Gender Segregation in the Occupations of Finnish Engineers

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Gender segregation in the occupations of Finnish engineers

Introduction

The Finnish labor market is among the most gender segregated in Europe - women head for professions in care, whereas men opt for technology [1]. Within different fields, the segregation shows as differences in occupations, wages, and career paths. Research has shown that the careers of women and men diverge upon labor market entry and continue to diverge along the career [2]. Much of the divergence reflects the horizontal segregation in educational choices, but also the career paths of women and men with the same educational background differ in many respects. This vertical segregation has not been studied extensively in Finland. Understanding the gender differences is necessary to design effective measures to reduce the vertical segregation and promote equality in the engineering profession.

Horizontal and vertical gender segregation

All over the world, women and men tend to work in different occupations and fields. “Gender segregation” refers to the gendered division of labor in paid employment, which can be horizontal (between occupations) or vertical (within occupations). Gender segregation reduces the choices of men and women in education and the job market, increases the gender pay gap, and perpetuates gender stereotypes [2, 3]. Moreover, it may exacerbate skill shortages insofar as it impedes the efficient reallocation of male and female workers and distorts the allocation of future flows of workers [4]. Because of these considerable negative impacts, numerous studies have sought to illuminate the causes and consequences of gender segregation.

Certain occupations can be categorized as male dominated, whereas others are dominated by females, meaning that the majority (above 60%) of persons working in them belong to the dominant gender [3]. This phenomenon is known as horizontal or occupational gender segregation. It starts already in primary education and continues to the highest levels of education, thereby also shaping the labor market. Careers of women and men diverge upon labor market entry and continue to diverge along the career path [3]. Much of the divergence reflects horizontal segregation in educational choices, but the career paths of women and men with the same educational background also differ in many respects. This phenomenon is referred to as vertical or hierarchical gender segregation as women and men inhabit different positions in the hierarchy of the labor market. While overt barriers have been discarded, covert biases still linger. Examples of vertical segregation include closer rungs on ladders in the career tracks of feminized jobs, discretionary managerial practices for selection, hiring, and promotions that favor men, as well as a lack of networking resources among women [4]. Over the last few decades, vertical segregation has generally decreased as the educational level of women has increased [4], but men and women still end up in different tasks, even with the same education and within the same occupation [5].

The differing educational choices of women and men are often considered the main cause of gender segregation in the job market [5], although many intertwining factors have been found to contribute to segregation. Various theories provide different explanations of the factors underpinning gender segregation, and thus, the views on the necessity of mitigating its effects also differ. Burchell et al. point out that explanations tend to emphasize either supply-side or demand-side factors [3]. Supply-side explanations underline either the impact of women’s role as mothers on their career choices or notions of differences in women's talents and orientations compared with men, although the choices women make are conditioned by actual employment and childcare support options in specific labor markets. On the demand side, employer behavior helps create and sustain gender segregation through their employment and recruitment practices, which may exclude women or men from certain jobs [3].

Tanhua provides a useful classification of gender segregation theories, identifying individual, organizational, and societal or macro level (see Fig. 1) [6]. Supply-side theories focusing on the individual level include, for example, human capital theory (person's rational and free will to invest in certain skills) and preference theory (different valuations and choices). Demand-side theories include those that investigate discrimination and privileges at the organizational level, such as queuing theory, which proposes that the most wanted jobs go to the most favored workers—usually white men. A critical feminist intersectional viewpoint underlines that gender segregation is caused by gendered processes, as certain groups and individuals are included, whereas others are excluded [6].

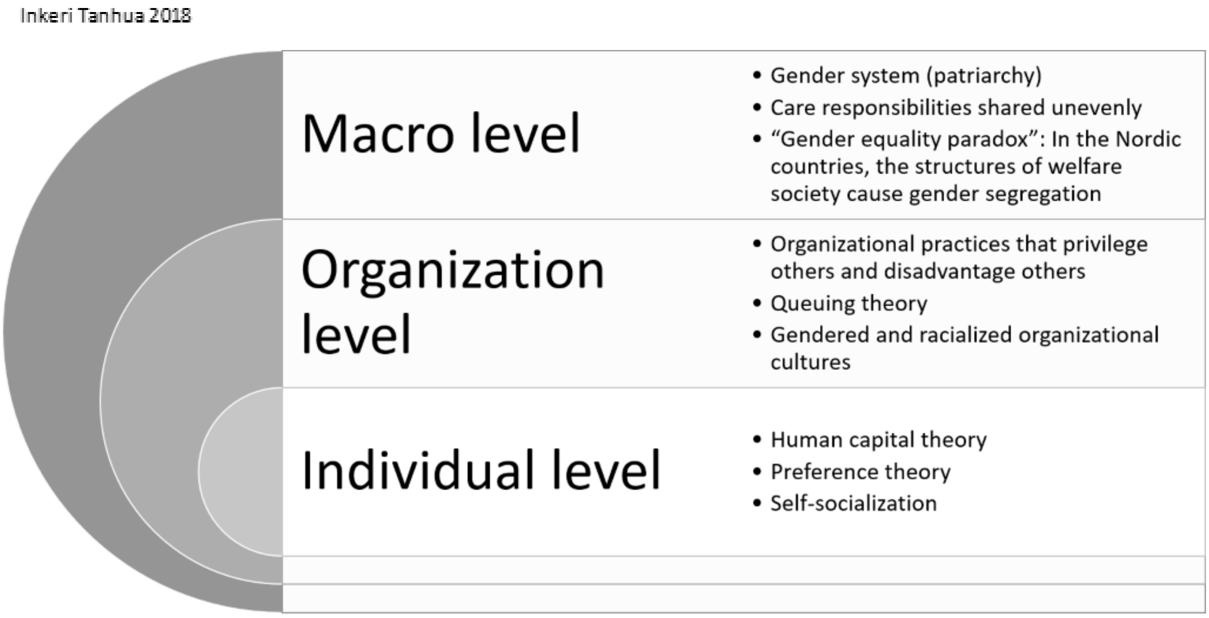

Fig. 1. Theories of gender segregation [6].

Although the phenomenon of horizontal segregation appears universal, there is still considerable variation and complexity in how it manifests in different countries. For example, while Finland is well-known for its gender equality [7], the Finnish labor market is among the most gender segregated. An EU report found that concerning both horizontal and vertical segregation, the same four European countries belong to the high-segregated group: Estonia, Slovakia, Latvia, and Finland [4]. Women head for professions in care and education, whereas men opt for technology, dominating the fields of engineering, manufacturing, construction and ICT [1]. Furthermore, gender segregation persists despite efforts to mitigate it: only minor changes have occurred in the past 30 years. For example, the percentage of women being awarded degrees in technology (at all levels) only increased from 16% in 1987 to 20% in 2017 [1].

Vertical segregation in STEM/engineering

There is a complex array of socioeconomic factors that affect the participation of women in engineering, and hence, the participation of women in engineering is not the same throughout the world [8]. Nonetheless, some patterns are evident in the majority of countries: for example, women's share of professors in engineering and technology has been consistently low, less than 10% [9]. Additionally, "only few women either participate in awarding and decision-making on excellence in technological and engineering research as different gatekeepers or are identified as 'excellent'" [9, p. 132].

Previous studies have indicated that women and men working in engineering and technology have differing career paths and outcomes. Xu found that in STEM occupations in the United States, gender inequality (salary and employment status) is significant from the beginning of post-college employment [10]. Pertaining to full-time employees only, women in STEM occupations reported an average annual income that was 23% lower than the income of their male counterparts in STEM and about 9% lower than males in non-STEM occupations. Roughly one (22.4%) out of five women with a STEM degree worked in occupations not related to their undergraduate major, which was significantly higher than that of STEM men (15.7%). Xu thus observes that with the data indicating that women and men in STEM have comparable academic performance, the evidence is clear that gender-based inequity in STEM is substantial even at the entry to the labor market [10].

Holth, Almasri, and Gonäs show that in the Swedish IT sector, women's and men's chances of obtaining employment in an occupation or position that matches their qualification level differ considerably [11]. Women and men find employment to the same degree after graduating, but men reach higher position levels to a greater extent than women. They argue that the systematic underutilization of women's technical competencies becomes a form of structural discrimination. This underutilization also runs the risk of reproducing and reinforcing perceptions of the strong link between men and technology in general, and men and computer science in particular [11].

Similar results concerning Finland have been presented by Vuorinen-Lampila, who illustrates gender differences in the employment success of Engineering and Economics graduates in favor of men [5, 12]. At the time of graduation, men had adequate employment more often than women, while three years after graduation, men were more likely to have a full-time job and a permanent contract and reached higher organizational positions in the companies they worked for [12]. However, since Vuorinen-Lampila uses survey results of one cohort (graduates of 2002) collected in 2005, albeit with a large sample and high response rate, we wanted to assess the situation with comprehensive register data covering all graduates in engineering and architecture, employed in 2017. Our data also enables us to examine differences between engineering subdisciplines as well as compare differences between age groups. Although we expect our results to concur with previous studies [10, 11, 12], our analysis will provide a more nuanced understanding of occupational gender segregation in engineering in Finland.

Some studies indicate that the career aspirations of women and men in engineering/technology may differ because women have stronger preference for work environments that provide more opportunities and activities to work with people and help others [13]. However, as Kossek, Wu, and Su point out, what appear to be women's individual "choices" are shaped by social context factors in which they are embedded. They propose 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. Nonetheless, workplace initiatives often focus on changing women instead of changing contexts that disadvantage women [13].

Leaky pipeline

Prior research suggests that women are less likely than men to pursue engineering/STEM careers, and more likely to drop out from STEM careers at all stages. This phenomenon has been called the Leaky Pipeline. The Leaky Pipeline metaphor indicates 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. A recent study by Cech and Blair-Loy appears to demonstrate the impact of the leaky pipeline, showing that up to 43% of women leave fulltime STEM employment in the United States after having their first child [14]. New mothers are more likely than new fathers to leave STEM, to switch to part-time work, and to exit the labor force. On the other hand, 23% of new fathers also leave STEM after their first child [14], manifesting that difficulties in combining STEM careers and caregiving responsibilities also cause 'leakage' among men.

The Leaky Pipeline metaphor may, nonetheless, lead to an oversimplified understanding of gender dynamics, indicating that all women experience the same pressures and respond to them in similar ways. Alegria and Branch call the pipeline metaphor woefully inadequate as it assumes that "all women from all schools and backgrounds experience the same science 'pipeline' carrying future scientists equally to all science fields" [15, p. 325]. Differences within subfields of STEM or technology are usually not considered [15, 16]. Moreover, the most significant "leakage points" and their underlying reasons vary depending on the country [8] and may also change over time.

Petray et al. argue that conceptualizing a pipeline may be useful to identify leakage points, but it is unfortunately a limiting metaphor [17]. It suggests a singular career pathway and thus makes it difficult for engineering to truly diversify, relying on individuals being funneled (by schools, and more broadly by society) into the correct pipeline, as well as on their ability to shape themselves to fit within that pipeline. Instead, Petray et al. propose the metaphor of a "deep pool" [17, p. 24] as a more inclusive and less restrictive metaphor of who may enter engineering. Despite its shortcomings, we find the Leaky Pipeline metaphor useful in assessing the situation of women in engineering, particularly in Finland, where the "leakage points" have not yet been established.

Methods

This paper sheds light on the vertical gender segregation in engineering careers in Finland. The analysis is based on national data about the population in employment in Finland in 2017. The objective of the study is to understand the nature and extent of gender differences in different occupational positions held by people graduated with master's or doctoral degrees in engineering and architecture. We also want to see whether the data presents any evidence of the leaky pipeline of female graduates leaving engineering jobs more often than men, and to discover possible subdisciplinary differences among the vertical segregation.
The objectives are pursued by seeking answers to three research questions:

1. What kinds of occupational differences occur between men and women holding a master's or doctoral degree in engineering, technology, and architecture?
2. How do the potential gender differences in occupations vary by subdiscipline, degree, or age?
3. What can we infer from potential gender differences in technical versus nontechnical occupations: is there a Leaky Pipeline in Finland?

Data collection

The data were retrieved from Vipunen, which is a national database based on data and registers collected by Statistics Finland, the Ministry of Culture and Education, and the Finnish National Agency for Education [18]. Data used in this study are freely available from the section "Population, educational and vocational structures," table "Occupations and education of the population in employment," and the report "Employed by occupational group and education." The occupational data provide information on persons aged over 18 and are collected from different sources, such as employer organizations, and central and local government employment relationship registers. The occupation of employed persons is based on their main job during the last week of the year.

The classification of occupations is based on the occupational classification of Statistics Finland, revised in 2010 [19]. The classification has twelve main categories, one of which is "Missing data", and a varying number of secondary categories underneath them. The whole list of occupational categories can be found in Appendix 1. Tables 2 and 3 present information about the categories and subcategories with sufficient representation (>500 persons for the Master level and >100 persons for the doctoral level) to ensure readability of the results.

The scope of the study was restricted to university graduates in engineering and architecture with a total of 74 493 persons. The more practical engineering degrees from universities of applied sciences (which are somewhat similar to engineering technology degrees in the U.S.) were excluded from the analysis. In addition, the bachelor-level university degrees were left out of inspection, as the bachelor-level degree in Finland is more of an intermediate degree, which is not intended to provide actual working life proficiency. The holders of master's and doctoral degrees were analyzed separately. The doctoral degrees actually consist of two different types of post-master's degrees, namely the licentiate and the doctorate, with the former being a shorter and often slightly more practice oriented. Although both degrees still exist, the completion of the licentiate degree has in recent years declined close to zero. However, a couple of decades earlier it was a relatively popular degree, which was completed either as an end point or as an intermediate step to the doctoral degree.

The occupational data of engineering and architecture graduates were divided into four subdisciplinary groupings in the database: Information and Communication Technologies (ICT), Engineering and engineering trades (ENG), Manufacturing and processing (M&P), and Architecture and construction (A&C). A more nuanced division of different engineering disciplines is not possible in the data from this database. The numbers of people employed in 2017 with master's and doctoral or licentiate degrees by their discipline of degree are presented in Table 1.

Table 1. People employed with master's and doctoral or licentiate degrees in engineering or architecture by their subdisciplinary grouping in Finland, 31st of December 2017.

	Professionals with a Master's degree				**Professionals with a Doctoral or licentiate degree**			
Occupation grouping (level 1)	**ICT**	**ENG**	**M&P**	**A&C**	**ICT**	**ENG**	**M&P**	**A&C**
01 Agriculture and forestry work	69	483	63	120	6	75	6	9
02 Manufacturing work	1 884	16 551	1 773	804	174	1 800	228	42
03 Construction work	120	1 542	162	5 859	1-4	60	12	189
04 Transport and logistics work	60	369	42	51	6	6	1-4	1-4
05 Service work	1 104	4 377	648	627	45	162	30	18
06 Office work	1 188	1 314	129	153	42	84	6	1-4
07 Health and social care work	96	246	42	48	9	33	6	1-4
08 Teaching and education	675	1 059	126	288	411	837	54	111
09 Cultural and communications work	321	300	36	93	9	21	1-4	9
10 Other executive and expert work	11 973	8 400	729	1 386	1 014	1 206	81	114
11 Rescue and safety work	42	75	6	12	1-4	9	1-4	
Missing data	441	999	138	231	72	192	12	15
Grand total	**17 973**	**35 718**	**3 894**	**9 675**	**1 791**	**4 485**	**444**	**516**

Data analysis

The data were analyzed mainly with descriptive statistics. Analyses were conducted separately for master's degree holders and for licentiate or doctoral degree holders. The distribution of men and women for each occupational grouping was calculated for all four disciplinary groupings and their totality. The gender distribution in a specific occupation group was compared with the total gender distribution in the respective disciplinary group and with the gender distribution of all the disciplinary groupings combined. The statistical significance of the over- or underrepresentation of women in an occupational group in the disciplines combined was evaluated using Pearson's Chi-square test on a 95% confidence level ($p<0.05$).

To study the leaky pipeline phenomenon, the occupation groupings at level 2 were divided into technical and nontechnical occupations. This was done in agreement with the three authors. The allocation is presented in Appendix 1. The gender distribution in technical and nontechnical occupations was compared both at total level and at the level of disciplinary groupings, and the statistical significance was determined by using Pearson's Chi-square test. To examine whether age plays a role in the analysis, we cross-tabulated the age and gender distributions in level 1 occupational groupings. The possible effects were evaluated by inspecting the results graphically.

Results

The results of the analyses of gender differences in occupational groupings are collected in Tables 2 and 3. Table 2 contains the results for employees with a master's degree in engineering or architecture for those occupational groupings that have at least 500 employees, and Table 3 provides the results for employees with licentiate or doctoral degrees in engineering and architecture for occupational groupings containing at least 100 employees. The blue color in the table cells signals that the share of women within that occupational grouping is at least five percentage points higher than the average share of employed women with the respective degree either in the disciplinary grouping or in total. The red color in the table cell tells that the share of women is at least 5 percent points lower than the average share of women considering the holder's degree. The Pearson's Chi-square values show that at the level of all disciplines, most of the gender differences are statistically significant at the 95 percent confidence level ($p<0.05$) for both levels of degrees.

Table 2. Share of women among employees with a master's degree in engineering or architecture for occupational groupings with more than 500 employees in Finland.

	Professionals employed with a master's degree in engineering or architecture										
	ICT		**ENG**		**M&P**		**A&C**		**All disciplines**		
Occupation grouping (levels 1 & 2)	**All**	**W**	**All**	**W**	**All**	**W**	**All**	**W**	**All**	**W**	**p-value**
01 Agriculture and forestry work	**69**	**17%**	**483**	**37%**	**63**	**52%**	**120**	**45%**	**735**	**38%**	**0.000***
02 Manufacturing work	**1 884**	**13%**	**16 551**	**15%**	**1 773**	**34%**	**804**	**29%**	**21 009**	**17%**	**0.000***
02.5 Mechanical engineers	255	11%	5 127	10%	207	38%	57	32%	5 646	11%	0.000*
02.9 Chemical process engineers	27	44%	1 401	37%	399	32%	18	33%	1 845	36%	0.000*
02.11 Electrical and electronics engineers	843	11%	5 058	12%	69	52%	54	22%	6 024	12%	0.000*
02.14 Managers and other professionals in manufacturing	657	15%	4 449	18%	1 026	32%	636	29%	6 765	21%	0.038*
03 Construction work	**120**	**18%**	**1 542**	**24%**	**162**	**28%**	**5 859**	**36%**	**7 683**	**33%**	**0.000***
03.4 Managers and professionals in construction	108	17%	1 461	25%	156	29%	5 817	36%	7 542	34%	0.000*
04 Transport and logistics work	**60**	**10%**	**369**	**11%**	**42**	**14%**	**51**	**18%**	**525**	**12%**	**0.000***
05 Service work	**1 104**	**23%**	**4 377**	**19%**	**648**	**31%**	**627**	**33%**	**6 756**	**22%**	**0.792**
05.3 Shopkeepers and sales workers	339	25%	1 920	18%	321	32%	213	34%	2 793	22%	0.838
05.4 Managers and professionals in trade	612	23%	2 148	18%	270	30%	291	31%	3 318	21%	0.121
06 Office work	**1 188**	**31%**	**1 314**	**31%**	**129**	**51 %**	**153**	**45%**	**2 784**	**33%**	**0.000***
06.1 Accounting and bookkeeping clerks	156	56%	312	42%	36	58%	45	47%	549	48%	0.000*

06.2 Other office workers	795	24%	639	25%	57	47%	72	42%	1 563	26%	0.000*
06.3 Office work managers and professionals	234	37%	363	32%	36	42%	36	50%	669	35%	0.000*
08 Teaching and education	**675**	**36%**	**1 059**	**31%**	**126**	**67%**	**288**	**32%**	**2 151**	**35%**	**0.000***
09 Cultural and communications work	**321**	**26%**	**300**	**27%**	**36**	**67%**	**93**	**42%**	**753**	**31%**	**0.000***
09.5 Public relations professionals and journalists	252	23%	216	25%	18	67%	45	47%	531	27%	0.000*
10 Other executive and expert work	**11 973**	**16%**	**8 400**	**18%**	**729**	**38%**	**1 386**	**27%**	**22 488**	**18%**	**0.000***
10.2 Professionals in social sciences, humanities and business	681	20%	2 058	19%	264	35%	327	24%	3 330	21%	0.098
10.4 Public administration managers and professionals	477	28%	1 383	25%	147	53%	621	29%	2 628	28%	0.000*
10.5 Computing managers and professionals	10 443	15%	3 747	14%	186	34%	348	25%	14 721	15%	0.000*
10.6 Research and development managers	330	11%	795	12%	93	29%	72	21%	1 287	13%	0.000*
Missing data	441	20%	999	21%	138	41%	231	32%	1 806	24%	0.042*
Grand total	**17 973**	**18%**	**35 718**	**19%**	**3 894**	**37%**	**9 675**	**34%**	**67 260**	**22%**	

Blue colour of the cell signals that share of females in the occupation grouping is 5 or more percent points greater than the total share of females in the respective disciplinary grouping

Red colour of the cell signals that share of females in the occupation grouping is 5 or more percent points smaller than the total share of females in the respective disciplinary grouping

At the level of all the master's degree holders in engineering or architecture, women appear underrepresented in the first-level occupational groupings of Manufacturing work and Transport and logistics work, and overrepresented in Agriculture and forestry work, Office work, Teaching and education, and Cultural and communications work. The service work does not seem to contain gender differences in the second-level occupational groupings either, but the Other executive and expert work, although not over- or underrepresented in the top level, contains segregation in the second-level groupings with women overrepresented among public administration managers and professionals, and underrepresented among Computing managers and professionals, and Research and development managers. Within Manufacturing work, the overrepresentation of women among Chemical process engineers makes an exception to all other second-level groupings, where women are underrepresented.

The two largest disciplinary groupings, Information and Communication Technologies (ICT), and Engineering and engineering trades (ENG) seem to hold fairly similar profiles at the master's level with much the same occupational groupings over- or underrepresented among women. Manufacturing and processing (M&P) differs from the two especially in some occupational groupings within Manufacturing work, and Architecture and construction (A&C) differs from the rest of the three in some groupings within Other executive and expert work.

Table 3. Share of women among employees with a licentiate or doctoral degree in engineering or architecture for occupational groupings with more than 100 employees in Finland.

Employed with a licentiate or doctoral degree in engineering or architecture	**ICT**		**ENG**		**M&P**		**A&C**		**All disciplines**		
Occupation grouping (levels 1 & 2)	**All**	**W**	**All**	**W**	**All**	**W**	**All**	**W**	**All**	**W**	**p-value**
02 Manufacturing work	**174**	**21%**	**1 800**	**21%**	**228**	**39%**	**42**	**29%**	**2 244**	**23%**	**0.200**
02.5 Mechanical engineers	15	0%	294	10%	21	29%	1-4	0%	330	12%	0.000*
02.9 Chemical process engineers	1-4	0%	246	34%	69	48%	1-4	0%	318	38%	0.000*
02.11 Electrical and electronics engineers	36	17%	660	14%	6	0%			699	14%	0.000*
02.14 Managers and other professionals in manufacturing	117	23%	576	29%	129	37%	36	33%	858	29%	0.001*
03 Construction work	**1-4**	**0%**	**60**	**30%**	**12**	**25%**	**189**	**40%**	**264**	**36%**	**0.000***
03.4 Managers and professionals in construction	1-4	0%	60	30%	9	0%	186	40%	261	37%	0.000*
05 Service work	**45**	**13%**	**162**	**24%**	**30**	**20%**	**18**	**33%**	**255**	**22%**	**0.502**
05.4 Managers and professionals in trade	24	13%	96	22%	21	29%	9	0%	150	18%	0.080
06 Office work	**42**	**21%**	**84**	**43%**	**6**		**1-4**	**0%**	**135**	**38%**	**0.000***
08 Teaching and education	**411**	**20%**	**837**	**22%**	**54**	**28%**	**111**	**30%**	**1 416**	**23%**	**0.223**
10 Other executive and expert work	**1 014**	**16%**	**1 206**	**28%**	**81**	**33%**	**114**	**18%**	**2 415**	**23%**	**0.116**
10.1 Mathematicians and natural science professionals	1-4	0%	303	36%	6		6		315	36%	0.000*
10.2 Professionals in social sciences, humanities and business	84	25%	258	33%	21	43%	48	13%	411	29%	0.021*
10.4 Public administration managers and professionals	63	19%	225	32%	21	43%	42	21%	351	30%	0.015*
10.5 Computing managers and professionals	807	16%	258	13%	12	25%	6	0%	1 083	15%	0.000*
10.6 Research and development managers	54	11%	150	20%	21	14%	9	0%	234	17%	0.008*
Missing data	72	13%	192	25%	12	25%	15	40%	294	23%	0.780
Grand total	**1 791**	**18%**	**4 485**	**25%**	**444**	**36%**	**516**	**33%**	**7 233**	**24%**	

Blue colour of the cell signals that share of females in the occupation grouping is 5 or more percent points greater the total share of females in the respective disciplinary grouping

Red colour of the cell signals that share of females in the occupation grouping is 5 or more percent points smaller than the total share of females in the respective disciplinary grouping

At the level of licentiate or doctoral degree holders, the gender differences within occupational groupings are scarcer, as can be seen in Table 3. Also here women are overrepresented in Construction work and Office work, but there are no other statistically significant gender differences among the first-level occupational groupings. Similar to the master's level, women are underrepresented in the second-level occupational groupings of Mechanical engineers, Electrical and electronics engineers, Computing managers and professionals, and Research and development mangers, and overrepresented among Chemical process engineers and Public administration managers and professionals. Opposite to master's level findings, women are overrepresented among the Managers and other professionals in manufacturing. Women are also statistically significantly overrepresented among Mathematicians and natural science professionals and Professionals in social science, humanities, and business, where the master-level differences are nonsignificant, whereas among Teaching and education occupational grouping the statistically significant overrepresentation of women at the master's level turns into slight, statistically not significant, underrepresentation.

The disciplinary groupings seem to have more distinct profiles from each other than at the master's level when it comes to gender differences, especially in the occupational groupings in Manufacturing work. Some of this is probably due to very small numbers of employees in certain second-level occupational groupings and disciplinary groupings. In Other executive and expert work, the profiles of ICT, ENG, and M&P appear quite similar, but the profile of A&C is rather different from the other three.

Categorizing occupational groupings into technical and nontechnical occupations reveals that women holding a master's degree are statistically significantly overrepresented in nontechnical occupations in total and in disciplinary groups of ICT and ENG. Women with a licentiate or doctoral degree are overrepresented in nontechnical occupations in total and in the disciplinary group of Engineering and engineering trades, which is also by far the largest of the four disciplinary groups. Results are presented in more detail in Table 4.

Table 4. Share of employees with a higher technical degree in nontechnical occupations.

Employees in nontechnical occupations	**ICT**			**ENG**			**M&P**			**A&C**			**All disciplines**		
	M	**W**	**p-value**	**M**	**W**	**p-value**	**M**	**W**	**p-value**	**M**	**W**	**p-value**	**M**	**W**	**p-value**
Master-level degree	18%	31%	**0.000**	28%	36%	**0.000**	36%	38%	0.228	18%	18%	0.937	25%	31%	**0.000**
Licentiate or doctoral degree	13%	15%	0.294	17%	25%	**0.000**	20%	23%	0.369	23%	20%	0.430	17%	23%	**0.000**

The cross-tabulation of age and occupational grouping (level 1) shows no striking differences between men and women for both degree levels. The distributions are illustrated in Figs. 2 and 3. Women with a master's degree in all age groups are less likely to work in the manufacturing occupations, and the tendency to move out of manufacturing work grows with age for both genders. Women in all age groups have a greater share of employees working in the construction work, whereas the share of people working in other executive and expert work occupations appears rather similar to both genders. In general, women seem to be more evenly distributed throughout all occupational groupings in all age groups, but the gender difference does not strike as radical.

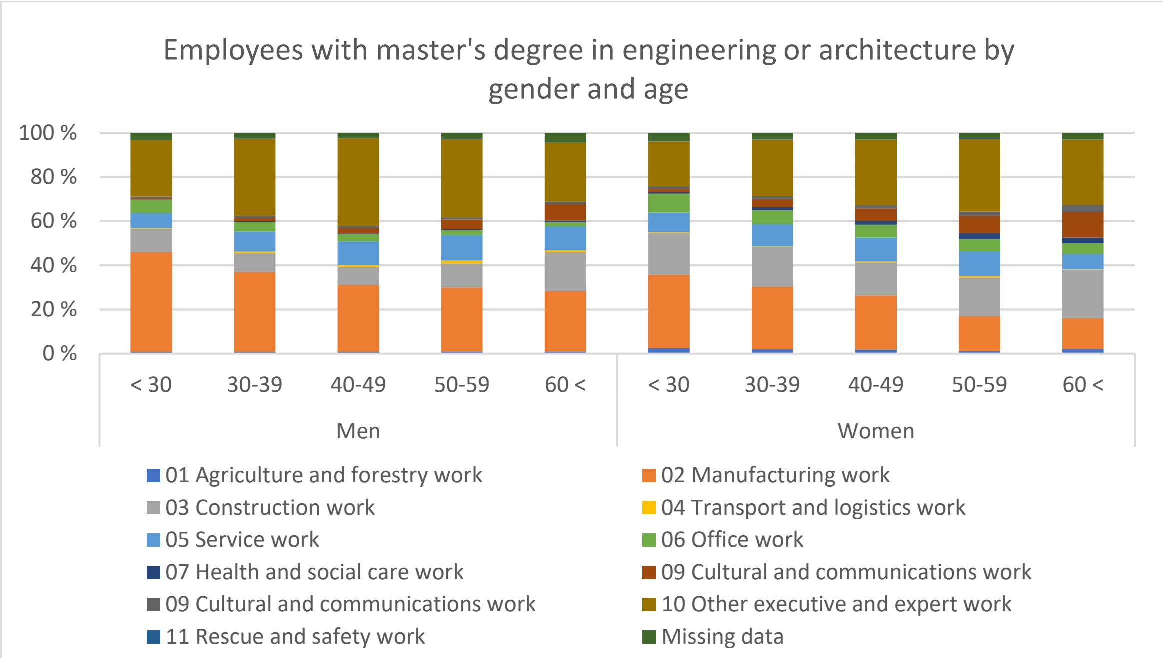

Fig. 2. Employees with a master's degree in engineering or architecture by gender and age.

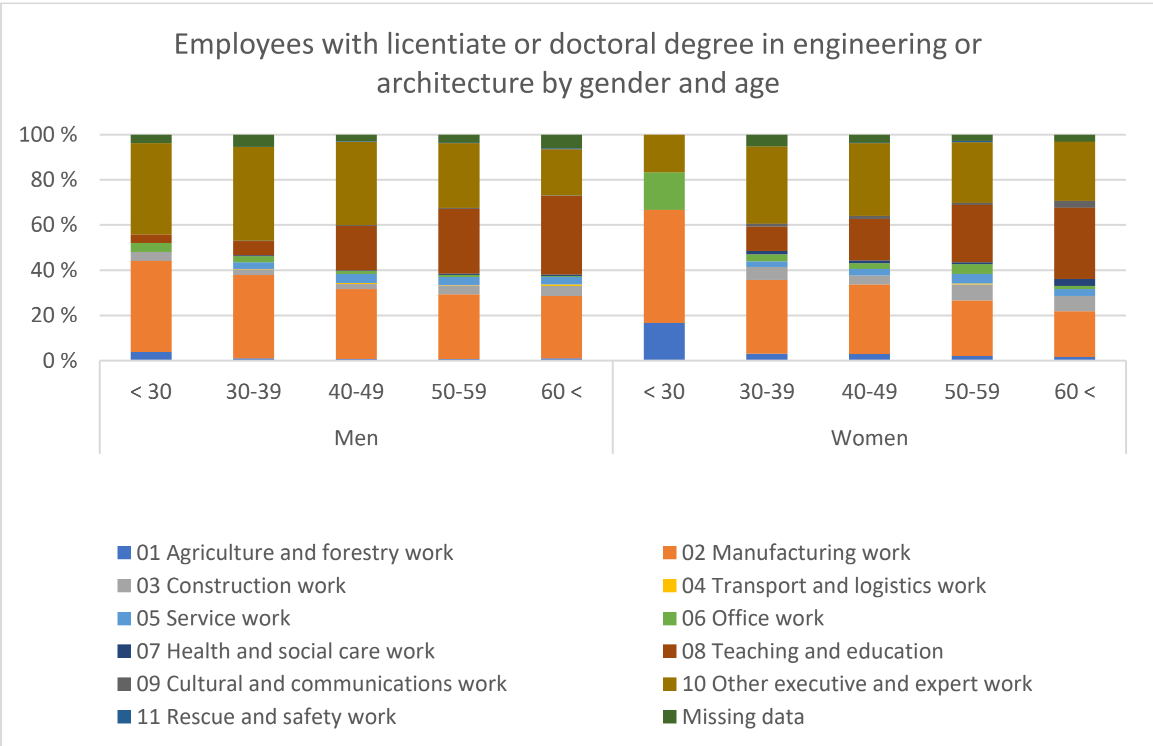

Fig. 3 Employees with a licentiate or doctoral degree in engineering or architecture by gender and age.

Also at the level of higher degrees, the distribution of workers in different occupational groupings in all age groups, except for the youngest ones, meets the eye as very similar to both genders. In the age group below thirty, the distribution of men and women in different occupations looks quite different, but this is most probably due to the far smaller numbers of people in these groups compared with the other age groups—only 48 men and 12 women belong to this age group. Hence, it seems that at both degree levels, the gender differences in different occupational groupings are not likely to be explained, to a great extent, by the age of the employed.

Discussion

In this paper, we strive to describe and understand the disparities that possibly lead men and women with a higher degree in engineering or architecture in Finland into different occupational paths. Based on our data, it is evident that women and men are not employed in identical occupations. Our results thus confirm those of Vuorinen-Lampila [12] as well as extend them to identify differences between engineering subdisciplines. The major dividing lines are drawn, on the other hand, according to subdisciplinary groups, but on the other hand, according to the position in the occupational hierarchy. Men are more often employed in technical occupations versus nontechnical and are, in general, overrepresented in managerial positions. On the other hand, age and level of degree do not seem to make major dividing lines in the occupational structure.

When we look at the subdisciplinary differences more closely, women are especially underrepresented in manufacturing work, such as mechanical engineering and electronics engineering, professions that employ a large mass of the men educated in the field. Expert occupations within ICT, and research and development roles are likewise occupations where women are significantly underrepresented. Women are instead overrepresented in expert roles in material and process technology, and in a vast array of commercial roles, such as accounting, clerical work, PR and communications, and public administration management. These differences in occupations seem to also hold quite consistently when looking at engineering degrees from different fields, albeit architecture and construction has a differing profile from other engineering educations, architecture being currently a field in Finland where women make up the majority of graduates.

Similar differences persist when looking at professionals holding a doctoral degree. However, it should be noted that in many occupational groupings the numbers of female degree holders per subdisciplinary group are so small that it limits the power of statistical explanation. Even at the doctoral level, women are underrepresented in manufacturing work and overrepresented in commercial work, although differences are somewhat less distinct. An exception to this is the women with a degree in ICT, who are overrepresented in managers and other professionals in manufacturing, for reasons we cannot anticipate based on our data. A clear deviation from this pattern is related to educational professions. At the master’s level, women have a higher share of teaching- and education-related roles, but this difference disappears when observing the occupations at the doctoral level. However, we do not see this development as plausibly challenging the overall picture of the occupational differences, as the doctoral-level teaching positions tend to simultaneously be the leadership roles of the academia.

Overall, women are underrepresented in managerial positions in our data. This conclusion should be regarded as tentative as some of the occupational categories in our data combine expert and managerial positions. Previous research, however, supports the assumption that the same differences seen between categories hold within the categories. Finnish Academic Engineers’ and Architects (TEK) annual working life survey documents the underrepresentation of engineer women in leadership roles year after year, and the differences become even more distinct on higher organizational ladders [20]. Our data also suggest that, with the exception of construction work, women end up more often in managerial positions in less technical areas, such as office work or public administration, and less often in managerial positions in computing or R&D, which are often thought to require technical expertise. This may be explained by the inverted role hierarchy in engineering, where technical is valued over managerial, and it can bring about unintended consequences even when women are actively promoted into managerial positions [21].

We also examined the possibility if the occupational differences of men and women at hand could be explained by the respondents' age. A statement often heard is that the representation of women in leadership roles in technology will self-correct with time as the share of women in the industry increases in general. Our data do not support the assumption of underrepresentation disappearing with time, as the representation patters remain stable through different age cohorts in our data. This also means that the higher share of men in expert positions is not due to the on average longer work experience men hold, as differences are visible already in the early phases of the career.

Our data demonstrates clearly that women are more often than men employed in occupations that can be classified as nontechnical, meaning that women are not working in occupations where the core technical knowledge is being utilized. This can lead to many unwanted professional developments, as the occupational hierarchy and professional competence within engineering is highly intertwined with the level of technical knowledge required for the role [22]. We therefore conclude that our results provide evidence of the leaky pipeline also in Finland, meaning that women engineers tend to drift to the sidelines of the core engineering professions or are employed in completely or partly unrelated professions.

Results unveiling gendered processes within fields are an important step forward in the Finnish discussion about gender segregation. If we only focus on dismantling gender segregation between fields, the discussion may stay on the individual level focusing on occupational preferences that are gendered. Examining the inequalities that persist even between men and women with similar educational choices makes visible the discriminatory processes in organizations and biased ideas about genders that, in part, contribute to producing a steeply gendered workforce.

Conclusions and implications

Altogether, the role of nontechnical jobs, underrepresentation in managerial positions, and stability of the occupational structure by age give evidence of the leaky pipeline phenomenon also in Finland. It is evident that gender segregation of occupations persists regardless of several attempts to combat it even in Finland [23]. Simply encouraging to choose fields of study that are not typical to one's gender or to take on more demanding roles is not sufficient to deal with the labor market segregation, as particularly women working in male-majority workplaces still seem to experience more gendered problems than others in their working life, for instance with wage levels and career advancement [24].

When looking at the implications of our findings, the evident next question would be about the causes of the differences. As Tanhua lays out, occupational segregation can be an implication of individual, meso- and macrolevel developments, choices, and attitudes [6]. To understand how the differences in occupations are created, it is crucial to examine the variation in the level of occupational segregation in different organizations. If much of the segregation can be explained by organizational differences, much of the segregation can thus also be tackled by addressing the policies and practices of organizations where engineering professionals are employed. However, if it holds more true that a macrolevel patriarchal system affects the various ways the paths women take and are given within engineering, it is evident that these kinds of structures and deep cultural and symbolical meanings that produce different occupational roles cannot be addressed by simply paying attention to organizational policies.

Another interesting implication is the decrease in women's underrepresentation in certain roles when reaching doctoral-level education. This phenomenon could be viewed as education being a protective factor against a less-appreciated occupational status. However, this would require a closer analysis of the roles men and women hold, to see if for example the quality and pay of managerial roles is similar for men and women holding a doctoral degree in engineering.

References

[1] M. Keski-Petäjä and M. Witting, "Alle viidennes opiskelijoista opinnoissa joissa tasaisesti naisia ja miehiä – koulutus-alojen eriytyminen jatkuu" [Less than a fifth of students study in disciplines with even numbers or women and men – the gender segregation of educational fields continues], *Tieto & trendit*, Statistics Finland, 2018. [Online]. Available: https://www.stat.fi/tietotrendit/artikkelit/2018/alle-viidennes-opiskelijoista-opinnoissa-joissa-tasaisesti-naisia-ja-miehia-koulutusalojen-eriytyminen-jatkuu/.

[2] A. Kauhanen and K. Riukula, "Työmarkkinoiden eriytyminen ja tasa-arvo Suomessa," [The segregation of job market and equality in Finland] in *Näkökulmia sukupuolten tasa-arvoon. Analyyseja tasa-arvobarometrista* 2017, M. Teräsaho, and J. Närvi, Eds. Helsinki: Finnish Institute for Health and Welfare and Ministry of Social and Health, 2019, pp. 80–100.

[3] B. Burchell, V. Hardy, J. Rubery, and M. Smith, *A new method to understand occupational gender segregation in European labour markets*, European Union, 2014. [Online]. Available: https://op.europa.eu/en/publication-detail/-/publication/2f6938c9-86ac-11e5-b8b7-01aa75ed71a1/language-en.

[4] F. Bettio and A. Vershchagina, *Gender Segregation in the Labour Market. Root Causes, Implications and Policy Responses in the EU*. Luxembourg: European Commission, 2009. [Online]. Available: http://ec.europa.eu/social/main.jsp?catId=738&furtherPubs=yes&langId=en&pubId=364.

[5] P. Vuorinen-Lampila, *Korkeakoulutuksen eriytyvät työelämätulokset* [Diverging employment outcomes of higher education], Doctoral dissertation, Faculty of Education and Psychology, University of Jyväskylä, 2018. [Online]. Available: http://urn.fi/URN:ISBN:978-951-39-7529-6.

[6] I. Tanhua, *Teorioita sukupuolenmukaisen segregaation syistä* [Theories of gender segregation], Research report by SEGLI project, 2018. [Online]. Available: https://www.kaikkienduuni.fi/teorioita-segregaation-syist/ [English translation of graph provided by Tanhua to the Authors].

[7] R. Hutt, “These 10 countries are closest to achieving gender equality,” *World Economic Forum*, 17 Dec 2019. [Online]. Available: https://www.weforum.org/agenda/2019/12/gender-gap-equality-women-parity-countries/.

[8] S. Singh and S. Peers, “Where are the Women in the Engineering Labour Market? A Cross-Section Study,” *Gender, Science and Technology,* vol. 11, no. 1, pp. 203–231, 2019.

[9] L. Husu and P. Koskinen, “Gendering Excellence in Technological Research: A Comparative European Perspective,” *Journal of Technology Management & Innovation,* vol. 5, no. 1, pp. 127–139, 2010.

[10] Y.J. Xu, “Attrition of Women in STEM: Examining Job/Major Congruence in the Career Choices of College Graduates,” *Journal of Career Development,* vol. 44, no. 1, pp. 3–19, 2017.

[11] L. Holth, A. Almasri, and L. Gonäs, “Career patterns for IT engineering graduates,” *Economic and Industrial Democracy,* vol. 34, no. 3, pp. 1–7, 2013.

[12] P. Vuorinen-Lampila, “Gender segregation in the employment of higher education graduates,” *Journal of Education and Work,* vol. 29, no. 3, pp. 284–308, 2016.

[13] E.E., Kossek, R. Su, and L. Wu, “Opting Out” or “Pushed Out”? Integrating Perspectives on Women’s Career Equality for Gender Inclusion and Interventions,” *Journal of Management,* vol. 43, no. 1, pp. 228–254, 2017.

[14] E.A. Cech and M. Blair-Loy, “The changing career trajectories of new parents in STEM,” *PNAS,* vol. 116, no. 10, pp. 4182–4187, 2019.

[15] S. N. Alegria and E. H. Branch, “Causes and Consequences of Inequality in the STEM: Diversity and its Discontents,” *International Journal of Gender, Science and Technology,* vol. 7, no. 3., 2015. [Online]. Available: http://genderandset.open.ac.uk/index.php/genderandset/article/view/307/717.

[16] M.A. Kanny, L.J. Sax, and T.A. Riggers-Pieh, “Investigating forty years of STEM research: How explanations for gender gap have evolved over time,” *Journal of Women and Minorities in Science and Engineering,* vol. 20, no. 2, pp. 127–148, 2014.

[17] T. Petray, T. Doyle, R. Harrison, E. Howard, and R. Morgan, “Re-Engineering the “Leaky Pipeline” Metaphor: Diversifying the Pool by Teaching STEM “by Stealth”.” *Gender, Science and Technology,* vol. 11, no. 1, pp. 10–29, 2019.

[18] Vipunen, Vipunen – Education statistics Finland, n.d. Available; https://vipunen.fi/en-gb/.

[19] Statistics Finland, Classification of Occupations 2010, n.d. [Online]. Available: https://www.tilastokeskus.fi/en/luokitukset/ammatti/ammatti_1_20100101/.

[20] S. Bairoh, “Valitaanko pätevä vai nainen? Sukupuolten tasa-arvo ja johtotehtäviin eteneminen tekniikan korkeakoulutettujen työpaikoilla,” [Hiring a woman or a qualified person? Gender equality and leadership positions in engineering labour market] Diversiteetti

tekniikan alalla tutkimushankkeen tuloksia, TEK, 2019. [Online]. Available: https://www.tek.fi/fi/cmis/browser?id=workspace%3A//SpacesStore/254047c1-b9dc-46aa-926b-12c4978292d8&filename=cmisattachments/tek_pateva-vai-nainen_raportti_2019.pdf.

[21] M. T. Cardador, “Promoted Up But Also Out? The Unintended Consequences of Increasing Women’s Representation in Managerial Roles in Engineering,” *Organization Science*, vol. 28, no. 4, pp. 597–617, 2017.

[22] E. Cech, B, Rubineau, S. Silbey, and C. Seron, “Professional Role Confidence and Gendered Persistence in Engineering,” *American Sociological Review*, vol. 76, no. 5, pp. 641–666, 2011.

[23] T. Koivunen, S. Ojala, T. Saari, and N. Viitasalo, “Sukupuolten tasa-arvo työelämässä,” [Gender equality in working life] in *Työelämän myytit ja todellisuus*, P. Pyöriä, Ed. Helsinki: Gaudeamus Helsinki University Press, 2017.

[24] M. Teräsaho and J. Närvi, ”Johdanto” [Introduction] in *Näkökulmia sukupuolten tasa-arvoon. Analyyseja tasa-arvobarometrista* 2017, M. Teräsaho, and J. Närvi, Eds. Helsinki: Finnish Institute for Health and Welfare and Ministry of Social and Health, 2019, pp. 12–16.

Appendix 1: Occupational classification and the inclusion of occupational groupings in different types of analysis

Names of Level 1 and 2 Occupational groupings	Included in the reporting tables		classified as technical occupation
	Master's degree (>500)	**Licentiate or doctoral degree (>100)**	
01 Agriculture and forestry work	x		
01.1 Agricultural entrepreneurs and workers			
01.2 Horticultural entrepreneurs and workers			
01.3 Forestry workers			
01.4 Agricultural and forestry professionals			
02 Manufacturing work	x	x	
02.1 Food workers			
02.2 Textiles, clothing and leather workers			
02.3 Metal workers			x
02.4 Machinery mechanics			x
02.5 Mechanical engineers	x	x	x
02.6 Construction and industrial equipment operators			
02.7 Wood processing workers and technician			x
02.8 Chemical process workers			x
02.9 Chemical process engineers	x	x	x
02.10 Electrical and electronics workers			x
02.11 Electrical and electronics engineers	x	x	x
02.12 Graphics workers			
02.13 Packaging and assembly workers			
02.14 Managers and other professionals in manufacturing	x	x	x
03 Construction work	x	x	
03.1 Builders			
03.2 Heating, plumbing and ventilation fitters			
03.3 Building painters			
03.4 Managers and professionals in construction	x	x	x
04 Transport and logistics work	x		
04.1 Land transport workers and entrepreneurs			
04.2 Water traffic operators and officers			
04.3 Air transport managers and professionals			
04.4 Warehouse workers and forwarding agents			
05 Service work	x	x	
05.1 Property managers and building caretakers			
05.2 Cleaners			
05.3 Shopkeepers and sales workers	x		
05.4 Managers and professionals in trade	x	x	x
05.5 Restaurant and catering workers			
05.6 Hotel, restaurant and catering managers and professionals			
05.7 Travel service workers			
05.8 Beauty care workers			
05.9 Other service workers			

06 Office work	x	x	
06.1 Accounting and bookkeeping clerks	x		
06.2 Other office workers	x		
06.3 Office work managers and professionals	x		
07 Health and social care work			
07.1 Health care assistants			
07.2 Nurses and other health care professionals			
07.3 Medical doctors and other health professionals			
07.4 Social services workers and instructors			
07.5 Social work professionals			
07.6 Health and social services managers			
08 Teaching and education	x	x	x
08.1 Teaching professionals			
09 Cultural and communications work	x		
09.1 Crafts and design workers			
09.2 Artists and other artistic professionals			
09.3 Artistic and cultural services managers and producers			
09.4 Librarians, archivists and curators			
09.5 Public relations professionals and journalists	x		
10 Other executive and expert work	x	x	
10.1 Mathematicians and natural science professionals		x	x
10.2 Professionals in social sciences, humanities and business	x	x	
10.3 Legal professionals			
10.4 Public administration managers and professionals	x	x	x
10.5 Computing managers and professionals	x	x	x
10.6 Research and development managers	x	x	x
11 Rescue and safety work			
11.1 Police officers, firefighters and prison guards			
11.2 Armed forces			
11.3 Other rescue and security workers			
Missing data	x	x	