THE TECH GENDER GAP AND COMPUTATIONAL LEARNING IN DENMARK

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RESEARCH QUESTION

The tech gender gap that exists in the United States has been studied by many researchers, and numerous theories exist around why it has been so difficult to remedy. Many of the factors suggested as contributing to the tech gender gap are rooted in social norms around gender roles. Women are less likely to view technical careers as viable choices due to messages received from a very early age, reinforced by experiences both in and out of school. The message that technical subjects are 'hard' and that technical hobbies are for 'geeks' is reinforced repeatedly, leading girls and women to view both are the realm of boys and not suitably 'feminine.' There are significant differences between US and Danish society, yet a similar tech gender gap exists in Denmark. What factors in Danish society and education contribute to the existence of this tech gender gap in Denmark? This paper will examine the Danish tech gender gap in the context of Danish society and examine how technical expertise is acquired by women in Denmark today.

1 Introduction

In the 1980's, it seemed that women in the United States were making steady inroads in both attaining degrees in computer science and in finding employment as engineers. However, since that time, the proportion of women in both computer science majors and in technical positions in industry has declined. Today, only about 18% of students majoring in computer science are women and women hold fewer than 20% of tech jobs in the United States. It is thought that the decline in women studying computer science started when introductory classes were transformed into "weed out" classes when computer science programs were not able to keep up with the their increasing course enrollments. As a result of societal conditioning starting at an early age, women enter college lacking confidence in their ability to succeed in technical majors such as computer science. In addition, the tech domain became infamous for its toxic environment for women. In the United States, this gender disparity has been the focus of much academic research and is a frequent topic of public discourse, as shown in Figure 1 [1].

Denmark, in contrast to the United States, is recognized as a world leader in gender equality. In a promotional website maintained by the Ministry of Foreign Affairs of Denmark, one learns that equality is a deeply ingrained Danish value [2]. The website goes on to discuss the *Law of Jante*, that dictates that Danes should not consider themselves, individually, as special or better than others. In keeping with this fictional law, Danish schools avoid ranking students or drawing too much attention to individual achievements [2]. One would think that in an environment so committed to keeping everyone on an even footing, women would not be discouraged from considering technical fields due to a lack of confidence in their abilities, the way they are in the United States.

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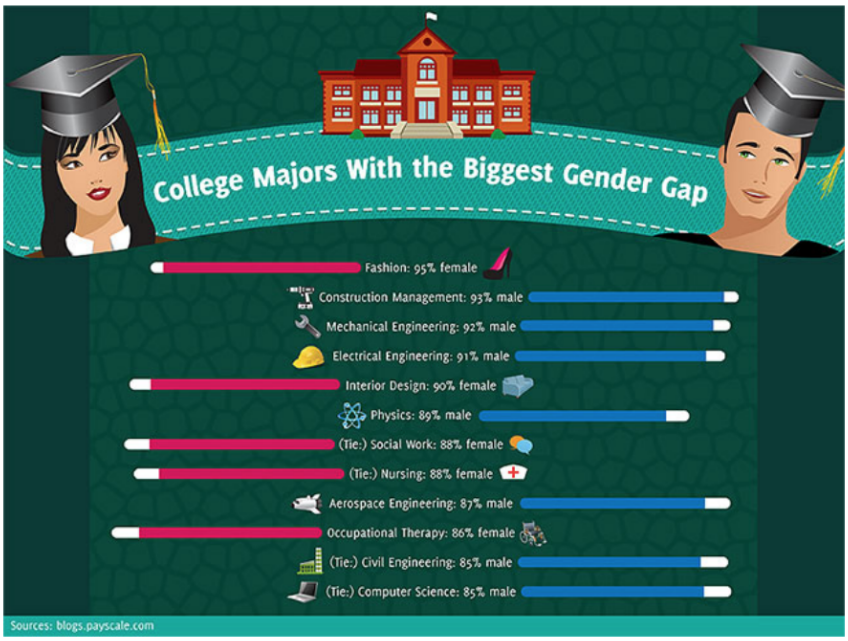

Figure 1: Gender gap infographic from US blog site. [1]

2 Background: The Copenhagen Tradition

Computer science education in Denmark has been strongly influenced by Peter Naur, a pioneer in the field who worked at the University of Copenhagen from 1969 to 1999 [3]. He recognized that computer science could be more effectively taught if it were closely connected to applications and other fields of knowledge. It should not be studied in isolation – rather, it should be considered as a human activity [4]. So that students got this applied, human experience of computer science, learning was primarily accomplished via comprehensive projects [4]. This emphasis on learning programming in context, combining the technical requirements with an awareness of the human factors was named "datalogy" – "the science of the nature and use of data" [4]. The relationship between the components of a project is illustrated in Figure 2, where computers were viewed as tools to aid in problem solving [4].

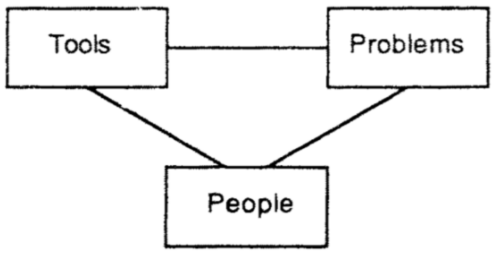

Figure 2: The basic components of problem solving situations according to Naur. [4]

Computer science curricula in Denmark thus developed in an interdisciplinary manner, with researchers from many different domains collaborating on projects, leading to very creative and productive research environments [4]. With the guidance of their teachers and more advanced student mentors, computer science students were thus engaged in solving real problems that required them to draw upon their acquired theoretical knowledge [4]. In addition, Peter Naur believed strongly that computer science should be taught as part of general education, as he foresaw that it would soon be necessary to "prepare ourselves for life in the era of the computers, just as reading and writing are regarded as necessary prerequisites for life in a society characterized by the printed word." [4]. With With such beginnings, why didn't computer science education and employment in Denmark become more inclusive?

3 The Status of Gender Equality in Denmark

As mentioned earlier, Denmark's position as a world leader in gender equity is enviable. The table shown in Figure 3 was published in a brief put out by the Organisation for Economic Co-operation and Development (OECD). It shows Denmark as the top performer overall in an assessment of a number of measures of gender equality in employment [5].

Key measures of gender gaps in employment, Nordic and selected other OECD countries, 2016 or latest available year

	Top performer		Moderate performer		Bottom performer		
	Gender gap in the labour force participation rate, 15-64 year-olds (p.p.)	Gender gap in the employment rate, 15-64 year-olds (p.p.)	Gender gap in the employment rate, low education, 25-64 year-olds (p.p.)	Gender gap in the employment rate, high education, 25-64 year-olds (p.p.)	Gender gap in usual weekly working hours, all ages (p.p.)	Female share of managers, all ages (%)	Gender gap in median earnings for full-time employees, all ages (%)
Denmark	6.3	6.2	17.9	4.9	4.2	27.3	5.8
Finland	3.0	2.0	16.7	4.0	4.0	33.8	18.1
Iceland	4.8	4.8	11.3	5.5	8.4	33.3	9.9
Norway	4.3	3.6	11.3	1.4	4.8	37.8	7.1
Sweden	3.6	3.0	13.7	1.5	3.6	39.4	13.4
Canada	7.6	6.1	19.7	6.7	5.6	35.5	18.2
France	7.9	6.4	13.9	5.8	5.6	32.9	9.9
Germany	9.1	8.0	16.4	6.7	8.7	29.3	15.5
Italy	20.0	18.3	30.8	10.0	7.3	27.7	5.6
Japan	18.2	17.2	..	21.1	..	13.0	25.7
United Kingdom	10.3	9.4	20.6	8.0	9.0	36.0	16.8
United States	11.5	10.8	25.2	9.8	4.0	43.4	18.1
OECD average	12.2	11.4	20.4	8.7	5.9	32.3	14.1
OECD std. dev.	8.0	7.8	9.0	5.5	2.5	8.0	7.2

Figure 3: Table comparing performance on several measures of gender equality. [5]

Upon closer examination, however, gender equality is perhaps not as universal as it is perceived to be. A few years ago, in 2015, a pair of political science researchers presented their findings from what they thought might be the first study of attitudes towards gender equality in Scandinavia [6]. They found that Denmark, at that time, lacked any real conversation around gender equality, and in contrast with other countries, most notably Sweden, being identified as "feminist" in Denmark was seen as being shameful [6]. Furthermore, both men and women largely placed the responsibility for disparities that existed on individual choices made by women to prioritize their families over their careers (60% of men, 55% of women) or to choose not to seek certain positions of leadership (61% of men, 61% of women) [6]. In contrast, only 18% of men and 37% of women identified being passed over for promotions as a possible reason for the disproportionate lack of women in leadership positions [6]. Finally, very few men (28%) and only half of all women (50%) agreed with the statement "In some important areas, gender equality is still not obtained" [6]. It is hard to "fix" something that is not recognized as being a problem.

4 Denmark as a World Leader in IT

The International Trade Administration (ITA) of the U.S. Department of Commerce classifies computer software and information technologies as a "best prospect industry sector" for Denmark, presumably an area that is likely to experience strong growth and profitability [7]. Denmark is described as being "a highly computerized society with a large and steady demand for state-of-the-art software and IT products," and the Information and Communication Technologies (ICT) sector is valued at USD 35 billion [7]. Areas singled out as likely to be especially important include green IT, medical information systems, and cybersecurity [7]. Denmark's highly developed IT infrastructure was also recognized in its top ranking in the 2018 UN e-Government Survey [8]. This 1 ranking in access and use of information technologies was determined based on Denmark's Online Services Index, Telecommunication Infrastructure Index, and Human Capital Index [8].

In addition to having superlative digital services, Denmark also has string research programs in areas that rely on computing, such as biotechnology, ICT, and new production technologies [9]. Denmark competes with much larger nations in these areas, and would only benefit from having as high a percentage of its population being digitally literate (i.e. being able to design and produce, not simply use new technology) as possible In 2016, Denmark's Agency for Digitisation published the Digital Strategy for the country for the next 4 years (2016-2020). This document laid out how all segments of Danish society, private businesses, NGOs, universities, hospitals, municipal administrations, etc. would need to work together to achieve digital transformation and to help"secure the foundation for a strong and secure digital Denmark" [10]. The strategy has 9 focus areas, the last of which addresses "Digitisation for Everyone" and lists, as one of its major initiatives, ensuring that children are provided with "digital skills to interact digitally with society" as part of their pre-university schooling [10].

5 Technology Gender Gap

While the issue of gender inequality in technology does not seem to have gotten as much attention in Denmark as in the United States, there are signs that this may be changing. Statistics Denmark, a governmental organization under the Ministry for Economic and Interior Affairs, collects data on education in Denmark, including higher education. These data sets are available online [11]. Using the interactive query system, one discovers that 20,558 of 59,938 STEM students (34.3%) are women (`https://statbank.dk/ligeub6`). However, if you look specifically at H60 (Research) Bachelors enrollments, only 19.6 % of students are women (`https://statbank.dk/ligeui6`). Unfortunately, this databank does not break the data down further, but computing is likely to have an even lower representation of women, as STEM likely includes other areas of study that attract more women students (e.g. life sciences).

Students who do enter computing majors are likely to encounter further inequity-related challenges. In academia as a whole, the proportion of women at increasing levels in the Danish academic hierarchy drops consistently. As shown in Figure 4, this pattern is not unique to Denmark, but it is especially pronounced in Denmark, with Denmark being the only Scandinavian country falling below the European averages [12]. In human terms, this means that new students considering computing majors or careers are facing a lack of mentors and role-models, and may receive the message (either subliminal or overt) that they are considering entering a domain where they are not welcome.

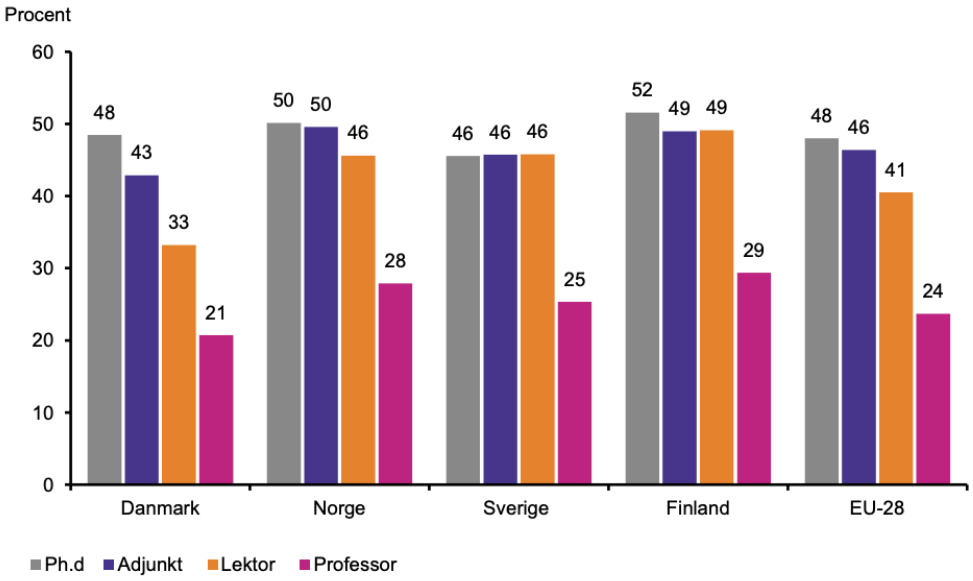

Figure 4: Proportions of women at each stage of the academic hierarchy. [12]

Fifteen years ago, a pair of computer science instructors working with students in a joint program in computer science and business administration conducted a study to investigate the apparent lack of motivation among students in the program. Although it was not the central focus of the study, the gender breakdown they presented in describing their study population is telling: of the students in the program, 90% are male and only 10% are female [13]. It seems not much has changed. Furthermore, the technology gender gap at the university level continues to receive little official notice. Danish Universities collect data and prepare annual reports on the status of university enrollment. In 2017,

this report did not contain any specific references to women, and none of the statistics reported differentiated between genders [14]. In 2018, the single paragraph in the report that specifically commented on the progress of women described how enrollment of women in technical and scientific fields had increased from 30% in 1990 to 37% in 2017 [15]. Yet again, no deeper analysis of the data was reported.

In 2013, the Danish Council for Independent Research released a report examining gender distribution in the Danish research domain [16]. Among their findings were the following:

- Women are earning PhDs at rates approaching those of men.
- Women are still underrepresented among lecturers and professors in Danish universities, with the greatest disparity existing in the domain of science and technology.
- Women are slightly less successful at obtaining grant funding.
- Women are recruited by their supervisors for postdocs about half as frequently as their male peers are.
- Within 4 years of receiving grant funding, males may expect to have advanced in their careers, while the career advancement of women grant recipients is similar to that of male grant rejectees.

These findings are consistent with those presented by other groups, such as The European Commission's periodic "She Figures" reports [17].

Just a year later, a special experimental grant to support women in research launched in Denmark. Due to the political uproar generated by the gender exclusivity of the grant, it is unlikely to be offered again [18]. Ironically, this special grant was much harder to obtain than regular grant funding through Danmarks Frie Forskningsfond (DFF), with only 3% of grant applications funded, versus the typical 11% for grants submitted by women [18].

Outside of academia, the picture may be even worse. If trends in Denmark follow trends in the United States, the proportion of women holding non-academic tech jobs are likely to be even lower than those holding academic positions. In the United States, this gender gap in employment, along with a concurrent gender gap in salary, has received considerable attention (see Figure 5), with a number of prominent technology companies publishing their (often less-that-impressive) gender employment statistics and stating their commitment to invest in recruiting and retaining female employees [19].

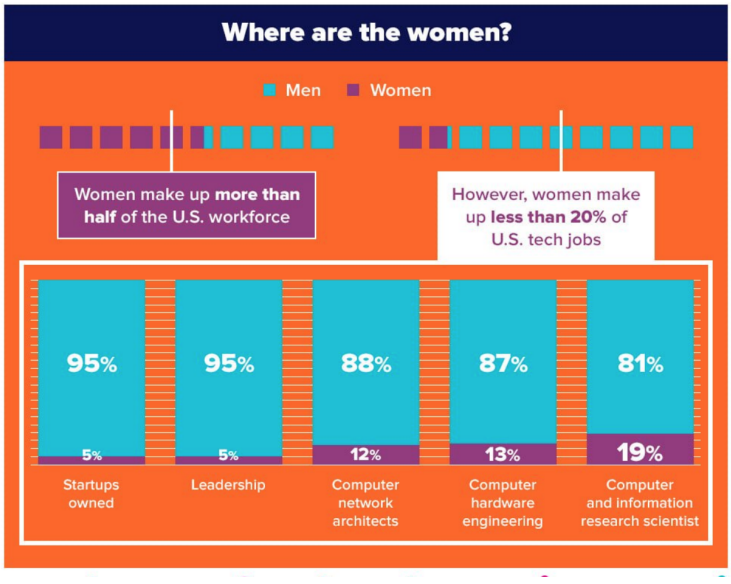

Figure 5: Infographic illustrating the gender gap in U.S. tech employment. [19]

6 Initiatives Addressing the Technology Gender Gap

Collective action to address the tech gender gap in Denmark is still in its infancy. A number of initiatives have been started, and a selection of these are described below. The efforts of programs such as these are having an effect. As an example of the progress being made, last year (in 2018), 50% more women were accepted into the country's largest

computer science program, at the University of Copenhagen [20]. In addition, when incoming students in the combined computer science/business program were surveyed back in 2002, only 10% reported having gained programming skills in primary school or lower secondary school and only 42% gained these skills in upper secondary school [13]. The primary way incoming students had learned programming skills was through self-directed learning, with 61% of incoming students having gained experience in this manner [13]. As programs such as those described below become more widespread, the proportion of Danes, both male and female, with a strong interest in and enthusiasm for learning computing skills should increase.

6.1 Promote Me Campaign

The Promote Me Campaign, a petition intended to draw attention to inequity in the funding of grants submitted by women, took place between September 28, 2018, and December 7, 2018 [21]. The petition was signed by 425 individuals and was sent to the Minister of Higher Education and Science and senior members of the major grant foundations [21]. The organization's website includes a short video describing the campaign's purpose and a response letter from the Independent Research Fund Denmark, a major grant funding organization. While the organization does not appear to still be active (i.e. there are no obvious ongoing updates to the website), the campaign did draw needed attention to this issue.

6.2 Femtech.dk

Femtech.dk is a research project that was launched at the University of Copenhagen in 2017 to promote the creation of "new methods that facilitate diversity and inclusion in computing" [22]. The program puts on events to expose girls and young women to computing in a way that is fun and that actively engages students. For example, one of the first events sponsored by Femtech.dk had students hacking an IKEA bear to transform it into an Internet of Things (IoT) device that would check if students' morning classes were cancelled, thus allowing students to sleep in [20]. On a larger scale, in 2017, Femtech.dk took part in the Copenhagen Maker Faire, presenting an installation in which paper origami "bugs" equipped with LEDs and movement-servos could be added to a public display of a vintage electromechanical computer [23]. These bugs could then be controlled via an app users downloaded to their own mobile devices [23]. In recalling the physical nature of the first "computer bug," the display taught participants about a seminal event in computer science history and provided a fun, engaging, interactive, and inclusive experience. Femtech.dk researchers estimate that at least 300 individuals engaged with the display during the maker fair [23].

6.3 Co-coders

Co-coders is an Aarhus-based initiative founded by two women. The organization's mission is to teach anyone who would like to learn how to code [24]. The group sponsors classes and events, with events typically taking place monthly. While not exclusively aimed at attracting women, the most recent event have covered topics such as "Sustainability, diversity & tech" [25].

6.4 Ultra:bit

In 2018, the national Danish Broadcasting Corporation (DR) launched the Ultra:bit program, with the intention of providing 65,000 Danish fourth graders with their own micro:bits – small, programmable devices designed to introduce children to writing software for things they create [26]. This year (2019), the initiative was expanded to reach 100,000 students in grades 4 through 6 [27]. The ultra:bit seems to be succeeding at achieving the program goals – 95% of teachers reported that children find programming the devices easier than they anticipated, based on their prior impressions of programming, and 96% of teachers reported that after using the ultra:bit, students want to learn more about coding and technology [27].

7 Discussion

As an American woman studying computer science, I was aware of the tech gender gap that exists in the United States, both in general and on a personal level (e.g. taking computer science classes as the only woman in the class). That a similar tech gap exists in Denmark surprised me, as I had assumed that the country's commitment to equality would have removed many of the barriers faced by women entering tech in the United States. In fact, some of the obstacles students face here have been removed. I regularly teach introductory computer science classes at a community college in a lower-income area of Seattle, WA. The student population includes many first-generation college students, recent

immigrants, and working students. Danish students do not have to deal with the everyday stressors the students at the community college do.

The need for workers with computational skills is just as urgent in Denmark as it is in the United States. An employment informational site based in the United Kingdom lists engineering and IT as areas where the Danish workforce is facing skills shortages [28]. While Danes have resources for lifelong learning and presumably could seek out training in these areas, it is not clear that they perceive any real need to do so. The same employment advising site reports that the unemployment rate in Denmark is one of the lowest in the EU, at 5.6% (December 2017) [28]. Thus, unless the country plans to import workers to fill these positions, or rely on outsourcing, these positions will need to be seen as attractive to new entrants to the job market.

With initiatives such as Ultra:bit and the Digital Strategy put forth by the Agency for Digitisation, it seems apparent that this need is being recognized at the policy-making level. The push to involve children from a young age is a sensible approach, but I wonder if the relative lack of initiatives aimed specifically at girls and young women is short-sighted. It is, however, understandable, given prevailing attitudes in Danish society that make such gender-selective approaches problematic. The survey on gender equality attitudes mentioned previously, revealed that as recent as 2015, the majority of Danes, both male and female, felt the government was doing neither too little nor too much to promote gender equity – in other words, they were satisfied with the status quo [6].

While it is possible that as more attention is drawn to the existence of inequities, particularly in tech education and employment, it is not necessary to wait for the social climate to change. As more programs are established to engage young people across the entire spectrum of their pre-university educations, Danish educators and policy makers can look to research conducted in other countries, such as the United States, on how to promote inclusivity in tech. As technology becomes ever more pervasive in our daily lives, I foresee ever expanding opportunities for inclusive programs and curricula. Opportunities to both collaborate with others and to work on projects of social significance are also likely to make computer science and tech, in general, more appealing to women [29, 30]. Active learning approaches, rather than the tradition of lecturing so common in the U.S, have also been shown to be effective at maximizing learning [31]. The Ultra:bit is a good example of such an active learning approach.

Going forward, initiatives to increase computational skills in Denmark should incorporate methods that have been shown to engage people from diverse backgrounds in tech. For example, as more domains become reliant on computation, educational curricula and projects can reflect this diversity. As shown by Femtech.dk's display at the Copenhagen Maker Faire, including an artistic component (origami bugs) makes a project more accessible. Similarly, emphasizing the opportunities for creativity and design, areas in which Denmark already excels, can dispel preconceptions students might have of computer science being a dry and dull subject. As more women are (hopefully) attracted to computing domains, care should be made to ensure that the gender equality Denmark is known for extends to this arena. Possible steps to take in promoting such equity could include an anonymized grant application process and closer study of gender equality trends, including expanded coverage of such topics in annual reports.

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