnästä näyttävät linkittyvän vanhempaan ikään.

Taulukko 2. Sukupuoleen perustuvan syrjinnän ja epäasiallisen käytöksen kokemukset syrjintää kokeneista sukupuolen ja ikäluokan mukaan, Otostutkimus 2020

	Kyllä-vastausten osuus		Vastaajamäärä (n)	
Kokenut sukupuoleen perustuvaa syrjintää	**Mies**	**Nainen**	**Mies**	**Nainen**
Alle 45 v.	10 %	67 %	20	27
45 v. tai enemmän	32 %	50 %	19	18
Yhteensä	*21 %*	*60 %*	*39*	*45*

Syrjinnän teemat

Jäsenkyselyssä 2015 sukupuoleen perustuvaa syrjintää tai epäasiallista kohtelua kokeneista naisista (696 vastaajaa) 427 kuvaili ainakin lyhyesti kokemuksiaan. Miehistä sukupuoleen perustuvaa syrjintää oli kokenut kaikkiaan 161 vastaajaa, ja heistä 97 kuvaili kokemuksiaan ainakin muutamalla sanalla. Taulukossa 3 on yhteenveto avoimissa kommenteissa yleisimmin esiintyvistä teemoista.

Taulukko 3. Sukupuoleen perustuva syrjintä tai epäasiallinen kohtelu: luokitellut teemat avoimissa kommenteissa, Jäsentutkimus 2015

	Maininnat, naiset	% naisista (n = 427)	Maininnat, miehet	% miehistä (n = 97)	Yhteensä
Urakehitys	137	32 %	19	20 %	156
Kohtelu/käytös	88	21 %	61	63 %	149
Palkkaus	123	29 %	12	12 %	135
Uskottavuus osaajana	110	26 %	0	0 %	110
Työhönotto	36	8 %	14	14 %	50
Työtehtävät	36	8 %	2	2 %	38
Perhevapaa/raskaus/perhesyyt	24	6 %	4	4 %	28

Naisten kommenteissa esiin nousevat erityisesti urakehitys tai uralla eteneminen (137 mainintaa), palkkaus ja palkitseminen (123 mainintaa), uskottavuus osaajana (110 mainintaa) ja kohtelu/käytös (88 mainintaa). Huomiota herättää se, että kun naisilla "uskottavuus osaajana" on kolmanneksi yleisin teema, miesten kommenteista tähän teemaan luokiteltavia mainintoja ei löydy lainkaan. Tarkastelemme urakehitykseen, uskottavuuteen ja eriarvoiseen kohteluun tai käytökseen liittyviä naisten syrjinnän kuvauksia osana maskuliinisen kulttuurin ilmenemistä. Miesten vastauksissa korostuu naisten suosiminen, jonka perusteluna mainitaan myös tasa-arvon tavoittelu organisaatioissa.

Otostutkimuksessa 2020 sukupuoleen perustuvaa syrjintää kokeneista viisi miestä ja seitsemän naista kertoi omasanaisesti kokemuksistaan, ja yhdenvertaisuuden toteutumista työyhteisössään kuvasi neljä miestä ja seitsemän naista. Näissä vastauksissa esiintyvät teemat ovat samantyyppisiä kuin vuoden 2015 jäsenkyselyssä.

Maskuliinisen kulttuurin ilmeneminen

Naiset mainitsivat sekä vuonna 2015 että 2020 urakehityksen kaikkein yleisimmin tilanteena, jossa syrjintää tai epäasiallista kohtelua on tapahtunut. Useimmat jäsenkyselyn 2015 kommentit olivat hyvin lyhyitä ("urakehitys", "uralla eteneminen"). Yksityiskohtaisemmat kommentit uralla etenemisen haasteista sisälsivät usein myös mainintoja eriarvoisesta kohtelusta: (pätevät) naiset eivät pääse etenemään urallaan kuten miehet, vaikka haluaisivat. Johtotehtäviin eteneminen näyttäytyy erityisen haasteellisena.

> *Syrjintä on pääosin uravalintoihin ja vastuutehtäviin liittyvää nuorten miesten uran edistämistä. Noin 30-vuotiaille (urheileville) miehille tarjotaan etenemismahdollisuuksia niin avoimesti kuin tiskin alta. Naiset eivät tule yleensä valituiksi edes avoimessa haussa vaikka olisivat päteviä, koska "asenne" tai "tyyli" tai "löytyi kova jätkä".* (Nainen, 40–49 v., johtotehtävät)

> *En saanut ylennystä, selitys oli puuttuva kokemus senkin jälkeen, kun olivat valinneet tehtävään vähemmän kokeneen miehen. …Yrityksessä on hyvin vähän naisia ja eteneminen senioripositioon näyttää melkein mahdottomalta.* (Nainen)[2]

2 Vastaajien pienen määrän vuoksi vuoden 2020 aineistossa käytetään tunnisteena vain sukupuolta (mies/nainen).

Aineisto havainnollistaa samanlaisia etenemisvaikeuksia, joita Kupiainen (2019) sekä Kauhanen ja Riukula (2019) kuvaavat omissa tutkimuksissaan. Naisten osaamista ei tunnisteta selkeistä perusteista huolimatta, ja ylennystä vaille jääneille naisille ei ole tarjolla ”asennetta” ja ”tyyliä” parempia, konkreettisiin meriitteihin pohjautuvia perusteluita. Aineisto kuvastaa myös Cheryanin ja Markuksen (2020) maskuliinisuusoletuksia: naisten etenemisen esteet eivät johdu osaamisen tai kokemuksen puutteesta vaan siitä, ettei nainen sovi osaajan normatiiviseen maskuliiniseen muottiin.

Osa miehistä tunnistaa naisten eriarvoisen kohtelun, kun taas toiset eivät usko, että naisia syrjittäisiin sukupuolen perusteella. Aineistossa heijastuu muun muassa Seronin ja kumppaneiden (2018) kuvaama individualistinen ja meritokraattinen insinöörikulttuuri. Sukupuolta ei rakenteellisena tekijänä haluta nähdä syrjinnän syynä.

> *Jotkut naiset käyttävät sukupuolisyrjintäkorttia virheellisesti perusteena. Peiliin ja sieltä nimenomaan omiin ominaisuuksiin katsominen selittäisi tilanteen, ei housuista löytyvä laitteisto (jos esimerkiksi uraetenemistä ei tapahdu).* (Mies, 30–39 v., johtotehtävät)

Naisille myös ohjataan vähemmän arvostettuja tehtäviä. Kuten Kaukonen (2020) painottaa, työtehtävät tekniikan työpaikoilla eriytyivät roolistereotypioiden mukaisesti: naisille annetaan heille ”sopivina” pidettyjä tehtäviä, kuten sihteerin tehtävät ja siivoaminen. Ongelmallista on, että naisille ohjatut ei-tekniset työt eivät kehitä yhtä paljon heidän ammatillista osaamistaan, ja näin ne osaltaan vahvistavat perinteistä työnjakoa ja siihen liittyviä stereotypioita, kun taas miehille myönnetyt vaativammat työt uusintavat maskuliinisuuden ja tekniikan yhteyttä (vrt. Holth ym. 2013; Jansson & Sand 2021).

> *Uralla eteneminen teknisellä alalla on miesten kesken automaatio. Naisen oletetaan olevan tyytyväinen sihteeri-tehtäviin helpommin. Mieheltä ei vastaavasti edes kysytä tällaisten tehtävien tekemistä.* (Nainen, 20–29 v., asiantuntija)

Uskottavuus osaajana nousee vahvasti esiin naisten vastauksissa. Tähän ryhmään luokitelluissa vastauksissa esiintyi mainintoja arvostuksen puutteesta, puutteellisesta uskottavuudesta sekä vähättelystä ja tytöttelystä. Osaamisen epäileminen tai kyseenalaistaminen toistui lukuisissa naisten kommenteissa. Näitä kommentteja esittivät useammin nuoremmat, mutta myös jotkut yli 40-vuotiaat naiset mainitsivat asiasta. Korkeampi toimiasema ei myöskään näytä välttämättä lisäävän uskottavuutta, sillä myös keskijohdon ja johdon tehtävissä olevilta löytyi asiaa koskevia mainintoja. Vastaajat liittivät nämä haasteet nimenomaan naiseuteen ja totesivat, että miesten ei tarvitse vastaavalla tavalla todistaa osaamistaan.

> *Asiat menevät "paremmin perille", kun mies sanoo saman asian. Naiset joutuvat todistelemaan uudessa organisaatiossa omaa kyvykkyyttään, ennen kuin nainen otetaan tosissaan. Miehen ei tarvitse todistaa omaa osaamistaan.* (Nainen, 20–29 v., asiantuntija)

> *Harmittaa, että joudun osoittamaan kykyni ja osaamiseni uusille ihmisille jatkuvasti. Olen nainen, pienikokoinen, nuori ja kiltin näköinen. Voiko sellainen nainen työskennellä teknisellä alalla? Kun ihmiset tajuavat, että osaan niin sitten on ok.* (Nainen, 30–39 v., asiantuntija)

Aikaisemmissa tutkimuksissa on todettu, että tekniikan alalla työskentelevä nainen joutuu usein näkemään ylimääräistä vaivaa, jotta hänen pätevyytensä tunnistettaisiin ja tunnustettaisiin (esim. Faulkner 2011). Faulkner (2011) on kuvannut naisinsinöörien kokemaa näkyvyyden ja näkymättömyyden paradoksia: naiset ovat tekniikan työpaikoilla hyvinkin näkyviä naisina mutta silti näkymättömiä insinööreinä, joten heidän täytyy ponnistella miehiä kovemmin koko työuransa ajan. Lisäksi maskuliinisessa kulttuurissa osaamisen aktiivinen kehittäminenkään ei välttämättä riitä uralle asetettujen tavoitteiden saavuttamiseen, koska naissukupuolisena nähtyä asiantuntijuutta ei tunnisteta tai sitä ei tunnusteta riittäväksi (Kupiainen 2019). Miesten osaamista ei kyseenalaisteta, vaan sitä pidetään jopa automaattisena. Kuten eräs vastaaja totesi:

> *Suomessa kuvitellaan, että nuori mies automaattisesti hallitsee asiat, jotka vanha nainen on pitkän uransa aikana oppinut.* (Nainen, 50–59 v, keskijohto)

Naisten vastauksissa toistuvat myös maininnat epäasiallisista kommenteista tai käytöksestä. Halventavat kommentit ja jopa seksuaalinen häirintä nousevat esiin. Häirintään liittyvät kommentit tulkitsemme Wynnin ja Correllin (2018) nimeämäksi hyytäväksi kulttuuriksi, jossa osaamisen vähättely ja syrjintä yhdistyvät seksuaalissävytteiseen kommentointiin ja häirintään. Häirintää ei suinkaan aina pysähdytty aineistomme vastauksissa kommentoimaan, vaan se yhdistyi listan jatkoksi muuhun syrjintään. Tämä tuo esiin seksuaalisen häirinnän luonteen yhtenä vallankäytön ja maskuliinisen kulttuurin rakentamisen muotona.

> *Nuoriin naisiin suhtaudutaan joissakin toimistoissa ikävästi eikä palkkaus ja työtehtävät ole välttämättä samaa tasoa kuin miehillä. Olen joutunut kokemaan myös seksuaalista häirintää: ehdottelua ja ulkonäön kommentointia. Osa työkavereista puhuu halventavaan sävyyn yleisesti naisista.* (Nainen, 20–29 v., asiantuntija)

Maskuliinisen kulttuurin vaikutus miehiin näyttäytyy vain muutamissa yksittäisissä kommenteissa, esimerkiksi epäasiallisena käytöksenä. Tulkitsemme tämän johtuvan maskuliinisuuden kontekstista tekniikan alalla (Faulkner 2009; 2011) sekä siitä, etteivät miehet problematisoi maskuliinisen kulttuurin ilmenemismuotoja (Galea & Chappel 2021).

> *Jos puheääni on miehellä korkea niin nimitellään homoksi, vaikka on naimisissa ja on lapsia.* (Mies, 40–49 v., asiantuntija)

> *Esimiehet valitsevat omat etupiirinsä ja ”kaverinsa”, joille tarjotaan ylennykset, palkankorotukset ja uudet projektit. Ne jotka eivät näihin etupiireihin ole päässeet, unohdetaan käytännössä kokonaan eikä heille ole tarjolla ura- tai kehitysmahdollisuuksia. Pitkälti tämä tuntuu koskevan myös lähes kaikkia naispuolisia kollegoitani.* (Mies)

Naisten suosiminen ja tasa-arvon tavoittelu

Sukupuoleen perustuvaa syrjintää kokeneiden miesvastaajien näkemys tilanteesta tekniikan työpaikoilla on hyvin erilainen kuin naisten. Miehet kertovat kommenteissaan naisten suosimisesta ja kiintiönaisista tai epäpätevistä naisista. Miesten mukaan erityisesti johtotehtäviin halutaan naisia.

> *Epäpäteviä kiintiönaisia valitaan tehtäviin.* (Mies, 40–49 v, asiantuntija)

> *Selkeää naisten suosimista rekrytoinnissa ja päätöksenteossa.* (Mies, 40–49 v, johtotehtävät)

Organisaatioiden tasa-arvoon liittyvät tavoitteet mainitaan eksplisiittisesti vain miesten kommenteissa. Nämä yhdistyvät kokemuksiin (pätevien) miesten syrjimisestä, ja tilanteisiin saatetaan liittää kokemus suoranaisesta vihasta miehiä kohtaan.

> *"Tasa-arvo"-ohjelma, jonka tavoitteena saada lisää naisia vastuullisiin asemiin jättää pätevämpiä miehiä valitsematta.* (Mies, 30–39 v., asiantuntija)

> *Pienestä määrästä naisia halutaan väkisin nostaa naisia esi/johtotehtäviin ohi firman normaalien proseduurien.* (Mies, 40–49 v., johtotehtävät)

> *Päälliköllä (nais) kategorinen viha miessukupuolta kohtaan. AY-aktiivi* [tiiminvetäjä] *ajaa sukupuolensa ja etnisten ryhmien asiaa, niin ikään kategorinen viha kantaväestön miespuolisia kohtaan.* (Mies)

Vastaavia havaintoja esittävät Johansson ja kumppanit (2019) tutkimuksessaan ruotsalaisesta paperiteollisuudesta: kun naisilla koetaan tasa-arvon tavoittelun myötä olevan helpompi reitti työllistyä ja edetä urallaan, miesvastaajat ilmaisevat turhautumista ja kokevat jäävänsä syrjään nimenomaan sukupuolensa perusteella. Tasa-arvon lisääntymisen sijaan miesten kokemus on, että (naisten) sukupuoli korvaa pätevyyden (emt.). Kommenttien sisältö kytkeytyy jälkifeministiseen puhetapaan, jossa tasa-arvo on joko jo toteutunut tai mennyt liian pitkälle (esim. Kivijärvi & Sintonen 2021).

Keskustelua

Tekniikan akateemiset TEKin keräämät selvitykset tarjoavat ainutlaatuisen aineiston tekniikan korkeakoulutettujen kokeman syrjinnän tarkasteluun. Tuloksemme osoittavat, että naisiin kohdistuva syrjintä on tekniikan alalla merkittävä ongelma. Sekä vuosina 2015 että 2020 huomattava osa kyselyyn vastanneista naisista oli kokenut sukupuoleensa perustuvaa syrjintää työpaikallaan edellisen vuoden aikana. Naiset näyttävät hyvinkin tunnistavan syrjinnän, ja monet kertovat myös itse kohdanneensa sitä, toisin kuin on todettu joissakin kansainvälisissä tutkimuksissa (esim. Seron ym. 2018). Naisten kokema syrjintä liittyy vahvasti työpaikoilla vallitsevaan tekniikan, maskuliinisuuden ja osaamisen yhdistävään kulttuuriin: avoimissa kommenteissa tuodaan esiin haasteet uralla etenemisessä, osaamisen epäileminen, vähätteleminen, epäasialliset kommentit ja jopa seksuaalinen häirintä. Tekniikan alan maskuliinisen kulttuurin on aikaisemmissa tutkimuksissa havaittu muodostavan merkittävän esteen sukupuolten tasa-arvon toteutumiselle (esim. Faulkner 2011; Jansson & Sand 2021), ja tuloksemme todentavat, että maskuliininen kulttuuri, jossa pätevyys ymmärretään nimenomaan miesten ominaisuudeksi, vallitsee myös suomalaisilla tekniikan työpaikoilla.

Miesten kokemaa syrjintää tekniikan työpaikoilla ei ole juurikaan tutkittu, joten tutkimuksemme tuottaa aiheesta uutta tietoa. Miesten kokema syrjintä liittyy useammin ikään kuin sukupuoleen, ja lisäksi miesten kokemukset sukupuoleen perustuvasta syrjinnästä näyttävät linkittyvän vanhempaan ikään. Miehet painottavat kommenteissaan naisten suosimista ja tuovat esiin kielteisiä kokemuksia tasa-arvon tavoittelusta organisaatioissa. Näissä kommenteissa näkyy ajatus, että naisia suositaan ja (päteviä) miehiä syrjitään (vrt. Johansson ym. 2019). Maskuliinisen kulttuurin vaikutus miehiin on aineistossamme luettavissa vain ”rivien välistä”, muutamissa yksittäisissä kommenteissa. Aineistossa kerrotut syrjintäkokemukset eivät suoraan tue oletusta, että miehetkin kärsivät maskuliinisuuden kapeasta normista, ellei ikäsyrjintää tulkita merkiksi kapeasta maskuliinisuuden normista. Aikaisempaa tutkimusta miesten kokemuksista on melko vähän, minkä koemme selkeänä puutteena ja jatkotutkimuksen aiheena. Emme myöskään juurikaan pysty aineistomme valossa tarkastelemaan sukupuoli- ja seksuaalivähemmistöihin tai esimerkiksi rodullistettuihin tekniikan alan osaajiin kohdistuvaa syrjintää, vaikka syrjivät käytänteet kohdistuvat naisten lisäksi myös kaikkiin muihin, jotka vallitseva maskuliininen kulttuuri rajaa ”toisiksi”, kuten sukupuoli- ja seksuaalivähemmistöihin (esim. Leyva ym. 2016).

Aineistossamme naiset kuvailevat kokemaansa vähättelyä ja osaamisen epäilemistä. Vaikka myös miehet kuvailevat eriarvoista kohtelua, kukaan heistä ei mainitse itsetuntoa nakertavaa epäilyä, joka kohdistuu uskottavuuteen oman alan osaajana. Esitämme, että siinä missä maskuliininen kulttuuri haastaa naisten pätevyyttä, se tukee käsityksiä miesten pätevyydestä. Miesten kokema syrjintä linkittyy nimenomaan toimiin, jotka yrittävät haastaa maskuliinista kulttuuria. Aineisto avaakin mielenkiintoisen kysymyksen siitä, miten naisten suosimiseen liittyvät miesten syrjinnän kokemukset kytkeytyvät maskuliiniseen kulttuuriin. Naisten pätevyyden kyseenalaistavassa kulttuurissa naisten yhdenvertainen kohtelu voi näyttäytyä naisten perusteettomana suosimisena. Näin on etenkin silloin, jos kulttuurinen lähtöoletus on, että naiset eivät meriiteillään ja osaamisellaan voi yltää vastaavaan urakehitykseen kuin miehet, eikä näitä oletuksia tunnisteta (ks. esim. Cheryan & Markus 2020; Galea & Chappel 2021).

Tasa-arvo näyttäytyykin näennäisesti kaikkien tukemana mutta kiistanalaisena tavoitteena, suorastaan (sukupuolten välisenä) taistelutantereena. Kuten Ylöstalo (2019) toteaa, tasa-arvoa koskevia kamppailuja ei käydä ensisijaisesti asenteista vaan teoista. Tasa-arvoon on helppo sitoutua arvona, kun se ei vielä edellytä tekoja, muutosta tai oman aseman ja toiminnan pohdintaa. Kun tullaan lähemmäksi omaa arkea ja toimintaa, heräävät selvästi ristiriitaisemmat tunteet ja jopa vastustus. (Lee ym. 2010; Ylöstalo 2019.) Vastaava ristiriita ilmenee myös Tekniikan akateemisten tutkimuksessa (Bairoh 2019): tasa-arvoa pidetään tärkeänä, mutta varsinkaan miehet eivät usko, että sukupuolella olisi merkitystä esimerkiksi uralla etenemisessä, joten korjaavia toimenpiteitä ei tarvita. Padavicin ja kumppaneiden (2020, 101) mukaan valtaa pitävät ryhmät voivat kokea eriarvoisuuden erityisen ristiriitaisena ja ahdistavana, mikä johtaa ”sosiaalisten defenssien” ylläpitämiseen.

Haluamme korostaa erityisesti miesten roolia tasa-arvon edistämisessä tekniikan alalla: pysyvää myönteistä muutosta ei tapahdu, mikäli tasa-arvo koetaan miesten syrjimisenä, kuten tässä aineistossa sekä esimerkiksi Johanssonin ja kumppaneiden (2019) tutkimuksessa. Kuten Hearn (2021) huomauttaa, miehillä voi olla toisistaan hyvinkin poikkeava ja ristiriitainen suhde sukupuolten tasa-arvoon: toiset haluavat edistää naisten tasa-arvoisuutta, toiset keskittyvät tiettyjen miesten (kuten seksuaalivähemmistöt tai isät) sukupuolittuneeseen epätasa-arvoon ja toiset puolestaan vastustavat feminismiä. Haasteena on, että tasa-arvon tavoittelu vaatii muutoksia miehiltä. Vaikka sukupuolten tasa-arvo ei ole nollasummapeli, se ei ole myöskään *win-win*-tilanne: miehet eivät välttämättä häviä, jos naiset saavat etua, mutta toisaalta naisten etu ei automaattisesti hyödytä miehiä, ainakaan lyhyellä tähtäimellä (Hearn 2021).

Aiheen kompleksisuudesta huolimatta on tärkeää muistaa organisaatioiden ja yksilöiden mahdollisuudet toimijuuteen. Niin kuin Acker (2006) kirjoittaa, eriarvoisuutta tuotetaan ja uusinnetaan juuri työelämässä. Maskuliinisessakin kulttuurissa työskentelevä voi omalla toiminnallaan muokata kulttuuria ja käsityksiä naisten ja miesten rooleista, ja johtoasemassa toimivalla henkilöllä on erityisen hyvät mahdollisuudet halutessaan edistää kulttuurin muutosta (Holgersson & Romani 2020; Johansson ym. 2020). Tunnistamalla syrjivät käytännöt voidaan estää niiden juurtumista osaksi työpaikan kulttuuria tai päästä niistä vähitellen eroon. Holgersson ja Romani (2020) kertovat ruotsalaisesta IT-alan yrityksestä, jossa yrityskulttuuria muuttamalla pyritään paljastamaan ja haastamaan implisiittinen maskuliinisuuden normi. Sukupuolten tasa-arvoa tavoitellaan monilla käytännöillä, ja muutosagentteina toimivat myös johtoasemassa olevat miehet. Onnistunut muutos edellyttääkin yhtäaikaisia ja samansuuntaisia muutoksia useammalla kulttuurin tasolla (Cheryan & Markus 2020).

Johtopäätökset

Sukupuolten erilainen kokemus tekniikan alalla työskentelystä ja syrjinnästä todentuu kahdella tavalla: naisten syrjinnän kokemukset ovat yleisempiä ja moninaisempia, ja miesten ja naisten näkemykset syrjinnän luonteesta ja yleisyydestä eroavat huomattavasti toisistaan. Tekniikan alalla sukupuoleen perustuva, naisiin kohdistuva syrjintä on merkittävä ongelma. Sekä vuosina 2015 että 2020 huomattava osa kyselyyn vastanneista naisista oli kokenut sukupuoleensa perustuvaa syrjintää työpaikallaan edellisen vuoden aikana. Naisten kokema syrjintä liittyy vahvasti työpaikoilla vallitsevaan maskuliiniseen kulttuuriin, jossa yhdistetään toisiinsa tekniikka, maskuliinisuus ja osaaminen: avoimissa kommenteissaan naiset tuovat esiin haasteet uralla etenemisessä, osaamisen epäilemisen, vähättelemisen, epäasialliset kommentit ja jopa seksuaalisen häirinnän. Miesten sukupuoleen perustuvaa syrjintää koskevat kommentit painottavat naisten suosimista ja tuovat esiin kielteisiä kokemuksia organisaatioiden tasa-arvon tavoittelusta. Väitämme, että joissakin miesten kokemuksissa maskuliinisuuden ensisijaisuuden purkaminen näyttäytyy syrjintänä, koska sukupuolen mukanaan tuomaa etuoikeutettua asemaa ei tunnisteta eikä tunnusteta.

Monissa tutkimuksissa on tuotu esiin, että tekniikan alan työpaikoilla tarvitaan muutosta kohti erilaisia osaajia arvostavaa ja erilaisuutta hyväksyvää kulttuuria. Nähdäksemme tämä edellyttää sitä, että sukupuolten väliset näkemyserot tasa-arvosta ja syrjinnästä tunnistetaan ja tunnustetaan. Syrjintää koskevat tuloksemme olisi tärkeää huomioida tasa-arvoa tavoittelevissa toimenpiteissä ja ohjelmissa. Tekniikan alalla vallitsevan maskuliinisuusnormin purkamista ja tasa-arvotavoittelun vastustusta on tarpeen käsitellä, jos halutaan edetä kohti erilaisia osaajia arvostavaa ja erilaisuutta hyväksyvää kulttuuria. Lisäksi on tärkeää haastaa narratiivi jo toteutuneesta tasa-arvosta Suomessa, koska naisten kokema syrjintä työelämässä todentuu vähättelynä, häirintänä, etenemisvaikeuksina ja heikompana palkkakehityksenä.

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Liite 1

Syrjinnän ja epäasiallisen käytöksen kokemukset yleisyysjärjestyksessä ja sukupuolen mukaan (kyllä-vastanneiden osuus vastaajista), Jäsentutkimus 2015

Syrjintäperuste	Kaikki (n = 10671) %	Mies (n = 8266) %	Nainen (n=2405) %
ikä, kohdistuen erityisesti vanhoihin	10,4	10,4	10,8
sukupuoli, kohdistuen erityisesti naisiin	8,7	2,5	29,9
työsuhteen tilapäisyys tai osa-aikaisuus	5,3	4,4	8,4
ikä, kohdistuen erityisesti nuoriin	5,1	4,0	8,8
perheellisyys tai raskaus	3,5	1,9	8,8
kielitaito	3,0	2,8	3,5
terveydentila tai vajaakuntoisuus	2,5	2,0	3,9
poliittiset mielipiteet tai toiminta ay-liikkeessä	1,9	1,8	1,9
kansallisuus tai ihonväri	1,8	1,7	2,0
sukupuoli, kohdistuen erityisesti miehiin	1,6	2,0	0,3
seksuaalinen suuntautuminen, kuten lesbous tai homous	0,5	0,4	0,7

Susanna Bairoh & Sanna Putila

"Qualified women are not promoted" or "women are favoured"?
Contradictory experiences of gender-based discrimination in the workplaces of higher engineering graduates

In this article, we analyse gender-based discrimination experienced by higher engineering graduate women and men in their workplaces. Previous studies in the field of technology have focused on discrimination towards women, rendering the experiences of men mostly invisible. Our data are based on two surveys conducted by a union of engineering professionals: the questions regarding discrimination come from a large-scale survey conducted in 2015 and a sample survey conducted in 2020. Our results confirm discrimination experienced by women yet provide new insights about how it materialises in the workplace. We show how women's experiences of discrimination are strongly linked to the masculine culture prevalent in the workplaces and compare these experiences with men's experiences of women being favoured, which we also associate with the prevailing norm of masculinity in the field of technology. In conclusion, we suggest that the dominance of masculinity in the field of technology is the main cause for discrimination against women, and the dismantling of masculine privilege gives rise to men's experiences of discrimination. We conclude that acknowledging gender differences in understandings about equality and discrimination is a requirement for a successful change of culture.

"DO WE HIRE ONLY WOMEN THEN?" EXECUTIVES NAVIGATING GENDER EQUALITY AND MERITOCRACY IN TECHNOLOGY COMPANIES

ABSTRACT

Purpose
The aim of this study is to understand how executives in technology companies relate to targets for gender equality of top management.

Design/methodology/approach
The study draws on nineteen interviews of CEOs, senior line managers and HR directors in ten technology companies operating in Finland. The method is (reflexive) thematic analysis.

Findings
Drawing on critical feminist theorizing, the study identifies three ways in which the executives relate to gender equality targets: endorsing, negotiating, and resisting. However, all these responses are constrained by the executives' assumption that technology companies are meritocratic. The study illustrates how executives' narrow understanding of gender equality and reliance on the presumably well-working systems, combined with underlying doubts about the competence of women, hinder the advancement of women to top management.

Originality
While previous studies have evaluated targets to increase the number/percentage of women, both in certain "ideal case" companies and in terms of their effectiveness more broadly, this study discusses how technology company executives navigate these targets in relation to women's assumed 'competence'.

Keywords
Gender, Equality, Technology, Executives, Finland

Paper type
Research paper

1 INTRODUCTION

Although more women in general have joined the ranks of managers in recent decades, women still face difficulties in advancing their careers and their proportion at top management level remains small (Glosenberg et al., 2022; Kossek, Su & Wu, 2017). The dearth of women in top positions of technology companies is particularly striking, despite decades of research and intervention efforts. For example, a recent Equileap study (2021) found that the proportion of women at executive level was 12 per cent within hardware and semiconductors companies and 19 per cent in software and services. Hence, STEM (Science, Technology, Engineering, Mathematics) fields provide a fruitful setting to study the challenges of women's progress to top management in male-dominated organizations.

To attract more diverse workforce, many technology companies have set targets to increase the percentage share of women and/or women executives among their ranks. However, we only have limited knowledge of how these targets are perceived in technology companies and whether they actually work in increasing gender equality. The role of managers and other executives as gatekeepers is vital since they make decisions about recruitment and career advancement (e.g., Smith, Eriksson & Smith, 2021). Therefore, we need to understand how executives relate to such targets in different settings if we want to improve gender equality in technology companies overall. Certain previous studies have explored managers' responses in case companies in Sweden (Holgersson & Romani, 2020; Wahl, 2014) and in the U.S. (Wynn, 2020) but these can be considered ideal cases as the companies openly advocate for gender equality.

Recent studies have drawn attention to the mechanisms of masculine privilege that hinder women's progress in male-dominated STEM organizations (Beddoes, 2021; Blair-Loy & Cech, 2022; Galea & Chappel, 2021; O'Connor, 2020). Prior research has established that masculine culture(s), prevalent gendered structures and the intertwining of technology and masculinity hinder women's advancement in technology companies (e.g., Faulkner, 2014; Galea et al., 2020; Jansson & Sand, 2021). Nonetheless, the importance of these factors is usually downplayed, and many executives continue to explain the low percentage by the lack of competent women or their unwillingness to pursue top jobs (e.g., Galea & Chappel, 2021). This may be linked to how high-level executives understand gender (in)equality, impacting their willingness to engage in change efforts (Wynn, 2020).

The aim of this study is to understand how executives in technology companies relate to targets for gender equality, particularly pertaining to top management. The study draws on nineteen interviews of CEOs, senior line managers and HR directors in ten technology companies operating in Finland.

The study shows how executives in technology companies navigate between promoting gender equality (which they understand as increasing the percentage of women) and adhering to what they consider a well-functioning merit-based system of recruitment and career advancement. Drawing on critical feminist theorizing on meritocracy and male privilege in STEM, and the role of executives in advocating for gender equality, the study identifies three ways in which the executives relate to gender equality targets: endorsing, negotiating, and resisting. However, all these responses are constrained by the executives' assumption that their companies are meritocratic.

The structure of this paper is as follows: The next section introduces literature related to meritocracy and male privilege in STEM, career paths for women in technology, and executives' role in advocating gender equality. The following section describes the data and methods used in the study, followed by the findings. These are followed by discussion and lastly by conclusions and implications for managers.

2 THEORETICAL BACKGROUND

2.1 Meritocracy and male privilege in STEM

A meritocratic system supposedly provides every person with equal opportunities solely based on their own individual merit and effort (Nielsen, 2016). Moreover, the meritocratic ideal assumes that "ability can be quantified, separated from social context and assigned to the individual" (Simpson & Kumra, 2016, p. 568). Recent studies have exposed the myth of meritocracy in STEM fields in academia (e.g., Blair-Loy & Cech, 2022; O'Connor, 2020; Vehviläinen; Korvajärvi & Ylijoki, 2021). O'Connor (2020) illustrates how gender inequality in male-dominated higher education institutions is reflected at a structural level in the underrepresentation of women in senior positions and at a cultural level in the legitimacy of a wide range of (informal) practices that value men and facilitate their access to such positions. At the same time, these cultural practices - legitimated by gender stereotypes - undervalue women and inhibit their access (O'Connor, 2020).

In their extensive study, Blair-Loy and Cech (2022) identify two schemas that characterize the professional culture in (academic) STEM: work devotion and scientific excellence. Work devotion means that STEM work is defined as a calling that deserves single-minded devotion undistracted by other (life) responsibilities while the schema of scientific excellence is a combination of characteristics (e.g., brilliance, assertiveness) that serves as a cultural yardstick for measuring competence and worthiness (Blair-Loy & Cech, 2022, p. 13). The problem of inequality in (academic) STEM is embedded in the cultural definition of merit itself: "the definitions of merit reproduce inequality because they infuse gender, racial/ethnic, and LGBTQ biases into the yardsticks along which professional competence and worthiness are measured" (Blair-Loy & Cech, 2022, p. 31).

Previous studies suggest that the ideal of meritocracy is entrenched in engineering education and in technology companies (Doerr et al., 2021; Nash & Moore, 2019; Seron et al., 2018). For example, Doerr et al. (2021) find that when early-career women explicitly and consciously recognized that gender matters in their workplace, they still forced experiences and observations of inequality to fit within a meritocratic logic, either as aberrations or as logical extension of different 'natural' abilities and preferences between men and women. Galea and Chappel (2021) illustrate how masculine privilege is sustained via three mechanisms: 1) a culture of denial (i.e., denying that privilege systems exist); 2) perceptions that rules are neutral, legitimate, and applied objectively; and 3) through backlash and resistance to keep the gender status quo in place.

2.2 Technical/social dualism and career paths for women in technology

Scholars drawing on feminist approaches have shown how women often struggle to establish their credibility and competence as technology professionals (e.g., Alegria, 2019; Faulkner, 2014; Galea et al., 2020) whereas men are considered to 'naturally' possess technical talent (e.g., Powell & Sang, 2015) and have more options for performing these roles (Faulkner, 2007; Tassabehji et al., 2021). Women's technical competence appears questionable as the technical/social dualism identified by Faulkner (2000) still assigns men as technical and women as social (also Alegria, 2019; Tassabehji et al., 2021). Moreover, feelings of lack of confidence or authenticity tend to be seen as a personal failing rather than something for which the organization bears responsibility (Faulkner, 2014; Nash & Moore, 2019).

Women's technical competence can thus appear fragile while their social competence is reinforced by supervisors and colleagues (Alegria, 2019; Faulkner, 2007; Tassabehji et al., 2021). In the United States, Alegria (2019, p. 729) finds that "white women tended to move upward into management positions when supervisors identified their feminine-typed 'people skills' and encouraged promotions". According to Cardador (2017), management roles in engineering firms are perceived - by both men and women - as more stereotypically feminine and thus more suitable to women. Therefore, somewhat paradoxically, women's stereotypical strengths in the male-dominated technology companies deem them a better fit for managerial than technical roles (Alegria, 2019; Cardador, 2017; Faulkner, 2007). Cardador (2017) argues that organizations wishing to promote gender diversity see women as attractive candidates for managerial roles and appear to be pushing them toward these roles, partly to satisfy diversity agendas.

Management roles may appear more 'gender authentic' for women than technical roles (Faulkner, 2007) but they come with significant trade-offs (Alegria, 2019; Cardador, 2017; Cardador & Hill, 2018; Holth, Bergman & MacKenzie, 2017). While project/team leaders and managers are formally higher positions, technological careers are usually more valued within technology organizations and moving into management means loss of technical competence for women (Alegria, 2019; Cardador, 2017; Holth et al., 2017). Moreover, Alegria (2019) argues that the management positions available to ('white') women may rather be a step stool than an escalator since they do not present a clear path to the executive level. Cardador (2017, p. 612) concludes that moving women into managerial roles fosters both their inclusion (through enhanced access to leadership roles and perceptions of role fit) and their exclusion (through lower identification with engineering and validation of persistent gender stereotypes).

2.3 Managers as change agents for gender equality

In technology companies, inequality regimes (Acker, 2006) have been found to favor men and gender-fluid women (Alfrey & Twine, 2017). Nonetheless, even when the culture is predominantly masculine, it is possible to initiate changes in the culture and provide alternative conceptions of prevailing gender roles. As Beddoes (2021) points out, technology companies could be working to establish practices, norms, policies, and cultures that do not reinforce dominant group privileges. For example, hostile or chilly climates in technology companies could be mitigated by effective mentors or sponsors in the workplace (Wilson & VanAntwerp, 2021). Especially managers and other executives may, if they are willing, promote such culture change (Cheryan & Markus, 2020; Holgersson & Romani, 2020; O'Connor, 2020).

Top executives in technology companies can challenge the prevailing gender order and act as change agents promoting gender equality (Holgersson and Romani, 2020; Wahl, 2014). As Wahl (2014) explains, even men who represent hegemonic masculinities can challenge the norm when questioning the ideology that justifies men's domination in management. Gender awareness opens space for reflections on the structural advantages that male managers experience as men (Wahl, 2014). Holgersson and Romani (2020) show how the purposeful management of organizational culture, drawing on gender egalitarian ideology, can expose and challenge the masculine norm within (IT) industry and society and provide a more gender equal norm for the organization. In the Swedish case company, normative control promoting gender equality is put into practice through multiple organizational practices, such as empowering management style and extra efforts to recruit women.

The findings of Holgersson and Romani (2020) and Wahl (2014), while hopeful, raise the question of how important the broader societal context for executives' engagement in structural changes is – gender equality is strongly on the management agenda in Sweden, as the authors also acknowledge. Based on an extensive case study in a Silicon Valley technology company, Wynn (2020) finds that top executives tend to limit their efforts to individualistic and/or societal types of change - such as unconscious bias trainings and mentorship programs - rather than organizational, structural changes. Wynn (2020) argues that this stems from the individualistic and societal explanations of gender differences and inequality favored by the executives whereas the structural ideologies supported by gender scholars are rarely endorsed. Although the company is described by Wynn (2020, p. 111) as an "ideal context" due to its comparatively inclusive culture, initiatives designed to achieve equality in the organization are limited in their reach and effectiveness because they remain anchored to individualistic gender ideologies and hence rather reinforce the status quo than challenge it.

As the above results from Sweden and the United States show, executives' willingness to engage in gender equality initiatives and advocate for change may depend partly on the country context but there is likely variation between companies as well. Therefore, we need to understand more about how managers and other executives relate to potential targets in various settings. This study focusses on Finland, a country that is in many aspects among the leaders in gender equality (like Sweden), but wherein top management positions in the private sector are still overwhelmingly dominated by men. For example, only 10 out of 132 companies (8 %) listed in the Helsinki stock exchange had a female CEO in 2018 (Lipasti, Pietiläinen & Katainen, 2020).

3 DATA AND METHODS

The aim of this study is to understand how executives in technology companies relate to targets for gender equality, particularly pertaining to top management. The data for the study is based on nineteen semi-structured interviews of executives in ten technology companies[1] operating in Finland. Interviews were selected as the research method since the purpose is to gain understanding of how executives understand and reflect upon (increasing) gender equality in their companies.

In the sample, six interviewees were CEOs (=CEO), nine were HR managers/directors (=HR) and four were senior managers (=Manager). Ten interviewees were men and nine were women; of the CEOs, five were male and one was female whereas of the HR managers/directors, six were female and three were male. The four managers were evenly men and women (two and two). The age of the interviewees ranged from 32 to 60 years, with most interviewees in their 40s and 50s. The nationality of the interviewees was not asked, but 18 interviewees were supposedly Finnish, and one was Western European. All interviewees were 'white', which is still typical in Finnish companies.

The first round of interviews was conducted in March - May 2019 (nine companies, 15 interviewees) and second round in May 2021 (one company, four interviewees) as part of larger research projects that also involved a survey and statistical analysis of survey data. In spring 2019, fourteen interviews were conducted face-to-face at the premises of the case companies and one by Skype. In 2021, all four interviews were conducted by Teams due to COVID-19 restrictions. The interviews lasted from 26 min. to 61 min. with an average of 47 minutes. Interview consent forms were signed according to the EU's

1 The companies represent the following sectors within technology: industry/manufacturing (5 companies); planning and design (3 companies); IT consulting (1 company); ICT solutions provider (1 company). All companies are large or mid-size and five are listed in the Helsinki Stock Exchange.

General Data Protection Regulation. The author conducted twelve of the interviews and observed three, whereas four interviews were conducted without the author present. All interviews were audio-recorded and most (13) interviews were transcribed verbatim (by a company with a confidentiality agreement). For six interviews conducted by the author, the original interview notes based on the recordings were used instead, and this is indicated in the quotes. Eighteen interviews were conducted in Finnish and one in English. The quotes used in this paper were translated from Finnish by the author (being mindful of the cross-language issues mentioned for example by Marschan-Piekkari & Reis, 2004)[2] and they have been anonymized to protect the interviewees. Pseudonyms were added by the author (all pseudonyms are Finnish names for purposes of anonymity).

The analysis method is (reflexive) thematic analysis (Braun & Clarke, 2020). The analysis process started with the author submitting the transcripts (or interview notes for six interviews) into Atlas.ti 9 software. Since the interviews covered various topics, the first step was to identify relevant content which for this study were comments related to top management, their recruitment, and gender equality. The initial coding stage produced over 50 codes or categories, such as "top management", "importance of gender equality", "discrimination of men" and "challenges in recruitment". Coded comments were then reread several times, checked, and merged into the eight main categories listed in Table 1. Please note that the categories are not mutually exclusive (one mention can belong to more than one category).

Table 1. Main categories and number of mentions

Categories	Number of mentions
Gender diversity of top management	29
Competence/skills of top management	35
Gender vs. competence (of top management)	58
(Gender) diversity in the company	41
Goals, processes, and follow-up of gender equality in company	106
Careers, career progression and recruitment processes in the company	114
Gender not important / no gender bias	38
Promoting company and/or technology field (to increase the number of women)	26

2 For example: the Finnish word "sukupuoli" means both 'sex' and 'gender' but has been translated as 'gender'.

In this paper, the focus is on the categories “Gender diversity of top management” and “Gender vs. competence (of top management)” although these overlap with other categories as well. Drawing on the data as well as the literature discussed in the previous section, the study identifies three ways in which the executives in technology companies relate to gender equality targets: endorsing, negotiating, and resisting. The findings are described and analysed in the next section.

4 FINDINGS

4.1 Executives endorsing gender equality targets

Four companies out of ten had specified targets to increase the percentage share of women in the company and/or in management, namely, Companies A, B, C and D. Nonetheless, only the executives in Company A and one executive in Company B expressed strong support for the targets.

In Company A, CEO Jari (male) clearly endorses the targets that have been set at the (international) Group level and seems genuinely satisfied that they are reaching the target for women executives at Business group level. Jari mentions hearing some criticism towards the targets but points out that it is necessary to have goals that drive taking gender equality into account in recruitment and other processes: ”[I]f we just say that we will try to fix this or wonder that we would get [MORE WOMEN] then it will not happen” (Jari, male, CEO, from notes). Jari explains that they demand from headhunting firms that the long list of candidates must also include women. Moreover, he says that in the case of two equal candidates, he would probably select the women because of the target. This view is echoed by Petri (male, HR) who says that there is a policy (in principle) to select the woman if there are two equal candidates.

Company B had recently specified an ambitious target related to increasing the percentage share of women among its ranks. Sanna (female, manager) comments: “[COMPANY B] has a rather strong message. Nowadays especially that more and more in my view it is emphasized that for example we are aiming at the percentage of women among employees to be at certain level and so on.” Kati, a manager with previous experiences of being the first woman in a top team, explains that increasing the number of women is beneficial for men as well: “If we get for example in the management group 30, 40 percent like women, so then it is liberating not only for those women but also for all the men because then it will be realized that gender has not been the primary thing that impacts that people are different" (Kati, female, manager). Here, Kati reflects on her experiences as a 'token' (Kanter, 1977; also e.g., Lewis & Simpson, 2012), suggesting that a more gender balanced team could shift the focus on other differences than gender.

Kati in Company B is the only interviewee who seems to be willing to take on the role of an advocate, like the executives in Holgersson and Romani's (2020) study. She feels it is her role to remind the rest of the organization as well: "Now there have been some cases for example just related to merit-based rewards and compensation where I had to remind global HR that hey, let's check before confirming the decisions that let's look at like gender [LAUGHTER] - so it does not seem to be quite standard process at every level yet." (Kati, female, manager).

4.2 Negotiating gender equality targets

Several executives keep negotiating what the gender equality targets mean in practice. Petri (male, HR) in Company A describes an incident where an employee representative asked what the target means:

"One employee representative asked in one meeting as a joke that does it mean that we hire only women then going forward? Of course it does not mean that. It requires that we start from getting more attention from women than the field has traditionally done, and then build these career paths to women once we get them in here". Petri (male, HR, from notes)

It is clear to Petri, and apparently to all meeting participants, that such a question – do we hire only women then? – can only be asked as a joke, and his immediate response is that "of course" the target does not mean that.

In Company B, other managers than Kati seem to distance themselves from the publicly announced target. Sanna (female, manager) points out that in their unit - which has a female majority, unlike most of the Company B - even discussing the issue is not necessary: "But for us, it is not like, it is not even something we need to think about because it is so self-evident". Jukka (male, manager) in Company B comments that "let's say the target is 50/50 but it cannot be the target that if I am the recruiting supervisor so every other of my recruits should be a female. Because then we would be very deeply in the swamp". Jukka further discusses that it is important to have goals but there should be room for maneuver in how to get there. Arto (male, manager) denies even knowing about the target: “I don’t know of any specific kind of targets that we should have X number or X percentage of [WOMEN]. I haven’t seen those” albeit he later explains his understanding of Company B’s policy: “I think [Company B]’s target is [--] to build an organisation based on competence [WHILE BEING] respective of those diversity issues”.

Company C had previously specified targets for the percentage of women in general and in management but the process of determining the new targets was still underway. Sari (HR) comments that since women in the company’s management group currently head support functions, their goal is to recruit women managers to the business functions: “It would increase equality, if we got women to [BUSINESS], has been a very male field.” (Sari, female, HR, from notes). While Sari thus expresses support the company’s goals, she also mentions that women should not necessarily be favored: “Not so that if there are two equal candidates, a man and a woman, the woman should be selected, because the man may have some other qualities that are better suited for that position.” Hence, although the company has set targets to increase the percentage share of women in management, and there would be two equal candidates – a man and a woman – Sari wants to have the option to select the man. Furthermore, CEO Jussi (male, from notes) discusses that it is challenging to get the right kind of candidates and ponders on prioritizing women: “To prioritize one gender at that point, that would a rather challenging decision to make, not saying that it could not occasionally be done, sometimes in important roles we have got women who are good”.

In Company D, there has been a target for the percentage of women at the (international) Group level, and Miia (female, HR) explains that the Group has systematically promoted women to top management and two of the major Business units are headed by women. She mentions of a Group guideline that there should always be two candidates (male and female) at the last stage and if these are equal, the woman should be selected. However, Miia says that the Group target “has not touched us or become part of this company’s doings”. Likewise, CEO Vesa (male) says that gender equality is talked about in the company and is promoted, albeit he does not see it as an issue. When asked if the Group target is binding, he responds: “No it is not obligatory. And for me it is very difficult to see that it could be obligatory, because if it was obligatory, then it would be discriminatory. [PAUSE] But of course, when it is there among the targets, it takes care that it will not be forgotten”.

4.3 Executives resisting gender equality targets

The executives presented numerous comments that can be interpreted as resistance to the gender equality targets of their company, or against setting such targets at all. Drawing on Galea and Chappel (2021), these comments are further classified into three groups: 1. denial of the need for any targets, 2. the competence-first approach, and 3. backlash. However, all these are strongly intertwined.

4.3.1 No need for gender equality targets

Neither of the two companies with only one woman in the management group have set targets for increasing the number of women in top management, because what counts is "finding the right person for the right post" (Mika, male, HR). Mika describes their management group as comprising of "nine male engineers and one woman" while in the other company, Teemu (male, HR) comments: "I am dissatisfied genuinely with the number of women in our management group. I wish there were more women, while on the other hand, it is the challenge in our field. [--] Only one out of nine is currently a woman". Nonetheless, both Teemu and Mika bring up quotas and resist them because they could indicate selecting women on other basis than merit: "I am scared of the idea of having quotas. Because we always head for skills, experience, we complement each other, but genuinily I would like to have more women in our management group" (Teemu, male, HR).

In Company D, Vesa (male, CEO) comments: "Are we now seven then? Two are women. And to me it is quite, and then of course that executive assistant acts as the secretary, so in meetings then we have one more woman. But I can't still really comment otherwise than that in my view both capabilities and these personality profiles, personal chemistry, so pretty well, rather well balanced." For Vesa, what seems to matter is the number of female bodies (in the meeting room). Although Vesa's view can be considered somewhat extreme, most executives only count the women (cf. Pecis, 2016) and rarely reflect other aspects of equality such as the role of women in the management groups.

Many of the respondents worry about even appearing to recruit women just to increase gender equality or diversity. For example, Pia (female, HR) comments how it is not a problem that the company has no targets for women in top management: "That we don't have some quota woman in the highest management group, because also there the evaluation has to based on other criteria than whether one is a man or a woman". Arja (female, CEO, from notes) explains that their company has no gender equality targets, because these might set the company in the wrong direction: “We don’t have targets, in my view equity and equality is about looking for a suitable person with suitable skills; I think it would go to the wrong direction if there was [TARGETS FOR WOMEN]”. Olli (male, CEO) considers that it would be “dangerous” to aim for too high percentage of women: “For example, if there are X percent of females as [FIELD] engineers, and if one would aim for significantly higher percentage than X in one’s own activities, then that could be also dangerous”.

4.3.2 Competence first – but do women have it?

All the interviewed executives agree that recruitment and career progression to top management, as well as in the company overall, is – and should be – based only on merit or competence. As Arto (male, manager) in Company B puts it: “[W]e are recruiting based on competence and not age, sex, nationality or any other kind of. We’re looking for competence” and further comments that “I would say there is nothing stopping people from getting there [TOP MANAGEMENT] overall in [Company B]. [--] I think then it comes down to desire and ambition”. In Company D, Vesa (male, CEO) comments that “I wonder who it was who recently said that it would be undermining to women that it is necessary to specifically emphasize some female quotas. Now we all move around with our own merits and professional qualities”. Likewise, Olli (male, CEO) comments that: “[w]hen talking about career advancement or any such thing then it has to be based on meritocracy and nothing else matters.” Thus, while only Olli uses the word ‘meritocracy’ to describe their company, all interviewees subscribe to the meritocratic ideal.

Similarly, Mika (male, HR) says that “gender or skin colour or anything else has no impact. Background, ethnical background of anything else so they should not impact that recruitment in any way. So we look at merits and look at what kind of person it is”. The comment by Mika is rather revealing; apparently “gender or skin colour or anything else” is detached from “what kind of person it is”. However, as scholars of gender in organizations have emphasized, evaluation is a subjective process and concepts such as leadership, excellence, competence and quality are social constructions in which gender is embedded (Van den Brink et al., 2016; also e.g., Blair-Loy & Cech, 2022). Thus, separating ‘merit’ and ‘person’ may not be feasible in practice.

Some respondents, nevertheless, express (at least some) awareness of potential bias that could prevent the career progression for women. For example, Olli (male, CEO), while explaining that only the best candidates are selected, mentions that he tries to be objective about the criteria for the best to avoid any structural bias. Juha (male, CEO) ponders that one would assume that headhunters don't have biases but considers that it is possible. Sanna (female, manager) sees quotas as a potential tool to bring in more women: "Especially then quotas are a good thing if there is tendency to select, let's say exacerbated a man for a post where a woman would be as competent or more competent of the candidates". Most strongly the concern for bias towards women is expressed by Miia (female, HR) who discusses that a woman needs to be "many times more competent" to be selected: "[W]ith traditional thinking, the man is just easier to select, just because it is a man, even if he was, was not that competent or something. I don't know what is this model of thinking, that a woman needs to be many times more competent, but… it just is so." However, even Miia seems to take "this model of thinking" for granted – "it just is so".

Yet, several executives expressed reservations about the competence of women, as some of the previous comments illustrate. Concerning quotas, for example, Vesa (male, CEO) comments: "Me, we are guided by competences and capabilities. It would be rather difficult for me to recruit the less competent one of two candidates just to fill in a female quota. To me that would not be fair from any point of view". Thus, it is self-evident to Vesa that the "less competent" would be the female candidate and that quotas would mean having to hire incompetent women. All interviewees who mention quotas (except Sanna) resist them for similar reasons. Heidi (female, HR) discusses that hiring to get diversity would be unfair also to the recruited person: "Well it is competence first, because it would be unfair to… It would be, I think, in a certain way degrading to the person also, if we were like yes, because you are a woman or of a different cultural background, we are going to recruit you now to get this kind of diversity, although sorry, you don't have the skills that we would need". Again, the person lacking the required skills is the woman (or of a different cultural background).

Interestingly, the executives were not explicit about what 'competence' the women are supposed to lack. However, Miia (female, HR) discusses that it has been challenging to find women who would be competent enough. She further reflects that what seems to be lacking is certain type of leadership:"[I]n my view many times, when recruiting women, it is that type of clear leadership that is lacking" which when prompted turns out to mean resolve or being assertive. As Cheryan and Markus (2020) highlight, merit in majority-male fields is often conflated with valuing attributes that are more associated with the male than the female gender role, such as taking risks, displaying confidence, promoting oneself, and being assertive (also Blair-Loy & Cech, 2022; Nash & Moore, 2019; Van den Brink et al., 2016). Hence, women may experience the "Teflon effect" as the required merit fails to "stick" (Simpson & Kumra, 2016, p. 572).

4.3.3 Backlash

Even in companies with gender equality targets, policies that would require deviating from the competence-first principle are considered troublesome. As Arto (male, manager) in Company B points out: "If people can see this person actually isn't on this level but is there just to make up some kind of number then that is visible and people aren't stupid. I think that creates more problems than it's worth." Jukka (male, manager) discusses that he shared Company B's target announcement on LinkedIn and then got inquiries about how the target would be reached without discriminating against male employees: "[W]ell that was an extremely good question [--] and I responded that in my view we need to define, in a certain way, based on skills and abilities and everything beyond those skills is secondary". Thus, although the company has announced the target that would significantly increase the percentage share of women, Jukka still believes that gender is a "secondary" consideration.

Worrying about the (potential) discrimination of men - in male-dominated technology companies – may be an attempt to legitimize resistance against gender equality targets and initiatives. Male executives in Company A (Jari and Petri) and Company B (Arto and Jukka) bring up the (potential) discrimination of men as a consequence of promoting women and/or gender equality but only Jukka and Arto critizise their company's targets on this bases. Similarly, Bairoh and Putila (2021) find that only (some) men were worried about the discrimination of men in companies with gender equality targets. As Lewis and Simpson (2012) argue, the privileged seek to preserve their advantage through defensive action as well as the mobilization of beliefs regarding who has the right to occupy positions of power.

5 DISCUSSION

All the executives in this study subscribe to the meritocratic ideal, agreeing that women need to earn recruitment/promotion to top management by being 'competent' since in their view, only merit, skills and willingness of the individual (should) count. Thus, the idea of hiring or promoting "only women" to increase gender equality is conceived as a blatant violation of meritocratic principles. Similarly, mandated quotas for the recruitment of women were resisted in Australian construction companies as they were considered to interfere with merit-based selection (Galea & Chappel, 2021). What most executives in this study apparently fail to recognize is that 'competence', 'merit' and similar concepts are subjective and socially constructed notions (e.g., Holgersson, 2013; Kupiainen, 2019; Simpson & Kumra, 2016). While the executives clearly consider 'merit' an objective, gender-less quality, Simpson and Kumra (2016, p. 572) underline that merit needs to "stick", to be effectively demonstrated through embodied performances that require recognition for it to carry conviction and have value. As Blair-Loy and Cech (2022) illustrate, 'white' heterosexual men are most likely to be seen as embodying scientific excellence in STEM.

Believing that one's organization is a meritocracy does not, on the surface, appear to be discriminatory, and leaders may believe that merit-based hiring is a shield against discrimination (Cheryan & Markus, 2020). As Niemistö et al. (2021) point out, many organizations simultaneously operate under the illusion of a gender-neutral meritocracy and view men in senior positions as self-evident representatives of leadership. This can, as Holgersson (2013) finds, lead to certain men being defined as competent and given the opportunity to ascend the organizational hierarchy whereas women as a group are constructed as deficient and excluded (also Van den Brink et al., 2016). While some executives in this study acknowledge that there may be bias against women, only few (women) seem to recognize the opposite, the privileging of men. Geiger and Jordan (2014) point out that the myth of meritocracy proposes that those who succeed are the most qualified, without acknowledging the advantages that come with privilege. Additionally, organizational cultures explicitly priding themselves on being meritocratic may encourage bias by convincing managers that they are unbiased and consequently discourage the managers from examining their potential prejudices (Castilla & Benard, 2010; also Begeny et al., 2020).

The executives in this study equate promoting gender equality with increasing the number/percentage of women. This understanding of gender equality can be considered rather narrow although it is not surprising – the mainstream view is that the underrepresentation of women in technology (or STEM) can be fixed by increasing the number of women (e.g., Faulkner, 2000; Jansson & Sand, 2021). Other aspects of equality, such as reviewing the current culture or processes from a gender perspective is mentioned by (some) interviewees whereas analysing male privilege is not mentioned. None of the executives in this study discussed attempts to challenge the prevailing culture or gender order, unlike in the study by Holgersson and Romani (2020). Only Kati (female, manager) in Company B is an advocate for gender diversity while Jari (male, CEO) in Company A clearly endorses the companies' targets and policies and expresses willingness to do more. As already suggested, the cultural context (Finland vs. Sweden) appears to make a difference albeit both countries can be considered gender-egalitarian on a global scale.

While many technology companies publicly espouse the importance of diversity, equity and inclusion (DEI), they still have considerable challenges in turning these values into day-to-day reality. The study shows that in the eyes of the executives, meritocracy trumps gender equality targets. The executives believe that increasing gender equality (i.e., the number/percentage of women) would require a wider applicant pool, both internally and externally, so that more women could be selected based on their merits. However, they do not seem to consider how their understanding of 'merit' and 'competence' impact who is seen to 'fit' in the pool. Moreover, while several respondents express doubts about the competence of women, it is not clear in what way the women are 'less competent'. Based on prior research, the executives could be referring to technological competence which often eludes women (e.g., Alegria, 2019; Faulkner, 2014) or some leadership traits that are coded masculine, such as assertiveness (e.g., Blair-Loy & Cech, 2022). Hence, the executives tend to perpetuate masculine privileges despite the declared values of gender equality and non-discrimination (Galea & Chappel, 2021; also Blair-Loy & Cech, 2022).

6 CONCLUSIONS AND IMPLICATIONS

While many technology companies have set targets to increase the number/percentage of women, this study analyses how executives relate to these targets. The study contributes to literature on gender in technology and in management by showing that setting gender equality targets in technology companies causes a dilemma for the executives: if they promote gender equality, they may be violating the ingrained ideal of meritocracy. Executives in this study responded to gender equality targets in three ways - endorsing, negotiating, or resisting - but all these responses were constrained by their assumption that technology companies are meritocratic. In companies with defined targets, executives kept negotiating them and some even distanced themselves from the targets. In other companies, the executives' unwavering confidence in the functioning of the merit-based system rendered gender equality targets unnecessary in their view. The study argues that when executives do not actively support gender equality targets, they are perpetuating male privilege by reinforcing the status quo.

The study shows how executives' narrow understanding of gender equality and reliance on the current systems, combined with underlying doubts about the competence of women, hinder the advancement of women to top management. Therefore, the study helps executives understand how similar beliefs may thwart gender equality initiatives in their own companies. The findings also indicate that while setting and announcing targets is vital, it is not sufficient. Executives may resist gender equality targets if these are deemed to violate the principles of meritocracy. If the companies are serious about improving gender equality, they need to engage in thorough discussions of what really are the skills required for each post and how competence/merit is defined, understood, and measured. To be successful, gender equality initiatives require guidelines, processes, and shared understanding of their importance. Wynn (2020) proposes that future change initiatives should focus on providing executives with the structural understanding and organizational framing necessary to execute effective change. Based on the findings of this study, such understanding of the prevailing and persistent gender inequalities is certainly needed in technology companies.

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SUSANNA BAIROH

The Gender(ed) Gap(s) in STEM
Explaining the persistent underrepresentation of women in STEM careers

Countless projects and campaigns have sought to increase the number of women in STEM (Science, Technology, Engineering, Mathematics) in recent decades. Nevertheless, women continue to be underrepresented in STEM education and workforce, particularly within many fields of engineering/technology. This study argues that instead of 'the gender gap' - the underrepresentation of women - numerous gender(ed) gaps exist within STEM, manifesting in different yet often subtle ways across various contexts. By 'gendered gaps', the study refers to the various ways in which gender matters in STEM, leading to differing expectations and experiences for men, women, and others.

In the study, the vast scholarly literature on women/gender and STEM is classified into two broad groups which are labelled 'mainstream' and 'critical'. The study critiques the mainstream approaches and draws on critical feminist theorizing to explain the persistence of the gender(ed) gaps. While (lacking) interest in STEM is among the most popular explanations for the gender gap in the mainstream literature, critical studies underline how gendered societal norms, expectations, and stereotypes influence what an individual can be interested in. The intertwining of masculinity and STEM, and its linkages to stereotypes and understandings of 'natural' male superiority in STEM, has received hardly any attention from mainstream scholars. Additionally, mainstream studies have not sufficiently addressed the impact of masculine culture(s).

The articles in this study cover four gender(ed) gaps along the pipeline of STEM careers in Finland: application to university STEM studies, graduation with Master's in engineering/technology, gender-based discrimination in technology workplaces, and recruitment to top management in technology companies. The study deploys a mixed methods approach, combining both quantitative and qualitative data and methods.

The study argues that the gender(ed) gap(s) in STEM in Finland persist due to the cumulated and compounded effects of masculine cultures favouring men as well as stereotypes affirming male superiority in mathematics, stemming from the strong linkages between masculinity with (physical) sciences, mathematics, engineering, and technology. Consequently, for (many) women, these lead to lower ability beliefs and less interest in STEM studies and careers as well as a more fragile identity as STEM professionals.

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