Department of Computer Science and Engineering

Women and Higher Engineering Education – Supporting Strategies

Aura Paloheimo

Aalto University

DOCTORAL DISSERTATIONS

Aalto University publication series
DOCTORAL DISSERTATIONS 180/2015

Women and Higher Engineering Education – Supporting Strategies

Aura Paloheimo

A doctoral dissertation completed for the degree of Doctor of Science (Technology) to be defended, with the permission of the Aalto University School of Science, at a public examination held at the lecture hall T2 at the Aalto University School of Science on 9 December 2015 at 12 noon.

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Aalto University publication series
DOCTORAL DISSERTATIONS 180/2015

ISBN 978-952-60-6503-8 (printed)
ISBN 978-952-60-6504-5 (pdf)
ISSN-L 1799-4934
ISSN 1799-4934 (printed)
ISSN 1799-4942 (pdf)
http://urn.fi/URN:ISBN:978-952-60-6504-5

Unigrafia Oy
Helsinki 2015

Finland

441 697
Printed matter

A? **Aalto University**

Aalto University, P.O. Box 11000, FI-00076 Aalto www.aalto.fi

Abstract

Author
Aura Paloheimo

Name of the doctoral dissertation
Women and Higher Engineering Education – Supporting Strategies

Publisher School of Science

Unit Department of Computer Science

Series Aalto University publication series DOCTORAL DISSERTATIONS 180/2015

Field of research Computing Education Research

Manuscript submitted 19 November 2014 **Date of the defence** 9 December 2015

Permission to publish granted (date) 4 September 2015 **Language** English

☐ **Monograph** ☒ **Article dissertation (summary + original articles)**

Abstract

The purpose of this study is to present new findings regarding women in higher engineering education. I aim to answer three important questions. Firstly, I present women's paths to our university of technology (first research question, RQ1). Secondly, I explain methods that are designed to help with the retention of female students during their early studies in a cost and admin-efficient way (RQ2). Thirdly, I present an analysis of female engineers' early-career prospects (RQ3). I have collected my research data from applicants, students and alumnae of the Helsinki University of Technology in years 2002-20012.

My research is based on the fact that women are strongly underrepresented in most of the engineering programmes in both the Helsinki University of Technology and around the world. I derived my research questions in the light of earlier research on this field, as well as my own experiences. My study uses a mixed method, with an emphasis on qualitative analysis.

I use different methods to answer different questions. In my first research question I use narrative inquiry: students wrote stories of their journey to engineering education. In my second question I use two separate case studies of women-friendly teaching methods using a mixed method approach: Firstly, I arranged exercise groups for an introductory computer science course using different ratios of females in each group. Secondly, I investigate the impact of a small course of literature. In my third research question I analysed female engineers' early career via second-hand data from two sources: Aarresaari (network of university career and recruitment services) survey and WomEqual (project interviews that chart web service user survey). The nature of this study is mixed method.

Female applicants leave their decisions regarding their place of study notably later than their male peers. Women are also more open to study other fields than engineering than their male peers. Women often choose to learn technical skills, not because of the skills themselves, but due to the possibility to apply them into something concrete in future work life. As students, women benefit from a good climate, as well as social and communicative study methods. Interdisciplinary teaching improve, apart from other benefits, motivation for more traditional engineering studies. In early working life women face more challenges in their early career than their male peers: Women, compared to men, are more risk averse, less competitive and they have more challenges combining family and work and they constantly need to reaffirm their expertise in the work place. The average pay cap after five years of graduation is approximately €500 per month in favor of men.

Keywords women in engineering education, gender distribution, minorities, diversity, interdisciplinary teaching

ISBN (printed) 978-952-60-6503-8 **ISBN (pdf)** 978-952-60-6504-5

ISSN-L 1799-4934 **ISSN (printed)** 1799-4934 **ISSN (pdf)** 1799-4942

Location of publisher Helsinki **Location of printing** Helsinki **Year** 2015

Pages 206 **urn** http://urn.fi/URN:ISBN:978-952-60-6504-5

A! **Aalto-yliopisto**

Tiivistelmä

Aalto-yliopisto, PL 11000, 00076 Aalto www.aalto.fi

Tekijä
Aura Paloheimo

Väitöskirjan nimi
Naiset ja korkea-asteen insinööriopetus - tukistrategioita

Julkaisija Perustieteiden korkeakoulu

Yksikkö Tietotekniikan laitos

Sarja Aalto University publication series DOCTORAL DISSERTATIONS 180/2015

Tutkimusala Tietotekniikan opetustutkimus

Käsikirjoituksen pvm 19.11.2014 **Väitöspäivä** 09.12.2015

Julkaisuluvan myöntämispäivä 04.09.2015 **Kieli** Englanti

☐ **Monografia** ☒ **Yhdistelmäväitöskirja (yhteenveto-osa + erillisartikkelit)**

Tiivistelmä

Tässä väitöskirjassa käsitellään naisia ja naisten asemaa korkea-asteen insinööriopetuksessa Suomessa. Vastaan tutkimuksessani kolmeen keskeiseen kysymykseen. Ensiksi esittelen tyttöjen valintoja ja kokemuksia, jotka lopulta johtavat opintojen aloittamiseen korkea-asteen insinööriopetuksessa Otaniemessä (entinen Teknillinen korkeakoulu, nykyinen Aalto yliopiston teknilliset korkeakoulut) (Tutkimuskysymys 1). Toiseksi esittelen kaksi erilaista kustannustehokasta ja hallinnollisesti ketterää tapaa tukea naisopiskelijoita heidän opinnoissaan (Tutkimuskysymys 2). Kolmanneksi esittelen nuorten nais-diplomi-insinöörien työuria (Tutkimuskysymys 3).

Käytän erilaisia menetelmiä eri tutkimuskysymyksissä. Ensimmäisessä kysymyksessäni käytän narratiivista tutkimusta: opiskelijat kirjoittivat tarinoita, joissa he kuvasivat niitä tapahtumaketjuja, jotka johtivat opiskelupaikkaan korkeakoulussamme. Toisessa kysymyksessä käytän kahta tapaustutkimusta naisystävällisen opetuksen alalta: Ensimmäisessä tapauksessa järjestelen harjoitusryhmiä tietotekniikan alkeiskurssilla siten, että ryhmien naisopiskelijoiden osuus vaihteli. Toisessa tapauksessa seuraan pienen kirjallisuutta opettavan kurssin vaikutusta opiskelijoihin. Kolmannessa tutkimuskysymyksessäni käsittelen naisten työuran alkupään haasteita ja mahdollisuuksia. Kolmannen kysymyksen aineiston keräsin analysoimalla kahta luotettavaa toisen käden tietolähdettä: Aarresaari (Akateemiset rekrytointipalvelut) -verkoston kartoitusta viisi vuotta työelämässä olleiden diplomi-insinöörien työurista ja toisaalta WomEqual -projektin haastattelujen litterointeja.

Teknillisen korkeakoulun naisopiskelijat jättävät päätöksen opiskelupaikan valinnasta myöhäisempään kuin heidän mieskollegansa. Naisilla on myös enemmän kiinnostuksen kohteita insinöörialojen ulkopuolella. He eivät arvota tekniikkaa tekniikan vuoksi, vaan sen perusteella, miten sitä voi hyödyntää tulevaisuuden työelämässä. Opiskelijoina naiset hyötyvät hyvästä opiskeluilmapiiristä sekä sosiaalisista opetusmetodeista. Monitieteinen opetus lisää, muiden etujen muassa, motivaatiota perinteisempää insinööriopetusta kohtaan.

Työuran alkupäässä naiset kohtaavat enemmän haasteita kuin heidän mieskollegansa. Miehiin verrattuna naiset ovat haluttomampia ottamaan riskejä, he ovat vähemmän kilpailullisia ja heillä on enemmän haasteita työn ja perheen yhdistämisessä. Muun muassa näiden asioiden vuoksi naisten täytyy jatkuvasti vakuuttaa osaamistaan työpaikalla. Suomessa sukupuolten välinen palkkaero viisi vuotta valmistumisen jälkeen on noin 500 € kuukaudessa miesten hyväksi.

Avainsanat naiset insinööriopetuksessa, diversiteetti, monitieteinen opetus

ISBN (painettu) 978-952-60-6503-8 **ISBN (pdf)** 978-952-60-6504-5

ISSN-L 1799-4934 **ISSN (painettu)** 1799-4934 **ISSN (pdf)** 1799-4942

Julkaisupaikka Helsinki **Painopaikka** Helsinki **Vuosi** 2015

Sivumäärä 206 **urn** http://urn.fi/URN:ISBN:978-952-60-6504-5

Acknowledgements

Firstly, I would like to thank the Licentiate of Technology, Pirjo Putila, who came to the Department of Electrical and Communications Engineering with an abundance of fresh ideas on girls, women and technology. This provided the start for TiNA's gender and technology education projects, as well as my research.

I would like to thank my supervising professor, Lauri Malmi, for his support and great work. I also want to thank my superior professor, Heikki Saikkonen, for encouragement. I am grateful of the opportunity to work at the Department of Computer Science in Aalto University School of Science. I would like to thank all my co-authors and other people who have participated in the work reported in this thesis. Also the effort and feedback of the pre-examiners of the thesis, Professor and Head of EER Division Tom W. Adawi and Associate Professor Liisa von Hellens is greatly appreciated. I am honored to have Professor Anette Kolmos as my opponent.

I want to thank my mother for encouraging me to get involved in engineering.

I want to thank my father for showing me the best way to work in the evenings: in an armchair in the middle of the living room, totally immune to the children running wild.

I want to thank the members and service troops of the Puhakan Laurin Perilliset team.

I want to thank the Mäkinen branch of our family for arranging the best work parties ever.

Lastly, the most important ones: Talvi, Pinja and Harri – the love of my life.

Espoo, 9, November 2015
Aura Paloheimo

Contents

List of Figures

List of Tables

List of Abbreviations and Symbols

ACS Academic Career Service

B.Sc. Bachelor of Science

CEO Chief Executive Operator

COO Chief Operating Officer

CR (Study) Credit

CS Computer Science

D.Sc. Doctor of Science

EE Engineering Education

EER Engineering Education Research

EI Emotional intelligence

GSD Global Software Development

HUT Helsinki University of Technology

ICT Information and Communications Technology

IT Information Technology

MEP Member of European Parliament

M.Sc. Master of Science

NSF National Science Foundation

OECD The Organisation for Economic Co-operation and Development

PISA The Programme for International Student Assessment

SEFI European Society for Engineering Education

STEM Science, Technology, Engineering and Math

TKK Helsinki University of Technology

List of Publications

This doctoral dissertation consists of a summary of the following publications, which are referred to in the text by their numerals

1. Paloheimo, A., Pohjonen, K., & Putila, P. (2011, June). Pathways to Male-Dominated Engineering Programs. In Proceedings of *118th ASEE Annual Conference*. (2011)

2. Paloheimo, A., Pohjonen, K., & Putila, P. (2011, October). Women and Higher Engineering Education — Choosing One's Degree Program. In Proceedings of *Frontiers in Education Conference, 41th Annual* (pp. T2H 1-6). © 2011 IEEE

3. Paloheimo, A., & Stenman, J. (2006, October). Gender, Communication and Comfort Level in Higher Level Computer Science Education — Case Study. In Proceedings of *Frontiers in Education Conference*, *36th Annual* (pp. S1G 13-18). © 2006 IEEE

4. Paloheimo, A., Putila, P., & Stenman, J. (2007, October). Beyond the Conventional Engineering Discipline — Teaching Prose. In Proceedings of *Frontiers In Education Conference, 37th Annual* (pp. T3H 7-12). © 2007 IEEE

5. Paloheimo, A. T., Auvinen, H. H., & Putila, P. H. (2012, August). Less is Not More–Female Engineers' Career Paths Five Years from Graduation. In Proceedings of *SEFI Annual Conference*. (2012)

6. Paloheimo A., Leppävirta J., Hyytiäinen M., & Putila P. (2007, June): Managing the challenges -introducing the female minority in technical research society. In *SEFI and IGIP Joint Annual Conference*. (2007)

Author’s Contribution

Publication 1: 'Pathways to Male-Dominated Engineering Programs'

The First author planned and conducted this study. Pirjo Putila gathered data from female students’ credits in each year and Harri Paloheimo marked-up the analysis. Author wrote the paper.

Publication 2: 'Women and Higher Engineering Education - Choosing One's Degree Program'

The First author planned and conducted this study, as well as wrote the paper.

Publication 3: 'Gender, Communication and Comfort Level in Higher Level Computer Science Education - Case Study'

The First author designed and conducted this study. Observations were carried out by a group of students under the first author’s supervision. The author wrote the paper with the course assistant Jenni Stenman.

Publication 4: Beyond the Conventional Engineering Discipline - Teaching Prose'

The First author designed and conducted this study, as well as wrote the paper.

Publication 5: 'Less is Not More - Female Engineers' Career Paths Five Years from Graduation'

Data was collected by Academic Career Service. The First author analysed data from gendered viewpoint, as well as wrote the paper.

Publication 6: 'Managing the challenges -introducing the female minority in technical research society.'

The data collection was done by workers in the WomEqual project. The First author used the interview transcriptions of 18 female researchers and diaries for her own study. The First author wrote the paper.

1. Introduction

1.1 Introduction

I have always been interested in women in engineering. Where do they come from? Why? How do they survive technical studies and where do they go after studies? As I will represent in this thesis, I myself was a typical female applicant in engineering: there were many engineers in my family and my mother supported my career choice. I completed my degree studies in 5.5 years and went on to work.

But what about the others?

Women have been a minority in engineering programmes around the world. Despite girls performing well in secondary schools maths and science in Finland, the number of female engineering students has not risen in recent years in our higher engineering education unit in Espoo: during the years 2005-2014 in our former Helsinki University of Technology (TKK), current Aalto University, the percentage of female students in engineering programmes has been approximately 20%.

In this thesis I map the female engineers path from the beginning (first recollection of engineering), through their studies and further on to early career.

1.2 Basis of Research

The underrepresentation of women in STEM (Science, Technology, Engineering and Mathematics) education and working life has long been a debated phenomenon. Researchers over the world have published on this subject. However, the number of women in higher engineering education has not risen.

Why would we then need women to enter engineering professions? Firstly, if we miss half of the eligible candidates based on gender, we lose a lot, since the engineering field is widening and becomes ever more critical for nations' economic growth. Other driving forces for change are, for example, globalisation and changing economics (Cago;Ziman;Caro;Constantinou;& Davies, 2004) (Kuenzi;Matthews;& Mangan, 2006) (Kuenzi, 2008) (Osborne & Dillon, 2008) (Dow, 2006). Secondly, the engineering projects become increasingly complex and more work is done in interdisciplinary or distributed teams. Women are needed, since they are good team players and socially skilled (Bass & Avolio, 1994) (Loufti, 2001) (Bannerot, 2003).

The loss of women in higher engineering education is something that starts at an early age and continues throughout the school system: beginning as small children, boys are the first to try out computers and other cool gadgets, whereas girls wait for their turn (Gürer & Camp, 2002). At STEM classes boys get more support and more attention from a STEM teacher than girls (Klawe & Leveson, 1995). Girls learning strategies are more passive, less demanding and less experimental (Seymour, 1995). Many schoolgirls 'know' they cannot perform well in STEM subjects. Girls also suffer from social pressure elsewhere, even though their STEM grades are better than their male peers (Klawe & Leveson, 1995).

In higher engineering education women discontinue their studies more often than their male peers (Seymour, 1995) (Seymour & Hewitt, 1997) (Brainard & Carlin, 1998). Also, the careers of female engineers are viewed with lower expectations than their male peers (Blau & Kahn, 2000) (Gneezy;Niederle;& Rustichini, 2003) (Bilimoria;Joy;& Liang, 2008) (Croson & Gneezy, 2009) (Cochran;Wang;Stevenson;Johnson;& Crews, 2011).

In my research I present accurate and relevant information regarding women's paths towards an education in higher engineering, as well as their support methods during studies and early career.

1.3 Research Questions and Methods

In my research I explain the essential turning points in women's journeys, from their first recollection of higher engineering education to early career. My methods depend on each research question and research paper. An emphasis is placed on qualitative methods.

The backbone of my thesis is a collection articles that are linked by subject (women in higher engineering education) and a timeline (first recollection of engineering as a study/work field to early career). The hierarchical timeline of my research questions is represented in APPENDIX A.

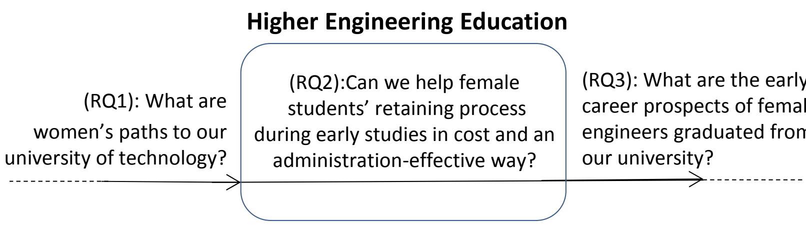


Figure 1 Timeline of my research questions

My first research question is: what are women's paths to our university of technology?

From a wider perspective I aim for answers in questions such as: what road do women take in order to reach our university of technology? Can we find common motives for women choosing engineering? Do connecting themes exist and explain the process of women choosing their degree programme? Can they be categorised?

As a research method, I use narrative inquiry to investigate student stories: narrative research explores the meanings of human action and phenomena constructed in narratives. My data is eligible data for narrative research, as the chain of events have a beginning, storyline and end (Connelly & Clandin, 1990). The narrative research method is justifiable, since I am interested in the path on which female applicants come to our university. Understanding the paths involves more than asking reasons: we get the chronological order of events that eventually leads to decision making and starting one's studies in our technical university.

My second research question is: can we help with the retainment of female students during their early studies in a cost and an admin-efficient way?

The few women enrolled in higher engineering education discontinue their studies more often than their male peers, especially during the first years of study. The important aspect is that they discontinue their studies even though their study success is good (Seymour, 1995) (Seymour & Hewitt, 1997) (Brainard & Carlin, 1998).

To answer my second research question I produced two different case studies to lower the discontinuance records of female students: adjusting arrangements in the regular CS course and monitoring a small interdisciplinary course outside official course selection. The emphasis in my study is efficiency: I aim for support activities that require the minimum budget and minimum effort from personnel. This way, it would be realistic to create and maintain these activities. The experiments like creating a whole programming course to attract women are theoretically significant, but they are not very practical, since creating a whole new course is very time-consuming and faculties are always short of resources (Rich;Perry;& Guzial, 2004).

By arranging CS course training sessions by gender in all-male, fifty-fifty and all-female groups, I answer questions such as: how do students interact with each other? Is there a difference between the ways female and male students interact in different kinds of groups? Does it matter if the gender balance in a group is even or not? If it does, what kind of balance would the different genders most benefit from? In what kind of group would they feel the most comfortable? I use questionnaires, observation and free-form feedback as research methods in this study.

For a small course outside basic faculty supply, I researched the features of a small cross-disciplinary course of literature. The teacher came outside the faculty and worked on an hourly basis, which made the course's costs low. I aimed to find answers to questions like: why was the course so highly appreciated among participants? Why are women enrolled on the course? What was the outcome of the course? What area of excellence does the course help to improve? I use three data sources: student course applications, basic course feedback and an open-question questionnaire.

My third research question is: what are the early career prospects of female engineers graduating from our university?

Women are good workers and good team workers (Bass & Avolio, 1994) (Loufti, 2001) (Bannerot, 2003). However, promotions in the engineering field traditionally require the capability to excel oneself in competitive environments. Women profit from non-competitive environments with good climate and the prospect of feeling comforted and accepted (Cohoon & Aspray, 2006) (Bilimoria;Joy;& Liang, 2008) (Croson & Gneezy, 2009).

The other burden is that for women, combining family and work is usually more problematic than for men. The novelty of my research is to highlight the power of using secondary data (data that is collected for another reason and by someone else than the user) (Jarvenpaa, 1991). I produce new understanding of women's daily routines, supporting methods and survival strategies.

I have divided the problem in two: firstly, I examine answers from career and employment surveys completed by Helsinki University of Technology graduates in 2005. The applicants answered to this survey five years after graduation, in autumn 2010. Based on this data I aim to clarify differences in women's and men's careers: contract of employment, duties, unemployment periods and family leave (and so on).

The second part of this study is the interpreting and analysing of interviews of female scientists in the research department of TKK, as well as those in Oulu University: a user survey for weme.fi, an internet community for women, was conducted in 2005. Here I also use secondary data: I got the interview transcriptions of 18 female researchers and diaries for my study. In this study the phenomenon called shrinking pipeline is a decisive factor. Shrinking pipeline (Camp, 1997) sketches the loss felt by women, which emerges on every hierarchical step within an academic career in computing. It is represented in Chapter 2.5.2.

1.4 Significance of My Research

The loss of women in higher engineering education is a phenomenon around the world. Despite the efforts, the number of female students in higher engineering education has not risen. This unbalanced situation causes problems in subjects of equality and loss of capable engineers and scientists in STEM fields.

Due to a variety of reasons, the traditional engineering curricula should be altered to include more interdisciplinary and soft-skill studies. We have two main driving forces:

1. More interdisciplinary study programmes attract a larger applicant pool, especially women (Beraud, A., 2003) (Borrego & Newswander, 2008).

2. Nowadays working life demands technical, interdisciplinary and soft skills from engineers (Dow, 2006) (Schultz, 2008).

Other forces for this transition can be driven from more and more complicated systems, rapid improvements in overall and new technologies, globalisation and complex societal processes (Rich;Perry;& Guzial, 2004).

Historically, engineering curricula have been based largely on an 'engineering science' model over the last five decades. Engineering is taught only after a solid basis in science and mathematics (Dym;Agogino;Eris;Frey;& Leifer, 2005).

Enhancing engineering education is strict and time-consuming work due to long traditions, legacy practices and the rigid structure of faculties, to name but a few examples. Additionally, many universities suffer from a constant shortage of resources (Erdil & Bilsel, 2005) (McAlpine, ym., 2005).

My research clarifies women's journey to higher engineering education in our university. It doesn't merely ask why women choose engineering, but what women's paths to engineering studies were. What were the turning points? This is very important information for recruiting campaigns.

Next, I present two methods to help the retaining process of female engineering students. This is because it has been proven through research that female engineering students discontinue their studies more often than their male peers (Cuny & Aspray, 2002) (Sagebiel & Dahmen, 2006).

My third contribution is to map women's early career into numbers and figures: what are the early career prospects for female engineers compared to their male peers? What are the challenges to female engineers' early work careers? What are their survival strategies?

1.5 Overview of the Thesis

In chapter 2 (Literature Review) I provide common knowledge of the journey or girls in Science, Technology, Engineering and Mathematics (STEM) education through primary, secondary and upper-secondary levels. Next, I represent young women's prejudices and reasons not to study engineering, as well as showing information as to why engineering is a suitable and favourable field for women. I represent role models in technical fields as a recruitment strategy. I present knowledge of women in higher engineering education and, further on, in engineering work life.

In chapter 3 (Research Background) I introduce the theoretical basis of my study: why are women in higher engineering education? Why engineering? I represent Belenky's theory 'Women's Ways of Knowing', which I use in my thesis.

In chapter 4 (Research) I discuss my research questions in more detail. In addition I present my methodological approach and important concepts of

Validity and Ethics. I introduce the methods I have used and results. I proceed from RQ1 (paper I and II) to RQ3 (paper V and VI)

In chapter 5 (Discussion) I present the wider perspective of my research and how the new knowledge can be put into practice. The emphasis is on recruitment strategies and female-friendly teaching.

In chapter 6 (Conclusions) I conclude my thesis: I summarize my research. I then present some field statistics. Finally, I present suggestions for my future research.

2. Literature Review

2.1 Introduction

This chapter presents the research literature related to the research questions in this thesis.

The Finnish schooling system is internationally renowned for its high quality. However, even our system cannot fight girls' prejudices against their ability to do math (or overall STEM subjects) (OECD, 2015). Earlier research depicts that teachers handle girls and boys differently in STEM classes: boys get more attention and support from the teacher. Also, girls' learning strategies are more passive than their boy peers. (Seymour, 1995) (Klawe & Leveson, 1995) (Tonso, The Impact of Cultural Norms on Women, 1996) (Gürer & Camp, 2002)

At university level our teaching is very gender biased: women study education and liberal arts, whereas men study STEM subjects. It is difficult to recruit women in higher engineering education. Basic reasons are the low self-esteem towards one's STEM ability and prejudices: young women often see engineering work as dull, boring, unfriendly and old-fashioned.

Women form a clear minority of freshers in technical universities. The second challenge is that they interrupt their studies more often than their male peers during the first two years of study. One reason for this could be the traditional two-year elimination pedagogy which suites women worse than their male peers.

Women in the engineering field see their career possibilities as good and versatile. However, they face more problems than their male colleagues. They also have lower career expectations than their male peers.

2.2 Girls, Science and Engineering

In Finland we have a nationwide welfare society, which provides a high-class child and family-care continuum through prenatal clinics, kindergartens and high-quality elementary, secondary and upper-secondary schools. This system is crucial for working mothers and it enables their career development and so-called mommy tracks to be avoided.

Mommy track is a phenomenon in the United States (U.S.) where women must decide between a mummy-track (home with children) and career-track, where the family is forced to make considerable concessions (Parker, 2009). This mommy track is very harmful to women's careers: in the U.S., a few years at home with children can result in up to a 30% loss in salary (Stone & Lovejoy, 2004) (Hewlett & Luce, 2005).

Considering U.S. working culture, many career women are practically forced to choose full-time motherhood (Yurtseven, 2002). However, previous research (Hill;Märtinson;& Baker, 2004) reveals a study of a part-time working model to avoid or diminish the US mummy track. In this study, women reduced their working hours by approximately 47%, or 23 hour per week. The model helped women balance work and family life while maintaining career opportunities. A significant notion in this research was that 'the extra time' women gained from part-time work was not spent on childcare or household, but on additional sleep, recreation and other renewal activities. Welfare of mothers creates welfare for the family.

Our system ensures fair prospects in the career market for both women and men. It is internationally rewarded for its high quality and equality (OECD, 2015). However, the system unintentionally favours boys. When a teacher in primary school brings new and interesting gadgets or computer applications, the boys will go first and the girls will step aside, waiting for their turn, like good girls. The school personnel do not do this on purpose, but there is a long tradition of favouring boys over girls. When further in secondary schools, the system unintentionally pushes girls into languages and boys into STEM fields (Seymour, 1995) (Gürer & Camp, 2002) (Hill;Corbett;& St Rose, 2010)

In Finland first graders are equally interested in most of the subjects at school. However, when they reach adolescence, they 'know' that reading is for girls and mathematics for boys, which is not true (Finland's Ministry of Education and Culture, 2015). Since teenage girls have very little confidence in their ability to learn STEM subjects, what they would need in their studies is support and encouragement. In the latest Programme for International Student Assessment[1] (PISA) (OECD, 2015) evaluation, girls slightly outperformed boys. This implies that the girls who attend STEM classes perform on average at least as well as their male peers.

However, there is strong evidence that girls have less confidence in their abilities and individual accomplishments than boys. This is one of the reasons why girls easily drop out from science and engineering (Seymour, 1995). Girls suffer from what we call a stereotype threat: being the potential target of a negative group stereotype creates a specific predicament: in any situation where the stereotype applies, behaviours and features of the individual that fit the stereotype make it plausible as an explanation of one's performance (Spencer;Steele;& Quinn, 1999).

2.2.1 STEM Education

According to an earlier study (Seymour, 2002), both genders find STEM subjects easily dull and boring. They also suffer from the poor quality of mathe-

[1]The Programme for International Student Assessment (PISA) is a triennial international survey that aims to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students. To date, students representing more than 70 economies have participated in the assessment. http://www.oecd.org/pisa/

matics and science education. All students, although girls especially, would profit from the change from teacher to learner-centred[2] education, which guides students through more active learning strategies and more responsibility over one's own learning process (Weimer, 2002).

Neglecting STEM subjects is a common phenomenon of which girls will suffer more than their male peers. Girls have the burden of negative perceptions: they believe that they cannot perform well in mathematics (Brown & Josephs, 1999).

In STEM classes boys get more attention and support than their girl peers, whereas girls' learning experiences are more passive, less demanding and less experimental (Seymour, 1995) (Klawe & Leveson, 1995) (Tonso, 1996) (Gürer & Camp, 2002). The interesting thing is that if the situation is corrected (for example both genders get the same amount of attention, the same amount of taking the floor and so on), then every party concerned experiences an unpleasantness and unanimously ask for permission to return to the old practice (Klawe & Leveson, 1995). This is regrettable because ensuring students equal access to the teacher and classroom resources is one of the cornerstones of improving the under-representation of women in STEM (Blickenstaff, 2005). Analogous to this phenomenon is the "couple's false equity point" of the household tasks: men find the division of labour to be fair when they contribute 36% of the time devoted to household tasks, whereas women find the division of labour to be fair when they contribute 66% of the total (Coltrane, 2000).

Our uneven resources, uneven attention system and old-fashioned attitudes create an illusion that boys are better in STEM, period. The girls' belief of boys' superiority wrecks a suggestion to create a more even learning environment: dividing advanced math and science classes by gender. Girls tend to resist this kind of act. One reason could be that since the girls believe that the boys are better, they are afraid to miss something important: since boys receive more support and encouragement, girls tend to believe in boys' supremacy (Seymour, 1995) (Blickenstaff, 2005).

Earlier research depicts that to gain a diverse and culturally competent engineering workforce, the educational environment for future engineering students must be systematically improved across all levels from primary to upper-secondary school (Clewell, 1992). If we do not raise the quality level of STEM/engineering education, we still get the core of technology enthusiasts but lose the wider pool of eligible candidates (Chubin;May;& Babco, 2005).

2.2.2 University Level

When it comes to our university level studies, our system is highly segregated into female (education and liberal arts) and male segments (STEM). The traditional female occupations are low-salary, little-respected and don't provide particularly good career possibilities, e.g. nursery, primary, secondary and

[2] In student-centred learning, the student is in the center of the learning process. Essential concepts are freedom of choice and responsibility of one's own learning. Cooperation and interaction with other students are sources of motivation

upper-secondary schoolteachers. This is quite contrary to the traditional male occupations (for example engineering), which have a fairly good salary, are well appreciated and have decent career possibilities (Finland's Ministry of Education and Culture, 2015).

The personnel that predominantly represent prenatal clinics, kindergartens and elementary schools are mostly women. The high quality of work in these occupations is vital for us to maintain our welfare system. However, we still don't appreciate their work contribution. This lack of appreciation could be one of the reasons that nursery/school teachers don't see the inconsistency in their behaviour towards boys and girls: since they are undervalued themselves, they apply the same criteria to girls.

2.3 Recruiting Women in Higher Engineering Education

Choosing one's study place is a complicated task. Persuading 18-year-old women to take up engineering with their background of zero self-confidence from STEM subjects just three years earlier is a challenge. In Finland, one must choose advanced courses in mathematics, physics and/or chemistry in the beginning of upper-secondary school to be able to manage the entrance examination. In an ideal case, to broaden the applicant pool, we should time the first recruiting events so that they are before the time that students have to make their selection concerning wide-ranging mathematics, physics and/or chemistry studies. However, in my study I did not find a suitable price-quality ratio in the recruitment process towards first and lower-secondary school girls. For example, according to our experience, when we have a stand in an event, upper-secondary school students come to the stand, get some information and perhaps chat a little with personnel. For lower-secondary school children our corresponding stand can easily turn to free candy. This is frustrating because earlier research depicts that student engagement or interest in science is largely formed by the age of 14 (Osborne & Dillon, 2008), or more generally at an early age (Klawe & Leveson, 1995). According to these studies, we should emphasize the activities aimed for children. This kind of mainstreaming is difficult and tedious work from the faculty point-of-view. It also needs a lot of cooperation between units. We don't have resources to save the world.

This year approximately 540,500 children took part in primary or lower-secondary school education in 2,717 units in Finland (Kumpulainen, 2014). In upper-secondary school a little more than 100,000 teenagers study in 459 units. Here is an example: in our university home town, Espoo, there is 350 units of schooling or day care, 58 primary schools, 29 secondary schools and 12 upper-secondary schools. There is a strong contest between the best candidates. Most of the upper-secondary schools are already specialised in some field, for example languages, IT and media, economics and sociology, music, arts, articulacy and media culture, International Baccalaureates in mathematics, as well as natural sciences and sports.

On our recruiting work in upper-secondary schoolgirls, we fight against prejudice and a twisted image of engineering in girls' eyes. Girls often see engineering work as dull, boring, unfriendly and old-fashioned (Adelman, 1998) (Anderson;Lankhear;Timms;& Courney, 2008).

2.3.1 Recruiting Girls in to ICT

The girls were enthusiastic and confident users of ICT but expressed an 'I can, but I don't want to' attitude towards ICT study and careers.

(Clayton, 2007)

Reaching the girls is too large a task to allow us to work alone. To effectively tackle this phenomenon, we need to work together. Earlier research (Miliszewska & Moore, 2010) presents the liability distribution of encouraging girls into ICT studies:

Government/Policy-Drive Activities

Education Institutions/Research Activity

Industry-based Groups

Voluntary Initiatives

This is both a relieving and intimidating division: we (university faculty) are only one sector in this model. We are not able to tackle this problem alone: we need co-operation between parties. An important question is who will take the lead for such activities. Participators need suitable incentives. The significant obstacles are the lack of constant funding and time allocation for such activities. (The above are the most significant challenges in all female-friendly projects, as is presented further in this thesis.)

Another important gender difference that emerged from the previous study is that girls perceive CS as more hardware- and programming-oriented than boys do, whereas boys, interestingly, view it as more human- and application-oriented than girls do (Papastergiou, 2008).

The image of programmers is a bunch of geeks who have poor communication and social skills, and can only talk to fellow geeks about computing in a language not understood by the general population. Because of this they have an aura of secrecy and intelligence and they use this to exercise power by excluding those who do not understand their language (Crump;Logan;& McIlroy, 2007).

Here are a few more general misconceptions:

- All computer scientists are nerd hackers.
- All computer scientists work 24-7-365.
- Women are not good at computing.
- Working with people and working with computers are mutually exclusive.
- CS is boring and irrelevant.

(Cuny & Aspray, 2002) (Crump;Logan;& McIlroy, 2007) (Anderson;Lankhear;Timms;& Courney, 2008).

The girls' misconceptions of programming describe the world of programming in the late seventies to late eighties: back then computers were not common consumer products, but tools for a small minority (nerds in universities). The software projects were substantially smaller than today and the army was the major educator for managers. The fact that the efficiency of programmers had (and still have) always varied a great deal lead to a situation where software development was dependent on certain programmers. As late as the nineties, projects still had the problem called single-point failure, meaning that one employee can be critical and hard to replace in the project (Holmengaard;Ulriksen;& Möller Madsen , 2010).

Today's' view on software projects is much more tempting: while the complexity of projects grow and critical time-to-market shortens, we are more and more forced to co-operate and have efficient team work: both in our team, cross-disciplinary and across the hierarchy (Tonso, 2006). This is the image we should deliver to the girls. However, we still have work to do against prejudices: Dilbert is perhaps one of the most known engineers in the world. He is smart, honest, inflexible - and dull (Yurtseven, 2002).

Computer science differs from other fields of engineering study in a way that there is a single skill, programming, that plays a very important role in the studies. The students' pre-knowledge of programming varies a great deal. This makes the first year studies very 'unfair' because the beginners must work very hard, whilst the more experienced first-year students pass the courses easily. (This has the same analogy as any hobby: if you start training at 18, you have a great deal of hard work on your hands in order to catch up with those who have started, for example, at 10).

Why should we then recruit students without prior programming skills? Firstly: if one is motivated and concentrated enough to learn programming, one can become a good programmer. Secondly, as stated earlier, computer science and information technology are much more than programming. Today, the personnel of IT (Information Technology) and ICT (Information and Communications Technology) projects consist of different kinds of experts: programmers are one group. Despite one's position, communication and teamwork skills are essential for everybody (Jamieson, 2007). Below, in Figure 2, is displayed a possible structure of a software project. It shows the 'much more'.

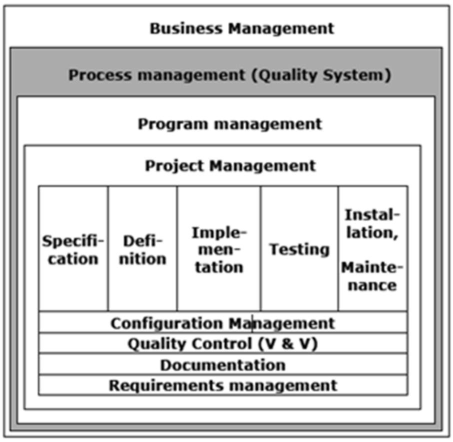


Figure 2 Example of programming project governance

2.3.2 Women as Valuable Work Force

Earlier research depicts that women enter engineering as one of several interesting possibilities. Men are more single-minded and have set their mind to one direction (Cuny & Aspray, 2002). Taking into account the present and future trends in engineering fields, the open-minded and versatile women are valuable labour force for our future work life: engineering fields offer interesting and challenging positions, as well as good career development. The future engineers must master several kinds of skills, not just pure technical know-how (Jamieson, 2007) (Schultz, 2008).

Since the size and complexity of our systems have widened, we have to do more teamwork and, most importantly, this teamwork must be workable, accurate and beneficial. Women are good in these kinds of negotiations when 'there is no winners or losers', but a common goal that the whole team aims towards (Bass & Avolio, 1994). In other words: women are good team workers (Loufti, 2001) (Bannerot, 2003). However, in the long run, to be efficient and competitive, we must have teams in which participants work as equals: the old-fashioned model, where men take the floor and women raise their hand in order to be addressed (which may never happen), does not work. Teamwork skills are, for both genders, essential for working life – and can be taught during university studies (Tonso, 2006).

In two of our conference papers, we presented some reasons for women to choose higher engineering education as their field of study. I will shortly present certain trends. First of all, the relatives have the most impact on women when choosing an engineering career (Adya & Kaiser, 2005) (Creamer;Amelink;& Meszaros, 2010). Secondly, the support of mothers is the best guarantee for women to choose engineering as a future career (Brainard & Carlin, 1998). In many cases women have different reasons for choosing their higher engineering studies than their male peers. Men are often straightforward in applying for some specified program in higher engineering education, whereas women puzzle more about what field to apply – both inside and outside engineering (Seymour, 1995). While male students weigh-up, for example, the technology and their previous hobbies like electronics or programming, women emphasise the possibility to apply their natural science skills into something useful, like environmental protection or a development of future medicines (Paper II). Earlier research (Blickenstaff, 2005) suggests creating examples and assignments that emphasise the ways that science improves the quality of life of living things.

2.3.3 Challenges

The issue of self-assessment, or how we view our own abilities, is another area where cultural factors have been found to limit girls' interest in mathematics and mathematically-challenging careers: research profiled in the report finds that girls assess their mathematical abilities lower than boys with similar mathematical achievements (Spencer;Steele;& Quinn, 1999). At the same time, girls hold themselves to a higher standard than boys do in subjects like math, believing that they have to be exceptional to succeed in "male" fields. One result of girls' lower self-assessment of their math ability—even in the face of good grades and test scores—and their higher standards for performance, is that fewer girls than boys aspire to pursuer STEM careers. By emphasising that girls and boys progress equally well in math and science, parents and teachers can encourage girls to assess their skills more accurately (Hill;Corbett;& St Rose, 2010).

The engineering profession contains several prospects and it is impossible and irrelevant to supply applicants with a comprehensive image. This is not what the candidates want to hear, because it creates uncertainty about one's future. This is more so a problem for women, because they are less likely to take risks than their male peers (Croson & Gneezy, 2009). This problem is tackled in recruiting materials that equip the applicant with some common work titles about their field of study. For example, in the web pages or our Aalto University (aalto.fi), future students of the Energy Technology Study Program are told that possible titles in their future profession could include planning officer or specialist, researcher or product developer, a techno-economic engineer in both public and private sector. The title listing is vague, but it gives a name to one's future position. The title will clarify when one's studies progress.

2.3.4 Study Programs to Attract Women

One tempting method for recruiting young women is interdisciplinary programs. In recent years, TKK created three interdisciplinary programs, which have been popular among female applicants:

In 1999, the Degree Program of Information Networks was launched to combine information technology, economics and communications in a new way. The entrance examination contains an aptitude test instead of physics. The programme educates new kinds of interdisciplinary Masters of Science in

Engineering, who are able to operate in and between teams with professionals of different fields. Also, they can work as a link between the end users and the developers of high technology. This study program has remained popular during the years and about half of the students are women. The employment rates are very high, and the average salary development five years after graduation (2010) was the second best in TKK. Only Industrial Engineering and Management gets higher figures. Thus we should not underestimate the interdisciplinary studies or female students.

The second interdisciplinary program, the Bioinformatics, was launched in 2003. This study program integrates electronics, information and automation technology, physics and chemistry with biology and medicine. This interests women, who want to apply their technical skills into something meaningful (medicine/patients) (paper I and II). The programme has been popular among both male and female applicants. Wide-ranging studies are shared by their interest in humans. Studies focus on problem solving and developing new solutions. The majority of courses are both technical and challenging. As a result, the early career and salary development is average in our school. Important in this programme is that it contains very difficult, technical courses ('male courses') – and women do accomplish them.

The third interdisciplinary program is Bio Product Technology, which was established in 2010. Its core concepts are sustainability and the controlled use of renewable natural resources. Studies include mathematics, natural sciences and bio-sciences. Some major topics are Bio refineries, techniques for renewable resources and fibre-product techniques, and environmental administrations. This programme is also very popular among women: the participation has been close to even between the genders. This is high above the university average (25%).

Besides a high percentage of female students, the example study programmes stand out from modern teaching methods, such as student activation methods, teamwork and problem-based learning (PBL). Even if tough courses exist, the students manage to pass them together. As an example, the Degree Program of Information Networks has a very extensive programming course. The course is divided into two sections: four credits of teamwork (PBL) and 10 credits of programming. Students gather in weekly group meetings to resolve programming-related problems. On the programming side, students program weekly exercises individually, as well as an extendable project work. Even though the course is extremely challenging, the dropout rate is close to zero.

2.3.5 Role Models

Earlier studies (Seymour, 1999) (Adya & Kaiser, 2005) depict that the personal influence of family, high-school teachers and other significant adults has more impact on women than their male peers. The tendency of becoming an engineer is bigger in families with other engineering or technology-related members. For girls, the most decisive factor is the mother's attitude towards science and engineering (Brainard & Carlin, 1998) (Gürer & Camp, 2002).

If there is not enough support by authorities, our best chance is to create other role models: A role model is a person who serves as an example of the values, attitudes, and behaviours associated with a role (Cohoon & Aspray, 2006). Role models are proven to be inspiring for young girls, students and graduates. For example, see (Gürer & Camp, 2002) (Roberts;Kassianidou;& Irani, 2002) (Cohoon, 2002) (Klawe;Whitney;& Simard, 2009) (Buzzetto-More;Ukoha;& Rustagi, 2010). Once again, while this support method has proven to effectively benefit women, it also profits men (Amelink & Creamer, 2010).

In Finland, there are only a few female CEOs in large companies. However, there are women close by. Some of them should be recognisable since they have attracted wide publicity. However, most of them work outside of the spotlight. There is a challenge to bring them into girls' awareness.

The current state in the business world is that, while most of the sharp-edge directorship positions are filled with men, women come right behind them in the hierarchy. The regrettable occurrence is that CEOs (the vast majority of which are men) and board members in large-scale companies easily gain publicity, whereas managers in lower levels do not (understandable). However, we must acknowledge that these female managers on the executive level, that are a step or two down from CEO, have done a tremendous job to get there. They are intelligent, hardworking women – perfect role models for teenagers/first-year students. But how do we get supply and demand to meet?

The role models in the business world have similar challenges than any other field: we have great women, great careers, but how can we bring them into girls' awareness. Below I shortly represent women suitable to be role models for young girls. It is an interesting palette both in national and international scope. Should we represent these kinds of female career stories in our recruiting materials?

2.3.6 Role Models in Finland

Here I shortly introduce four Finnish role models for girls. They represent four different career development models: Maija-Liisa Friman had a traditional career development: she started as an operating engineer and was promoted step-by-step into CEO and above. Hille Korhonen has had a bit of a see-saw career path: many different kinds of managerial positions, which have led to her latest position as CEO of Alko[3]. Tuija Pulkkinen is a Doctor from Helsinki University who has had a prominent academic career that has resulted in a vice rector (research) position in Aalto University. The fourth role model is a reversal from technology to politics: Satu Hassi is a licentiate tech of electrical engineering, but she switched careers and later became a writer and politician. She is best known as a member of the European parliament 2004-2014. Here we have gathered four women who represent different paths of career development. A short summary of these role models are listed below:

[3] A responsible and service-oriented specialty store (alcohol products)

Maija-Liisa Friman, Vice-Chair of Nest Oil board; board member in Finnair (Finnish airline) and LKAB (Swedish mining company)

Maija-Liisa Friman has a M. Sc. in chemistry. She has an impressive international career path, which started as an operating engineer in Kemira and later switched to more challenging positions in Mexico and the USA. During the last two decade she has been a CEO in Gyproc, Vattenfall and Aspocomp groups. In recent years she has been a professional board member in Neste Oil (vice-chairwoman), Metso (vice-chairwoman), Finnair, Telia Sonera and LKAB. She has been nominated as Finland's most powerful women in 2005 and 2012.

Hille Korhonen, CEO of Alko

Hille, Licentiate of Technology, started as the CEO of Alko company in 2013. Her earlier engagements involved several different managerial positions in Fiskars, Iittala Group and Nokia. Besides work in Alko, Hille is a board member in Nokia Tyres and Lassila & Tikanoja.

Tuija Pulkkinen, Vice Rector of Aalto University

Tuija Pulkkinen gained her Doctor of Philosophy from the University of Helsinki in 1992. She has an impressive international career. She is a member of the Finnish Academy of Sciences and Letters, the Finnish Society of Sciences and Letters, the Academy of Technology, the Royal Astronomical Society, as well as Academia Europa. She was nominated as the dean of the School of Electrical Engineering, Aalto University, 2011. Nowadays she is working as Aalto University vice rector (research).

Satu Hassi, Member of European Parliament (MEP)

Satu is a Licentiate of Technology from Tampere University of Technology. The foundation of Satu's engineering career was her wish to do concrete things instead of talking about them. Satu is an example of a multi-talented female engineer: besides a traditional engineering career and work in politics, she has published novels, essays and poetry. Besides, she has also worked on the renewal of physics textbooks for upper-secondary school. The most memorable position that Satu occupied is member of the European parliament from 2004 to 2014. (Satu literally moved from engineering to saving the world.)

2.3.7 Role Models Abroad

Picking international role models has challenges since there are different criteria for 'successful women in tech'. Around the globe are listings of people in high places. I picked out three, which I found to be essential. It has to be noted that the three have both similarities and differences. This points out the difficulty in ranking people and shows that listings are more suggestive than they are precise. Firstly, I briefly mention some tech women who feature in Forbes' The World's 100 Most Powerful Women. My second listing is Business Insiders' list of The 25 Most Powerful Women Engineers. Thirdly, I concisely summarise the engineers from Business Insiders' list of The 50 Most Powerful People In Enterprise Tech. It should be clear that the women are heavily underrepresented in both genders listings (five women among 50 people).

The most powerful woman in Forbes'[4] list of The World's 100 Most Powerful Women 2013 is Germany's Chancellor Angela Merkel. In second and third place are Dilma Roussefi (president of Brazil) and Melinda Gates. In the list there are 16 women from the field of technology. For example, no. six: Facebook COO (Chief Operating Officer) Sheryl Sandberg (Master of Business Administration); no. 12: Virginia Rometty, CEO (Chief Executive Operator, Bachelor of Arts/Science) of IBM; and no. 30: Susan Wojcicki, Senior Vice President of Google. That is a very good result. The competition in this list is hard, since women with a technical background are competing with presidents, politics, multi-millionaires, media persons (for example Oprah Winfrey at number 12), and so on.

Business Insiders'[5] list of The 25 Most Powerful Women Engineers in tech has a surprisingly different lead than the above-mentioned listings. In first place is Genevieve Bell (Director of Interaction and Experience Research in Intel Labs), in second is Jocelyn Goldfein (director of engineering at Facebook) and third is Marissa Mayer (CEO, Yahoo). Since there is a great deal of information on the above-mentioned women I don't need to introduce them any further. However, I created a small table, Table 1, which contains the 10 most powerful engineering women, their education and current work positions. These are hard figures, which should inspire girls to CS. It also shows that studying CS does not mean that you have to program for the rest of your life. The strong majority of CS' study field is explained by the fact that the computing industry has been strongly increasing since late 90's.

Table 1: Business Insiders' list of The 10 Most Powerful Women Engineers in tech

Name	Study field	Affiliation
Genevieve Bell	Anthropology	Director of Interaction and Experience Research in Intel Labs
Jocelyn Goldfein	Computer science	Director of engineering at Facebook
Marissa Mayer	Computer science	CEO of Yahoo
Kimber Lockhart	Computer sciene	Director of Engineering, Box
Maja Matarić	Computer science (PhD)	Professor of Robotics and Pediatrics at the USC

4 http://www.forbes.com/power-women/
5 http://www.businessinsider.com/

Diane Greene	Naval architecture	Angel Investor, Co-founder of VMware
Vicki Hanson	Cognitive psychology (PhD)	professor, University of Dundee and IBM researcher
Lauren States	Economics	Vice President, Strategy and Transformation, IBM Software Sales
Marianna Tessel	Computer science	Vice President of Engineering, VMware
Jen Fitzpatrick	Computer science	VP of engineering for Geo and Local, Google

Business Insiders'[6] list of The 50 Most Powerful People in Enterprise Tech 2013 has five women. The only Finn in this listing is (male) Linus Torvalds at number five. I shortly summarise the women's placing in the list, title, name and highest degree awarded in brackets:

In place 22: President and CEO of IBM, Virginia Rometty, (Bachelor's degree in Computer Science and Electrical Engineering.)
In place 26: President and Chief Executive Officer of Hewlett-Packard, Meg Whitman, (Master of Business Administration (MBA.))
In place 41: Senior Vice President of IBM Global Business Services, Bridget Van Kralingen, (Masters of Commerce.) (Bridget was classified as 'a growing star'.)
In place 42: Senior Vice President and General Manager of HP Networking, Bethany Mayer, (Bachelor of Science, MBA.)
In place 43: Senior Vice President and General Manager of the Data Center Group for Intel Corporation, Diane Bryant, (Bachelor's degree in Electrical Engineering.)

The above-mentioned listings of women in different leading professions around the world is to open the reader's mind in regards to women who have mastered their way to top managerial positions. The Fortune[7] 500 listing of most powerful persons with titles such as chairman, president, chief executive officer and chief operating officer had 17 women.

2.4 Women in Higher Engineering Education

The term 'contest' is probably the best word to describe the traditional engineering education: during the first one or two years there are eliminations caused by pedagogy (aimed to force the individuals that do not perform well to quit), and after that more personal mentor programs and teaching-personnel support. The key of this teaching is to challenge students and prepare them for future working life. Earlier research depicts that this working method has a

[6] http://www.businessinsider.com/
[7] http://fortune.com/

hidden masculine culture and that it is not profitable for women (Seymour & Hewitt, 1997).

There is light at the end of the tunnel: a bit-by-bit, pedagogical know-how has become one of the skills in the palette of engineering teaching (Ruicargia;Felder;Woods;& Stice, 2000). However, we are not so reformist as we would like to be. Even if we speak student-centred learning, the two-year elimination programme still holds:

In year 2013, the first two study years in Aalto School of Electrical Engineering the advisable timetable for electronics students contained 23 courses. Only three of them were taught in a format other than examination/mid-term examination and exercises. The three courses that did not go along with the pattern are listed and the main teaching method is mentioned below:

- Introduction to studies in an electronics study program (1 cr): small group working, exercises, tutoring, time-management workshop, learning diary and learning-style test.
- Electronics workshop (8 cr): lectures, laboratory work and optional project work.
- Electronics laboratory work (2 cr): laboratory exercises.

The introduction to studies course is the one of the rare courses that encompasses genuinely student-centred methods. However, six student-centred methods in a 1-cr course might confuse students. Traditional studies have long legacies and little interest in change. Faculties want students to achieve solid knowledge of, for example, mathematics and physics to proceed with their studies. Since the old methods have worked for ages, it is very difficult to find a readiness for change from responsible organisations.

As earlier depicted, women benefit from dialogue with personnel. The old competitive or rival method causes a proportion of women to drop out: not because they would not perform well, but because they become frustrated with the system (Seymour, 1995) (Seymour & Hewitt, 1997) (Brainard & Carlin, 1998). A key reason for leaving is the poor teaching methods (Chung;Husman;Stump;Maez;& Done, 2009). Many women who left mentioned some negative aspects of their school's climate such as competition, lack of support, and discouraging faculty and peers (Blickenstaff, 2005).

According to an earlier study (Brainard & Carlin, 1998), the majority of women discontinue their studies during their first or second study year. It is noticeable that those who persisted did so because of their interest in science and math, as well as their independent working skills. An earlier study (Cuny & Aspray, 2002) states that the majority of women who perform as well as their male counterparts have less confidence in their abilities and individual accomplishments than their male peers. This is deep-rooted in our society: boys demand and get more facilities and attention in day care and school. As I have represented earlier in this thesis, there is a continuum of encouraging boys and discouraging girls in the schooling system. This is a phenomenon that we don't even notice (Blickenstaff, 2005).

Positive perceptions of self-confidence were highly associated with female students staying in the programme and increased with the existence of mentor programmes, opportunities for networking with practicing female engineers and clubs like the Society for Women Engineers (http://societyofwomenengineers.swe.org/). In general, confidence in one's abilities and optimism has been shown to be strongly related to academic performance (Gneezy;Niederle;& Rustichini, 2003). I emphasise here that while these arrangements can be vital for female students they also profit male students (Chemers;Hu;& Garcia, 2001).

If the support is not coming from the faculty or another 'official channel', it is important to provide support outside the faculty. Common supportive acts are, for example, peer-to-peer support (Margolis;Fisher;& Miller, 2000) (Cuny & Aspray, 2002) (Cohoon, 2002) and role models (Cuny & Aspray, 2002) (Gürer & Camp, 2002) (Cohoon, 2002).

The old-fashioned engineering education taught mostly technical skills, in which environment male students were in their element: this can be due to the traditional division of handicraft for girls and woodworking (including small electricity work) for boys. However, this segmentation is to be pulled down since in current primary school curriculum both girls and boys take handicraft and woodworking. Other advantages for male freshers are their pre-university technology hobbies and more single-minded focus on the field of study (Paper I). So they are technically more competent than their female peers (when they arrive into higher engineering education. However, the world changes and so must the engineering education: the technical development cycle is so rapid and the engineering projects are so large-scale and complex that we cannot afford to purely produce the old-fashioned engineers with technical know-how. Instead we must deliver multifaceted professionals who are comfortable within international and interdisciplinary projects. Additionally, they must have very good soft skills (Schultz, 2008). This is good news for women, who are commonly multi-skilled: they were the good girls in the upper-secondary school and studied natural sciences as well as languages and psychology. All these skills are remarkably useful today and in future engineering work.

The higher engineering education is still in need of teaching technical skills that should be taught in a student-centred way that incorporates teamwork. Teamwork is especially important, since the complexities of technologies are rising drastically, which causes a need for engineers with well-researched teamwork and communication skills. Besides, the technological renewal cycle has accelerated. In university, courses that teach technology that will probably be old-fashioned in a few years. This is not a waste of time, on the contrary: if the teaching is good then the course will have hidden goals that, for example, improve one's problem solving skills. For example, teaching technology can be very rewarding if the material and student-centred education methods are accurate.

As I will disclose further, women profit from teamwork and social-based education. However, to benefit the student-centred learning process, we have to ensure that the teamwork functions: if we stick to the old-fashioned meeting practice where men play an active role in the problem-solving process and women stand back, the result will be unsuccessful. To guarantee the success of teamwork, we should firstly discuss the methods and goals of the team, and secondly discuss the gender-related aspects. To bring the gender differences to light, we should talk about them. Both items are important, because the students must assimilate them to make the teamwork succeed. Without prior knowledge, men can easily provoke women about their manner of speaking and undermine the female speaker (Kray;Thompson ;& Galinsky, 2001) (Wolfe & Powell, 2009).

There are a variety of ways to improve teamwork within student design: explicitly teaching about it, especially teaching how to respect one's teammates and the client's needs; organising teams to reduce conflict, balance gender composition (or have all-male or all-female teams) and improve trust; incorporating peer feedback throughout the duration of the team and using it to mediate disrespectful interactions and unacceptable practices, including a wide range of teamwork expectations in grading practices; and better training within faculties about ways to incorporate teamwork. Also, few researchers within the engineering education system have taken campus culture into account: that is, few see that comprehensive changes to engineering education might be needed to improve circumstances in teams. (Tonso, 2006)

However, women still have to accomplish traditional technical courses. The starting point of these technical courses is challenging for female students, who mostly apply to engineering or CS studies as one selection among many others and without or less prior knowledge of the field (Margolis;Fisher;& Miller, 2000) (Cohoon & Aspray, 2006). The basic examples of technical courses are electronics and programming. In both there is a group of male students who have had electronics and/or programming as a hobby (perhaps from their early school years) or at school. According to my research, most of the female students have had no such hobbies. Naturally they have to do much more work on those courses than their male peers. This easily further reduces women's self-esteem, as well as strengthening men's belief in their own superiority.

2.5 Women Entering Male Professions

In the 1960s more and more women started to work outside home. This was due to the change of having fewer children, while also having them at an older age. However, the equality in household work did not emerge (and it hasn't emerged so far). Most of the women continued to take on the main responsibility of family, home and children. To maintain this arrangement was not a sign of women's weakness, but a free choice. The traditional occupations for female were predominantly low paid, low valued: positions like nannies, nurses, teachers and librarians. Earlier research depicts that our culture rewards technical fields better than 'women professions'. (Bianchi;Milkie;Sayer;& Robinson, 2000) (Coltrane, 2000)

Earlier research (England, 2010) reveals that men had little incentive to move into badly rewarded traditional 'female' activities, such as homemaking or female-dominated occupations. Still, the phrase 'my son, a nurse' would sound much less favourable than 'my daughter, a physician'. However, if a man entered these fields, he was most likely to be promoted into leading positions (Williams, 1992) (Blau & Kahn, 2000).

Women's journey towards higher-valued, higher-paid and more demanding careers continues despite challenges and obstacles. In the 1990s three important concepts were launched that have lasted throughout the decades: the problem of the unattractiveness of science, technology and engineering (Seymour, 1995), the problem of the glass ceiling (represented in chapter 2.5.1), and, in the area of computer science, the third concept of the shrinking pipeline (represented in chapter 2.5.2). The above are scientific terms, which are not to be used colloquially when the criteria of these concepts are unknown. The concepts are quite often wrongly interpreted. I will shortly summarise the terms below.

The unattractiveness of science, engineering and math (STEM) subjects for girls is a severe problem in secondary and upper-secondary schools (Seymour, 1995) (Seymour & Hewitt, 1997). The girls don't consider STEM fields as future professions. Even though girls would be talented in STEM subjects, they don't trust in their abilities, and in most of cases end up choosing their studies to be outside STEM. At the age of 15, they take the Program for International Student Assessment (PISA) (OECD, 2015) tests. In Finland, according to those tests, girls are more talented in languages than boys. Traditionally, boys have been a little bit more skilled in mathematics than girls. However, the latest results (from 2013) depict that girls also outperform boys in mathematics. Still, girls suffer from low self-esteem in STEM subjects and mathematics (Spencer;Steele;& Quinn, 1999). The common outlook puts the pressure on girls to choose languages instead of STEM subjects – even when there would be room for both.

2.5.1 Glass Ceiling

In the history of female career development there are two essential concepts: the glass ceiling (Morrison;White;& Van Velsor, 1987) and the shrinking pipeline (Camp, 1997). Significantly, these concepts have held throughout the course of time. The term **glass ceiling** was first conceived of in 1987 as: 'The phenomenon that keeps women from reaching the top levels of organizations' (Lindsey & Homes, 1987). The glass ceiling effect is the more general term (and phenomenon), whereas shrinking pipeline is used in science.

Later on, the popular notion of glass ceiling became: 'The glass ceiling effect implies that gender (or other) disadvantages are stronger at the top of the hierarchy than at lower levels and that these disadvantages become worse later in a person's career´ (Cotter;Hermsen;Ovadia;& Vanneman, 2001).

Glass ceiling could be a suggestive factor. However, the term is largely debated because large amounts of studies have shown other factors that hinder women's career development. The significant factor in maintaining the glass ceiling is simply the reason that research tells us women are worse negotiators than their male peers what it comes to salary/career negotiations (Gerhart &

Rynes, 1991) (Stevens;Bavetta;& Kahn, 1993) (Kray;Thompson ;& Galinsky, 2001).

When media lists the most powerful people within the technical sector only very few women are mentioned (for example Forbes, Business Insider). The majority of women are finding success in the middle and lower tiers of management. In 2003 in the USA, 40% of managers were women (Eagly & Carli, 2007). The problem is that even though women are invading the workplace, they still lag behind men in representation of the top tiers of the American workforce (Carnes & Radojevich-Kelley, 2011).

However, the glass ceiling is a debated term and there is respected research (Eagly & Carli, 2007) that questions the phenomenon.

In 2001 a four-step criteria for glass ceiling was defined (Cotter;Hermsen;Ovadia;& Vanneman, 2001). When talking about glass ceiling, this criterion is a good benchmark.

1. A glass ceiling inequality represents a gender or racial difference that is not explained by other job-relevant characteristics of the employee.
2. A glass ceiling inequality represents a gender or racial difference that is greater at higher levels of an outcome than at lower levels of an outcome
3. A glass ceiling inequality represents a gender or racial inequality in the changes of advancement into higher levels, not merely the proportions of each gender currently at those higher levels.
4. A glass ceiling inequality represents a gender or racial inequality that increases over the course of a career.

Reverse phenomena takes place in workplaces where women form the majority of personnel. We are talking of a glass escalator: hidden advantages for men in the ‘female’ professions (Williams, 1992).

2.5.2 Shrinking Pipeline

The concept of the shrinking pipeline (Camp, 1997) sketches the loss felt by women, which emerges on every hierarchical step within an academic career in computing. This phenomenon describes how the ratio of high school girls (~50%) shrinks all the way to full professors (3-5%). As shown in Figure 4, The ratio of women decreases on each step (bachelor’s degree, master’s degree, Ph. D and the professor tenure).

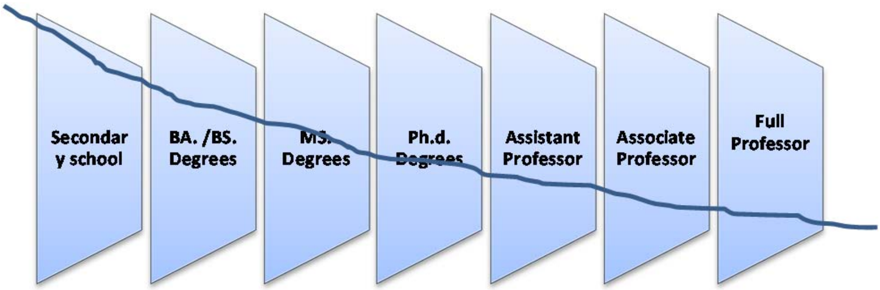


Figure 2: the shrinking pipeline (this diagram is an approximate since the figures vary from different countries and timelines). The figure is a remake of the one in (Camp, 1997). The phenomenon has been a corner stone for latter research of women and CS.

A few years later, some studies generalised the phenomenon into all engineering and technology fields (Rees, 2001) – and to all academic sciences (Fox, 2001). The latter announces an important message: even if academic women have already survived barriers of selection, (both self-election into science fields and selection by institutions), there is more to compete with. During each step a group of women will choose otherwise. Later on, the same model has been used to describe the number of girls that diminish with every upward step in the STEM fields (Chang, 2002) (Sanders, 2009).

In recent decades women have reached managerial positions within companies in industrialised countries. However, the proportion of women who hold top management positions has increased only slightly and the shrinking pipeline exists (Ibarra;Carter;& Silva, 2010).

2.6 Women's Career Paths

Women engineer's working career has lower expectations than their male peers (Blau & Kahn, 2000) (Gneezy;Niederle;& Rustichini, 2003) (Bilimoria;Joy;& Liang, 2008) (Croson & Gneezy, 2009) (Cochran;Wang;Stevenson;Johnson;& Crews, 2011). The first gap is formed in the first salary negotiation: several studies (Gerhart & Rynes, 1991) (Stevens;Bavetta;& Kahn, 1993) (Stuhlmacher & Walters, 1999) state that women are less successful in salary negotiations than their male peers. The severity of this varies according to country and culture. This phenomenon appears above all in the United States (US), where women's first salary negotiations result in approximately a 30% smaller salary than their male peers. Once the gap has emerged, for example in the first contract of employment, it is difficult to make up (Gerhart & Rynes, 1991). From this, people jump to the conclusions that women are worse overall negotiators than their male peers, says an earlier study (Stevens;Bavetta;& Kahn, 1993) (Byrnes;Miller;& Schafer, 1999) (Stuhlmacher & Walters, 1999) (Kray;Thompson ;& Galinsky, 2001) (Kray & Thompson, 2002). The approach to this phenomenon is to take into account that there is a wide variety of negotiations and in most of them there is no winners or losers but a common goal that the whole team aims towards – and women are good in those kinds of negotiations (Bass & Avolio, 1994)

At a general level, women are more averse to risk than men in working life (Croson & Gneezy, 2009). This might be the reason why men are easily evaluated as being better manager material. However, a less noticeable part of this phenomenon is that men tend to take more risks: even if it was clear that it was a bad idea to take that risk; whereas women seem to be disinclined to take risks both in fairly innocuous situations and when it was a seemingly good idea to take risks. (Byrnes;Miller;& Schafer, 1999)

Traditionally, women are described to be inherently more cooperative and collaborative than men, whereas men are more assertive and demanding than women (Kray;Thompson ;& Galinsky, 2001). A lack of delegation is bad management, which is a nasty habit for female managers. On the other hand, women are keen to ask questions and seek clarification. This makes them good managers and is crucial for success in large-scale projects. However, this comes with a price: when a woman opens her mouth in a meeting and asks – 'I didn't quite get it, could you elaborate?' – some colleagues interpret that her question reveals a lack of awareness, which can ultimately lead to her being disrespected. It has also been researched that male engineers form a group that responds badly to women's clarifying questions and other addresses in meetings (Wolfe & Powell, 2009). One more factor in the workplace is communication styles often differ between men and women. Society has socially conditioned most men to interrupt and insert their opinion in a meeting, while women will wait for an opening in the conversation, which often never happens (Gürer & Camp, 2002).

Another commonly debated phenomenon is how men and women perform in competitive environments: earlier research depicts that even if women and men perform similarly in non-competitive situations, men outperform women in competitive situations (Stevens;Bavetta;& Kahn, 1993) (Gneezy & Rustichini, 2004) (Niederle & Vesterlund, 2011). However, the less well-known research states that women exceed their normal performance level in certain working conditions: where they feel comfortable. Feeling comfortable is more important to female than male engineers (Bilimoria;Joy;& Liang, 2008).

It has been noticed that, besides the benefit of women-friendly working environments, women also lighten the atmosphere themselves: that the critical mass of women on the faculty and among the study body has a significant and positive impact on both men's and women's perceptions of their suitability in engineering (Creamer;Amelink;& Meszaros, 2010). It is once again noted that supporting female employees also benefits their male peers. (Who wouldn't like to work somewhere that has a good atmosphere?)

The true hot potato in women's careers is family absences and in-house responsibilities. In Finland, it is quite common that people aim to start a family after they get their first permanent employment. On average, women spend time at home with their children for substantially longer periods of time than males. According to the paper V, 40% of women who have a baby or babies in the first five years of their career stay at home with their children for more than one year. When it comes to the decision of who will take the family leave, it is greatly dependent on financial aspects: wage inequality (favouring men) between genders creates pressure for women to take parental leaves, which diminishes their wage trend (Shafer, 2011) (Sidle, 2011).

This leads us to the next challenge: since women spend more time at home (on family-based absence), they significantly do more at home even after returning to work. Earlier research depicts that women typically bear a disproportionate amount of responsibility for home and family, and thus have more demands on their time outside the office (Bianchi;Milkie;Sayer;& Robinson, 2000) (Coltrane, 2000) (Meyerson & Fletcher, 2000) (Coltrane, 2000). This leads to the complicated balancing between work and family. Since we can hardly contribute to couples' uneven domestic work, we should make small adjustments at work to gain equality (Rees, 2001). There are various ways to support women's career possibilities, for example:

- Work has to be able to be done in normal office hours.
- Working from home is encouraged when one has suitable duties.
- Last minute meetings are avoided.
- One doesn't need to show commitment by working long days at the office.

(Meyerson & Fletcher, 2000)

The above mentioned is profitable to women and their male peers: when both parents do decent hours a week, it will be easier to balance the home responsibilities as well. In Finland, both our working culture and childcare systems encourage this kind of strategy. However, women still do more domestic work and earn less in paid jobs: as long as we are unable to manage our work duties within a decent amount of hours, we feed the situation where qualified women have to turn down better career paths.

During one's career, a widely used support method is mentoring. Classical mentoring (ideal but rare) combines psychosocial and career support. Mentoring can take place in any level of the company hierarchy and should provide emotional support, feedback on how to improve and a suitable role model. When further up in the hierarchy, mentoring can be replaced by sponsoring which concentrates more on true career support. "Sponsors fight to get their protégés promoted". (Ibarra;Carter;& Silva, 2010)

Traditionally, the common hindrance for women's career development is the masculine culture and male leadership model. Masculine working models respect technical knowledge and disrespect so-called 'soft skills'. In addition, they are competitive and challenging individuals. Since women are less keen to take risks than their male peers, this kind of working model does not suit them well (Byrnes;Miller;& Schafer, 1999). However, while the technology evolves, engineering projects become more complicated and the processes diversify both in technical and administrative stairs, meaning that soft skills became more and more important (Schultz, 2008).

One problem in women's career development is that while avoiding risks and bearing the bigger responsibility of children and home, they do not apply for better positions: if women don't apply, so male applicants must be promoted

(Croson & Gneezy, 2009). This is regrettable from the world economics point-of-view: earlier research (Colaco;Myers;& Nitkin, 2011) depicts that women raise the efficiency of board working.

In traditional women occupations we talk about the phenomenon of the glass escalator: hidden advantages for men in the 'female' professions (Williams, 1992). In engineering we could argue for reasons against women applying, such as low self-esteem towards their skills and abilities, or the problems of combining work and family lives. One classic example is from the field of computer science: female Ph.D. graduates are more active in producing scientific publications in the Association of Computing Machinery (ACM) conferences than their male peers (Cohoon;Nigai;& Kaye, Gender and computing conference papers, 2011). However, according to the shrinking pipeline, their tenure track diminishes on the next level (associate professors).

As stated before, balancing work and family is, if not an obstacle, at least a hindrance towards women's careers. To tackle this, we should give tools, for example, for working at home and doing flexitime (Hewlett & Luce, 2005). The other aspect of the family-work puzzle is the family-based absences, which is often purely women's work. In Finland, our society is reforming the parental leave system in a way that means it would attract (more) men to take leaves.

We must see that both engineering education and work methods are in a transitional period. Women as managers confront obstacles because of their gender. Research has shown that women possess both advantages and disadvantages as leaders, with the disadvantages arising primarily in roles that are male-dominated or otherwise defined in masculine ways (Eagly & Carli, 2007).

2.7 Briefly on Women and Engineering Societies

There are various societies around the globe for women to take advantage of and lean towards. These societies can be very effective in supporting one's career. There are societies for female-engineering professionals that range from grass-roots level to informal peer-to-peer networks, to distinguished and respected international institutions. The significant obstacle in these kinds of societies is that the majority of female engineers are in a constant hurry: the work is demanding and women are still doing more domestic work than their spouses (Bianchi;Milkie;Sayer;& Robinson, 2000) (Coltrane, 2000) (Meyerson & Fletcher, 2000). The early career, where support is proven to be efficient, quite often overlaps with the time as starting a family and having young children. After the 'who takes/picks-up who' years, there is more time to use these societies.

However, I claim that the most difficult aspect in these societies is to reach out to women. The internet era, especially web 2.0, has made it possible to easily create and deliver all kinds of material for a large pool of people in wide geographic locations. The downturn of this phenomenon is that we have so much material, so little time and zero tolerance for information that we cannot reach instantly. Nowadays, the unquestionable challenge is mainstreaming: many organisations put an emphasis on web 2.0 technologies. There are large amounts of very cool websites, which most probably have been tailored for suitable audiences. However, many of these sites (including ours) fail to deliver: either they don't reach end users or cannot assure them or receiving added value by using them.

2.8 Summary

This chapter presents the literature background of my thesis. It represents the continuum from schoolgirls to engineering women. The journey can be hard and full of minefields, but it can also be very rewarding: many young female engineers consider their working conditions satisfactory and good.

Finnish women have fair prospects to combine work and family: our system starts with high quality pre-natal clinics and continues to high quality and rationally priced day care and free of charge schooling system. This enables women to potentially forge a career without making family sacrifices.

However, with respect to possibilities of equality, in Finland there still exists two regrettable phenomena:

1. The glass ceiling: 'The phenomenon that keeps women from reaching the top levels of organisations (Lindsey & Homes, 1987).
2. The shrinking pipeline: the loss felt by women, which emerges on every hierarchical step within an academic career in computing.

3. Research Background

3.1 Introduction

In this chapter I introduce women in higher engineering education: Why are women in higher engineering education? Why engineering? I represent the difference between engineering and traditional natural science teaching at university level. Next, I describe that the women who pursue a higher engineering education are not a homogeneous group: they don't have the same learning strategies or support measures that many others do. Next, I present Belenky's theory of 'Women's Ways of Knowing' – a model that I have used in my research work. Lastly I shortly introduce Sue Rosser's 'Reaching the majority' as a comparative theory.

3.2 University vs. Technical University

Research of girls studying math, physics and chemistry has roots in Finland that go back to the 1970s. The significant difference in studying natural sciences vs. engineering is in the nature of both studies and future career: nowadays the key of engineering, in both studies and work, is continuous change. While the technology evolves, it is important to teach problem-solving methods. Here is an example of computer-science teaching: instead of learning one programming language, we offer a palette of languages in different courses: our goal being to equip the students with both programming and problem-solving skills (to adopt new languages)..

Compared to engineering, the natural sciences offer a solid grounding and studies of a fixed nature. The studies are more theoretical than engineering studies. There is one important incentive into studying: the module needed for the qualification of a secondary school teacher (60 cr) is easy to accomplish during STEM studies. This acts as a safety net of assurance for students in regards to their future: female students are more insecure concerning their abilities and poorer risk takers than their male peers, and can create a safety net for themselves in the form of the respected education of a school teacher. They can imagine being a part of the school society: it is traditional, safe and there will always be work for teachers. Besides the selection process in finding a field of study, there are possible field shifters during the course of studying. Above I represented fundamental differences between traditional natural science and engineering perspectives. The traditional natural sciences appeal due to their stability, while the higher engineering education appeals due to its state of change.

3.3 Women and Higher Engineering Education

This subject has been studied for years. It is part of a continuum of girls' STEM studies to women's working life in the field of engineering. In my literature survey I concentrated on papers that spanned from two decades old to the present. In my research I test some viewpoints close to my work. I emphasise that this is not an extensive cross-section of this field. (It would take a lot more than one doctoral thesis.)

According to earlier research (Cuny & Aspray, 2002) (Cohoon, 2002), there are some common ways around the globe to improve the recruitment and retainment figures of women. However, these have not proved to be successful. (Otherwise we would not have the segregation problem anymore.) Even if they haven't solved the problem, they can still be defined successfully in some metrics, for example: spreading the word, turnout in events, pleased participants and positive feedback. However, we must take into account that many students/graduates do not want to participate in these kind of activities. I emphasise here that the gender-supporting acts must be carried out in a very delicate manner – and after thorough preparation.

Gender supporting activities should be well informed but voluntary: women are a heterogeneous group. We cannot state single activities that would suit them all. However, earlier research (Newton, 1987) depicts that female in engineering education students as a group differs from the students of economics or nurses, in being on average more androgynous. They are also more androgynous than their male peers.

I recommend using tailored support activities for specific student groups. The other important act is that we have to be very careful in our activities and keep our eyes open to other good practices. If we don't, we can easily create activities that are not helpful and might even be harmful for the target group.

An earlier work (Tonso, 1996) showed how the customary strategy of assigning one or two women to each team resulted in isolating female students from each other and significantly disadvantaged lone-female student engineers. However, when we have not studied our field sufficiently we can end up harming female students despite our efforts: in the late 1990s, in our technical university department of electrical and communications engineering, the women were scattered into groups in a way that every group ended up with one woman. According to my Paper III, an unbalanced gender situation leads to female isolation and can be very harmful for their study motivation and retention rate.

In contrast, teams where female students worked in (at least) pairs allowed for substantially different kinds of discussions, learning, and ways of completing coursework assignments. To my knowledge, the optimal gender representation for women is an even or majority of women. Understandably, if we can't create even gender groups for all our students, we should go for gender-even and male-only groups rather than spreading the females. However, this is not a problem since the study success of male students does not rise (significantly) in gender-even groups, revealing they are more resistant to poor communication and a lack of peer support (Bernstein, 1991).

The topic (women in higher engineering education) is contradictory and usually raises strong feelings – many of them regrettably negative. Activities must be thought through. The traditional engineering education is a straight continuation to old-fashioned upper-secondary school classifications between STEM (for boys) and humanities (for girls) subjects. Since boys are favoured before girls, girls have to be strong in order to follow the STEM path. Girls work hard to be one of the boys in order to be rewarded. When they finally get in to the higher engineering education, the majority of them are not interested in 'female activities'. Feminism is a very contradictory concept and women are easily undervalued even among themselves. The support from faculty management is crucial and one of the key advantages for project success.

Girl/women-only activities have to be arranged in a delicate manner: many women don't want to attend since there are no male participants. Girls have the common misconception that boys are better in STEM subjects. Since women are aware of 'men's superiority', they don't want to attend to activities aimed only for the 'weaker sex'. This same prejudice applies for women-only exercise sessions. In my work, I have observed that women-only or fifty-fifty exercise sessions are optimal considering women's learning curve.

3.4 A Few Common Steps to Female-centred Learning Strategies in Technical Universities

There are many beliefs of women, technology and engineering. Most of them are so deep in our society that we seldom stop to question them. Perhaps the most typical engineering-related misbelief is that girls can't perform well in science and mathematics (Brown & Josephs, 1999). We as female engineers know otherwise, but the challenge is to convince the people close to the girls.

The second old-fashioned perception is that women don't belong in the engineering field. This argument is based on old-fashioned views on engineering education and work life: it sees engineering work as a masculine playground where (mutual) competition is a dominant working model and individuals are favoured over teamwork. However, this working model hasn't functioned in years, but instead different kinds of teamwork models have taken place.

One step closer to equity is the attitude that women are welcomed into higher engineering education, but they will not receive any special treatment. The engineering education will not be altered to suit women better (but the culture will remain masculine.) Women will have to adjust.

The third step in higher engineering education reform is to create pedagogy to benefit women, men and working life.

3.5 Women's Ways of Knowing

Women's Ways of Knowing is a common theory of women's learning preferences. The central book, Women's ways of knowing: The development of self, voice, and mind, (Belenky, Women's ways of knowing: The development of self, voice, and mind, 1986), has been, despite criticism, a basis used in the creation of feminist pedagogy. The book emphasises the meaning of social environment and dialogue in women's learning process. The book has more than 10 000 citations in google.scholar.

The research revealed five learning strategies from passive (authority-originated) to active (student-centred).

1. *Silence* (relatively rare): women don't consider themselves from a data-management point-of-view. They see themselves as passive members of a world where men play a leading role.
2. *Received knowledge*: women believe authorities unconditionally. They consider listening the only way to develop their knowledge. They find it difficult to understand the development in the world and themselves.
3. *Subjective knowledge*: Women rely on their own subjective thoughts, feelings and experiences for knowledge and truth.
4. *Procedural knowledge*: recognition that multiple sources of knowledge exist, and that procedures are necessary for evaluating the relative merit of these sources.
    a. concepts also used at this stage*: separate knowledge* and *connected knowledge*
5. *Constructed Knowledge*: women aim to assimilate their know-how to the authorities' views. They understand that they can also have misconceptions.

The first two strategies occur often with schoolchildren and low-educated women. The transition period from *received* to *subjective knowledge* often takes place in technical university studies. Highly educated women (both in universities and technical universities) often have what we call the *separate knowledge.*

They consider this as an asset on which they can argue (both in the engineering field and traditional STEM) about what they can take a stand on. The other model of knowledge is connected knowledge: women's own experiences integrate to information gained from others. Women strive to combine knowledge from various sources to process it: aiming to get closer to the 'pure' (scientific) knowledge.

Regardless of hierarchical levels of studies, women often find their natural role in the knowledge-creation process. They emphasise collective data-acquisition models and assimilating their feelings and knowledge to others' skills and learning objectives. When working in level five, women can concentrate on producing know-how into fields relevant to them.

In 1995, J. Becker published a journal article of Belenky's theory applied to mathematics learning processes (Becker, 1995). In this article she applies Belenky's model into mathematics teaching in both graduate and undergraduate study levels. She suggests stage 4 (procedural knowledge/connected knowledge) to be appropriate for learning mathematics. Becker's article is a very good addition into Belenky's model for it is general as nature.

I heard of Belenky's model when I was still studying electrical and communications engineering. I found the theory very well suited in women's learning strategies in engineering. Besides interpreting and classifying women's learning strategies with it, I also found it to serve well in constructivist learning approach.

A common argument that is represented against Belenky's theory is that women produce information differently than their male peers. Additionally, (Maher & Tetreau, 1996) there is a criticism that "few of these individual 'whole stories' are heard". They argue that the theory misses the social and structural perspectives: influences of race, class, culture and other factors to shape the self-development process.

3.6 Reaching the Majority

As another theory about women in engineering education, I will present Sue Rosser's six-step model to reform the science/engineering education so that more women could enter in it (Rosser, 1995). However, this theory has not gained large publicity, and I do not use it further in my thesis.

1. *Absence of women is not noted.*
   Science is objective; gender does not influence those who become scientists or the science produced by those scientists.
2. *Recognition that most scientists are male and that science may reflect a masculine perspective.*
   The investigation of problems has a more holistic and global scope using interactive methods. In teaching, connections and broader content is created for problems and laboratory works.
3. *Identification of barriers that prevent women from entering science*
   Science reflects a masculine approach to the world. → We need supporting strategies.
4. *Search for women scientists and their unique contributions.*
   Women have always been in engineering.
5. *Science is done by feminists and women.*
   The science world has to be democratic.
6. *Science is redefined and reconstructed to include us all.*

In my opinion, Rossels' (1995), theory still holds in higher engineering education in Finland. For example, the majority of our research/teaching personnel at Aalto University Technical Schools are clearly in phase 1. (*Absence of women is not noted.)* Nationally, phase 2 (*Recognition that most scientists are male and that science may reflect a masculine perspective*) is acknowledged by some researchers, decision makers and other bodies (for example, The Federation of Finnish Technology Industries). There have been studies of barriers for women in STEM (phase 3), but we still have a long way to go until we welcome and include us all into learning and making science.

Sue Rosser's 'Reaching the majority' describes well the women in research society. However, I found it more meaningful to concentrate on learning strategies (not learning governance.)

3.7 Summary

In this chapter I represented the basics of women and higher engineering education. Essential in this chapter is Belenky's theory, 'Women's Ways of Knowing'. The theory introduced five learning strategies from passive (authority-originated) to active (student centred). Additionally I represented a more narrow theory of women in higher engineering education (Rosser: Reaching the Majority). However, I do not use the latter one in my research.

4. Research

4.1 Introduction

In this chapter I further elaborate my research questions:

RQ1: What are women's paths to our university of technology?
RQ2: Can we help with the retainment of female students during their early studies in a cost and admin-efficient way?
RQ3: What are the early career prospects of female engineers that graduate from our university?

After elaborating the research questions, I discuss important issues like scientific research, validity and ethics. Next, I present each research question, as well as its corresponding research methods, research and related papers. This chapter presents the research and results of my thesis.

4.2 Research Questions

Despite earlier research and supporting activities, women still form a clear minority in higher engineering education (Nelson, 2014) (Holly, 2014)(6.3 Student Enrollment Statistics After My Study). From previous studies we have learned that girls are unsecure STEM learners in secondary and upper-secondary schools (Seymour, 1995). They also suffer from poor self-esteem and mathematical uneasiness (Spencer;Steele;& Quinn, 1999) (Hill;Corbett;& St Rose, 2010). At university level, we have a clear division into women's field (education, liberal arts) and men's field (STEM and engineering) in Finland.

Earlier study has revealed common reasons for women not to enter STEM/engineering as lack or role models, self-doubt, negative view of science and scientists, as well masculine content and climate of technical universities (Brown & Josephs, 1999) (Sagebiel & Dahmen, 2006). On the other hand, earlier studies sum up that the family connections in the field of STEM have a positive influence on women's career choice (Adya & Kaiser, 2005) (Buzzetto-More;Ukoha;& Rustagi, 2010). However, the field is still missing the information on how women end up in the engineering field. How is the decision formed? What chain of events occur? During the journey, what were the crucial factors, events and central people? At what point in the timeline was the decision formed?

This is my contribution to this field – to clarify women's journey to higher engineering education in our university. On the strength of my research, I aim to present recommendations to help adjust recruiting materials to something more interesting for female applicants. My first research question is:

RQ1: What are women's paths to our university of technology?

As in earlier studies, women are more likely to discontinue their studies during the first two years than their male peers: while girls have poor self-esteem towards STEM subjects, women in higher engineering education have less confidence in their abilities and individual accomplishments than their male peers (Cuny & Aspray, 2002) (Sagebiel & Dahmen, 2006). Reasons for interruptions can be derived from poor climate, competition and discouraging faculties with a lack of support (Blickenstaff, 2005).

Earlier research reveals teaching experiments and recommendations for renewing courses (Rich;Perry;& Guzial, 2004) (Barker & Garvin-Doxas, 2004) or enhancing curriculum with interdisciplinary teaching (Beraud, A., 2003) (Borrego & Newswander, 2008) (Sagebiel & Dahmen, 2006). However, both of these methods demand large amount of work and financing.

My research aim is to find supporting strategies that can be arranged with little monetary contribution and little work from the faculty personnel. My second research question is:

RQ2: Can we help with the retainment of female students during their early studies in a cost and admin-efficient way?

After graduation, I follow women's early career paths. Earlier research presents findings of women as worse (salary) negotiators and less eager than men in using high-pressure methods to progress their careers (Gerhart & Rynes, 1991) (Stevens;Bavetta;& Kahn, 1993) (Kray;Thompson ;& Galinsky, 2001). Since we work in a field where salary is based on personal skills and personality, the successful salary negotiations are crucial for one's career. This phenomenon is quite contradictory to many traditional work fields, where salary level is defined by degree and years of work experience.

The one subject that causes problems is family leave: as stated earlier, women take more responsibility in home and children matters than their spouses (Shafer, 2011) (Sidle, 2011). All the above-mentioned phenomena are important for my research: my contribution is to map women's early career into numbers and figures: what are early career prospects for female engineers compared to their male peers? What are challenges in female engineers' early work career? What are their survival strategies? My third research question is:

RQ3: What are the early career prospects of female engineers that graduate from our university?

As a result of my study, I aim to find and represent supporting acts for:

1. Women to choose higher engineering education
2. Women to conduct studies in higher engineering education
3. Women to work in engineering positions – early career

As stated earlier, women are easier to be influenced than their male peers (Seymour, 1995). This has both a positive and negative impact: if we find the right activities and right channels, we can make a difference. If not, the girls and women have to continuously fight against old-fashioned thinking and prejudices (and this will diminish the applicant pool and raise the discontinuation rates of students).

4.3 Research Approach

A scientific research is always carried out by means of a scientific method. A research method comprises the backbone of a research. It consists of a research strategy, methods for data collection and data analysis. Each step is closely tied to another (Cohen;Manion;& Morrison, 2000).

The research begins with choosing the subject based on a structured literature review of earlier research in the field. The next step is to formulate the research plan (/strategy). A research plan consists of a full approach of representing the basis of research, execution of research and reporting (Cohen;Manion;& Morrison, 2000)

The starting point for my study is basic research: a systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena (Johnson & Christensen, 2004). My first aim is to produce new knowledge of women in a higher engineering education. However, as can be seen in my papers, my research aims also to serve as a basis for practical activities.

The backbone of my thesis is a collection of articles that are linked by subject (women in higher engineering education) and timeline (from first recollection of engineering as a study field to early career). The timeline of my research questions is represented in the 1st chapter (Introduction): Figure 1 Timeline of my research questions. The wider perspective of my research, mapped with some international trends in the field, is represented in (APPENDIX A).

4.3.1 Validity

Lincoln and Guba posit that trustworthiness of a qualitative research is important to evaluating its worth. Trustworthiness involves establishing:

- Credibility - confidence in the 'truth' of the findings
- Transferability - showing that the findings have applicability in other contexts
- Dependability - showing that the findings are consistent and could be repeated

- Confirmability - a degree of neutrality or the extent to which the findings of a study are shaped by the respondents and not researcher bias, motivation or interest.

(Lincoln & Guba, 1985)

My questionnaires contain both quantitative and qualitative questions. The validity of the quantitative part of the study is split into two central measures:

- Internal validity: The ability to infer that a causal relationship exists between two variables.
- External validity: The extent to which the study results can be generalised across populations of persons, settings, times, outcomes and treatment variations.

(Johnson & Christensen, 2004)

4.3.2 Ethics

(Johnson & Christensen, 2004) define research ethics as 'A set of principles to guide and assist researchers in conducting ethical studies'. Some central concepts of research ethics are informed consent, access and acceptance, privacy, anonymity and confidentiality. (Cohen;Manion;& Morrison, 2000)

I aimed to conduct my research according to high ethical standards. I will present below how my research follows the guidelines:

- Informed consent: all students in each research were informed of an anonymous use of material. All students were also advised how not to participate on research.
- Access and acceptance: I conducted part of the studies during my own courses, and I had my superior's acceptance of my work. In research outside my area of responsibility I had permission from a project manager or similar to carry out my study.
- Privacy: I do not expose any personal data that is not already in the public domain.
- Anonymity: I don't reveal any personal information of my participants. In one case, where the number of participants per study programme is low, I also blindfold the study participants (to ensure that no-one can be identified).
- Confidentiality: even if I have gained personal information of my research participants, I will not represent them in public and I will treasure the research data.

A violation of my research ethics is course feedback questionnaires: in my paper IV, I use the course's feedback forms as one basis of my actual study (Figure 5 Mixing quantitative and qualitative data). Part of the course feedback was collected before I entered the project and it did not contain the announcement that data was to use in scientific research and one could deny the research use of one's answers. However, I had the consent of the project manager for the data and I did not use the feedback material in my actual research.

4.4 RQ1: What are women's paths to our university of technology?

4.4.1 RQ1: Research method: narrative inquiry

I use the narrative research method for my first research question. I collected data in the form of an essay. I chose narrative inquiry as a research method, since I wanted to know the whole pathway (not merely the reasons) that women progressed to higher engineering educations. The narrative research method has a clear qualitative nature. Researchers have always been interested in narratives, since it gives us a tool to understand and govern the past. The narrative inquiry as a research field has roots in the 1980s, and in the 1990s the use of narratives spread largely and extended to different study fields. Narrative research explores the meanings of human action and phenomena constructed in narratives. The basis of narrative analysis is that creating stories is essential and typical for human beings. Narrative research is a broad framework, which contains different data-acquisition and analysis methods. The key question of this study is the concept of a story. Narrative analysis can use, for example, stories, tales, memoirs and anecdotes as data sources. Figure 3 presents the collection process of narrative data. (Connelly & Clandin, 1990)

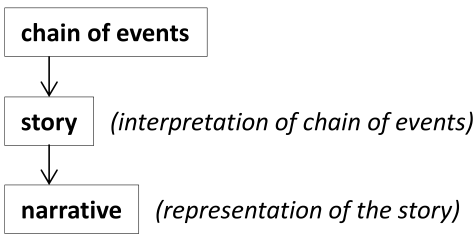


Figure 3 Origin of a narrative

To be eligible data for narrative research, the chain of events has to have a beginning, storyline and end. The researcher studies the material and aims to interpret the essentials from the narrative.

However practical narrative inquiry is, it has its weaknesses: firstly, the method has a strong cultural emphasis: it is not replicable in other cultural environments. Secondly, the interpretation is subjective and reflects the researcher's own thoughts. (To gain more accurate research, we must use researcher triangulation[8].) Thirdly, the data has to be chosen carefully to avoid the researcher's interference in the narratives (Connelly & Clandin, 1990). I did not try to fade out cultural influence: they are valuable knowledge and the higher engineering education varies greatly between countries and it would be interesting to replicate this study in the other country. I ensured the quality in

[8] Researcher triangulation: more than one researcher studying the same phenomenon.

my research by pre-reading hundreds of essays as preliminary study to get the big picture.

4.4.2 RQ1: Research

In RQ1, I examined what are women's paths to our university of technology. I used narrative inquiry as my data-collection method and narrative analyses as my research method.

I saw the process of choosing one's study field as a continuum of events that form a story. This story has a beginning (initial point – first recollection of engineering as a study/work field), progress (storyline) and ending (start of studies). I collected data in the form of an essay. I was very eager to find connective themes in stories so I used a traditional, categorical approach by means of content analysis that ended up with connective categories and themes (Lieblich;Tuval-Mashiach;& Zilber, 1998). However, in this thesis I present a few examples of typical stories as well.

Students produced the narratives during the first month of study in an introductive course that is obligatory for all new students. Students wrote essays of the continuum of events from their earliest reflections of engineering as a career choice, to their present state as first-year students. The instructions of the essays also encouraged students to sketch their future plans in the field of engineering. However, since the students strongly emphasised their path to the university, I did not include the future plans in this study (except in cases where it was a determining factor in students' decision of their place or field of study).

The students were informed that they could prohibit the research-based use of their material. Students wrote free-form narratives of their path into our university. The minimum length of this essay was two A4 papers with a maximum font of 12pt. Typical to the nature of narrative inquiry I did not limit the content of the student's essays. I did not demand any compulsory content that the essays should include, but I gave students examples of elements an essay could contain. I left the writing instructions intentionally broad so I did not exclude any aspects that the students wanted to write about. However, this made the analysis of essays somewhat complicated: if somebody wrote something interesting, I might not find that same matter in another's essay. Since students made their need to get some instructions of what they should write known, I created a list of topic questions that they could include in their essays. The topics are represented in Paper II.

I collected material from all study programmes in our university. Prior to my actual research activities, I pre-read hundreds of papers from all of our university's study programmes in order to get a broader overview. To the primary research at hand, I have analysed data from 84 essays in eight study programmes[9]. Data was collected as random samples. Besides this study there is

[9] Bio Product Technology, Transportation and Environmental Engineering, Chemical Technology, Real Estate Economics, Computer Science and Engineering, Automation and Systems Technology, Engineering and Mechanical Engineering

plenty of data leftover that will help continue my research activities in this field in the future.

I examined this selection process from two angles:

In paper I, I gathered the data of 18 female and 18 male students' paths into the three most male-dominated programmes in TKK. In our analysis, I found similarities within both genders and similarities within female/male applicants only. In paper II, I present common denominators and differences between genders in the process of choosing higher engineering education. I analyse processes to choose both our technical university and study programme within. In this study I examined paths for female and male candidates on their way to a higher engineering education. My hypothesis was that I could find congruent factors in female applicants' process in choosing their study field (engineering) and study programme. I chose the three most male-dominated study programmes in TKK: computer science (7 % women), automation and systems technology (10% women) and electronics (10% women). In this part of my study I aim to find differences between men and women.

In paper II I gathered data from 48 female students' essays in four study fields with a high proportion of women (>43 %) and compared them with data gathered from female students' essays in four study fields with a low proportion of women (<15 %). My hypothesis was that I could find similarities between study programmes with a high percentage of women and other similarities between study programmes with a low concentration of women.

I will explain the Finnish schooling system as a framework for my study: the Finnish schooling system includes two mandatory schools: primary school (age 7-11) and lower-secondary school (age 12-14). After lower-secondary school one can apply for 2-4 years at the upper-secondary school. To be able to start studying at university, one has to pass upper-secondary school or similar studies in academy and the Finnish Matriculation Examination (which is a collection of examinations of different study fields). One can emphasise her studies and examinations, for example, in natural sciences and/or languages.

4.4.3 Paper I: Pathways to Male-Dominated Engineering Programs

4.4.3.1 Data Collection

The data was collected in autumn 2010 in form of a course essay. The essay deadline was at the end of September. Approximately 810 students (24% women) wrote essays. The essay was a mandatory part of the basic CS course. However, students were informed that they can prohibit the research use of their essay in research purposes.

4.4.3.2 Research

I read hundreds of essays as a basis for my research. For the analysis in paper I, I picked a random sample of essays produced by 18 male students in computer science, automation and systems technology, and electronics, as well as 18 female students in corresponding study programmes. Male candidates were picked in random samples, whereas I had to include all the female students enrolled on these programs in order to achieve 18 essays for further analysis. We aimed to find similarities and differences between genders and study programmes.

The beginning of the story, noting TKK as a possible study place, took place much earlier in male applicants' stories, often at the latest in primary or lower-secondary school, compared to the female applicants' decision that took place in upper-secondary school (typically in year two or three). The paths varied greatly between students: some described the first encounter with TKK as a little child and narrated the process for us step-by-step, while others first considered TKK during the applications period. A very important result of this study was that almost all students were very satisfied in their study field, even if it was not their first choice.

Regardless of an applicant's gender, the most positive and strongest impact of one's choice was relatives or friends in the field. As in earlier studies (Brainard & Carlin, 1998), the most important factor for some girls to end up in engineering fields was the support of their mother. On the other hand some research suggest that the most important factor is the support of one's father. The elder relatives were trusted and they had more authority than, for example, school counsellors. The differences were found in women's and men's history with technology: many men had been interested in technology since an early age, whereas a common denominator for female students was their interest in applying mathematics in other fields.

Choosing one's degree programme was difficult for many applicants. The extremities in selection processes were, on one hand, candidates who visit stands to obtain information and survey deep-recruiting materials, versus those candidates who, on the other hand, choose the programme randomly or for its intriguing name. However, the majority of students were somewhere in the middle and leaned towards the internet material of universities. The main reason for male candidates to study was their interest in technology, versus the mathematical reasons of their female peers. I cite a story of a female applicant:

"I have always liked mathematics and I am interested to apply it into something concrete. During upper-secondary school I added TKK as one of my options. It stood out as a respected institute. I have engineers in my family. Choosing a degree programme was difficult, but I am happy with my selection." (**Linda**[10])

For a typical example of a male story, I selected Mark:

"Since a little boy I have had an interest in all kinds of technology. TKK was the only option for me. (To be on the safe side, I applied for the Helsinki University, but this was never a real option). Choosing the study programme was hard, but I am very happy with my selection." (**Mark**)

[10] All names are pseudonyms.

The majority of women who applied to engineering fields didn't exclude other possibilities, for example, the faculty of medicine or faculty of science (different from higher engineering education). This behaviour diverts greatly from their male peers. In my research I investigate (as one aspect) some of the reasons for women to choose our higher engineering education instead of other universities. The three most common reasons were:

- The women considered our university to be of better quality than competitors.
- The employment situation and career prospects were seen better in engineering fields compared to other universities.
- The studies and work will apply traditional natural science into something concrete.

4.4.4 Paper II: Women and Higher Engineering Education - Choosing One's Degree Program

4.4.4.1 Data Collection

This data uses the same data source as the Paper I: The data was collected in autumn 2010 in form of a course essay. The essay deadline was at the end of September. Approximately 810 students (24% women) wrote essays. The essay was a mandatory part of the basic CS course. However, students were informed that they can prohibit the research use of their essay in research purposes.

I closely examined 48 essays of female freshers for Paper II, taken from study programmes: Bio Product Technology, Transportation and Environmental Engineering, Chemical Technology, Real Estate Economics, Computer Science and Engineering, Automation and Systems Technology, Electronics and Electrical Engineering and Mechanical Engineering.

4.4.4.2 Research

The idea for students to write essays on their paths to our university and certain study programmes proved to be useful, as represented in paper I. I wanted to develop our study from another perspective: I used the same data collection method (narrative inquiry) in paper II as was used in paper I: incoming students wrote essays of their journey from first impressions of engineering careers, to actually starting their studies.

Compared to the research in paper I, this time I put an emphasis on female applicants' reasons to choose certain study programmes: 48 stories were analysed from eight study programs. I focus on similarities and differences of female students' paths in study programmes that have a high concentration of female freshers (over 43%), and programmes with a low concentration of female freshers (below 15%).

I compare essays from study programmes with a high/low proportion of women. I aimed to find similarities and differences between, a), study programmes, and b), study programmes with a high/low proportion of women.

Degree programmes in which the proportion of females is over 43% of the first-year students:

- Bio Product Technology (BT, 53% women)
- Civil and Environmental Engineering (CEE, 46% women)
- Chemical Technology (CHE, 45% women)
- Real Estate Economics (REIF, 44% women)

Degree programmes in which the proportion of females is below 15% of first-year students:

- Computer Science and Engineering (CS, 7% women)
- Automation and Systems Technology (AS, 9% women)
- Electronics and Electrical Engineering (EE, 10% women)
- Mechanical Engineering (ME, 14% women)

I have chosen my study in a way in which all study programmes in the research have approximately the same admission scores. The data acquisition arrangement is represented in Figure 4.

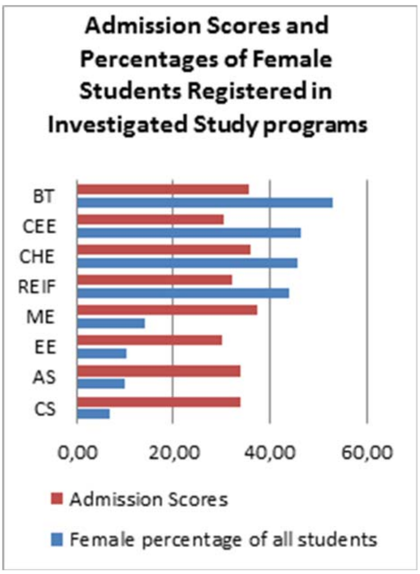


Figure 4: My study selected data from study programmes of high concentration of and low concentrations of female students. Red columns represent the admission scores for each study programs. Blue columns represent the percentage of women in each study programme. Figures are from year 2010.

The first and most important finding was that the family/friend connection was the most influential factor in choosing engineering as a study field. The mother's support was especially crucial. Women with a low-proportion of female study programmes emphasised applied mathematics (as also stated in Paper I). A common denominator for the majority of females was uncertainty: even if they had the recruiting materials and some of them had informal connections to the engineering field (perhaps in family, acquaintances, etc.), they still felt that they did not know anything about the study programme they were accepted into.

In study programmes with a low concentration of female students, the common denominator was an interest in natural sciences and mathematics. In their choosing process, they also valued positions which one can use applied mathematics to create something concrete.

In study programmes with a relatively high concentration of female students, many expressed an interest in using their engineering education as a tool for future interdisciplinary work life. Women expressed interest in socially-oriented studies, multidisciplinary studies and environmental influencing and protection. This is very typical of women, who emphasise humane and societal value. Many women's choices were altruistic: for example, students in chemistry wanted to heal people. In Bio Product, Transportation and Environmental studies, an engineering career was seen as a tool to diminish global warming and protect the environment. The stories by Betty and Anne (pseudonyms) illustrate this phenomenon.

"I can be proud of being accepted to Finland's best technical university. I've gotten used to achieve what I aimed for and this admittance was no exception. The possibility to study here is an honour and I want to bring my share to Aalto University <study program name>." (**Betty**, study programme of low percentage of women)

"<study program name> sounded just perfect for me, as I am interested in global warming and environmental issues. I also have a need to contribute my share and, in the best case, to improve society and the world." (**Anne**, study programme of high percentage of women):

4.5 RQ2: Can we help with the retainment of female students during their early studies in a cost and admin-efficient way?

4.5.1 RQ2: Research methods

4.5.1.1 Survey

A creation of a survey should always have a basis: theoretical, earlier research or own earlier research (Cohen;Manion;& Morrison, 2000). A survey can include quantitative questions (multiple choice), qualitative questions (open ended) or both. The most widely used scale in quantitative survey research is the Likert scale: the respondent is asked to indicate her/his agreement with a statement on the scale. The most popular scale is presented below:

1. Strongly disagree
2. Disagree
3. Neither agree nor disagree (neutral)

4. Agree
5. Strongly agree

(Cohen;Manion;& Morrison, 2000)

A successful survey study has two principles:

1. Make sure the survey instrument items match your research objectives: you must determine why you intent to conduct your research study before you can write a questionnaire.
2. Understand your research participants: you have to 'think like' your potential research participants.

(Johnson & Christensen, 2004)

Survey study is quite light weighed and can be conducted without massive research arrangements. However, to create a successful questionnaire with internal and external validity (Chapter 4.3.1 Validity) one has to plan the questionnaire careful: the questionnaire should anchor to earlier research. We should test the preliminary questions in pilot group. I shortly represent the quality aspects of questionnaires according to the research.

4.5.1.2 Content Analysis

In content analysis, the research data is broken down, analysed, contrasted, compared and classified (etc.). The researcher studies the material in search for similarities and differences. Content analysis is used in textual format of data. Content analysis is used for creating a condensed image, which both presents the results and connects them in a wider perspective. (Schwandt, 2007)

In this section I use three questionnaires: basic faculty feedback inquiry (APPENDIX B) and two of my own questionnaires (APPENDIX C and APPENDIX D).

A few words of course feedback forms:

In the 1990s, the department of Communications and Electronics started a campaign to raise the teaching quality via course feedback. Course feedback forms were brought to all courses. The questions on the course feedback form are presented in (APPENDIX B). The form was quite small. Questions were straightforward and clearly targeted in a basic course: lectures and exercises. It measured the course personnel and course material. Based on this student evaluation, the course personnel got a productivity bonus. It is important to note that course feedback forms are not scientific questionnaires. However, feedback questionnaires can serve as one basis for a more sophisticated research questionnaire.

4.5.1.3 Observations

In observation study, the researcher (or research assistant) observes the researched person's behaviour and, for example, interaction between parties.

One can observe both verbal and/or non-verbal communication. Techniques for observing are, for example: a researcher can be in the same room and make notes or take photographs; activities can be recorded (voice/multimedia). A researcher must know the field of the activities to observe the significant findings.

Observation research can be divided into three categories:

1. Highly structured observation: we know what we are looking for. (Testing hypothesis)
2. Semi-structured observation: we have an agenda, but gather data to illuminate issues in a less predetermined way.
3. Unstructured-observation: we observe what is taking place before deciding on its significance for the research.

(Cohen;Manion;& Morrison, 2000)

My observation is of highly structured nature. The course of my study is sketched in Figure 5. It is clear that the hypothesis is formed before observation study.

A clear weakness of the observation study is that the observation might interfere with the teaching: if an observer sits in the classroom, students might not be able to concentrate on the task at hand, or the observer might otherwise affect the group dynamics. To alleviate this problem I used older students as observers: the students should draw less attention than substantially older research personnel.

Another problem in observation studies is the use of technology: recording could stop in midstream, the quality of voice could be too poor and it might be difficult to distinguish who said what in the class and so on.

4.5.1.4 Mixed Methods Study

Mixed method research involves both the collecting and analysing of quantitative and qualitative data. A simple example of a mixed method study is research in which the quantitative inquiry is used as a basis for more extensive qualitative study. In successful research, quantitative and qualitative parts support each other and produce more accurate information of phenomenon at hand than either one alone. (Creswell & Clark, 2007).

A mixed method study involves eight distinct steps:

1. Determine whether a mixed design is appropriate.
2. Determine the rationale for using mixed design.
3. Select the mixed method or mixed model research design.
4. Collect the data.
5. Analyse the data
6. Validate the data.
7. Interpret the data.
8. Write the research report.

(Johnson & Christensen, 2004)

Mixed methods research has its limitations: mixed method research is often more complex than mono-method studies, and they tend to require more time and resources to undertake. Additionally, they require expertise in both quantitative and qualitative research methods. Some mixed method studies reveal contradictory findings between quantitative and qualitative phases (Johnson & Christensen, 2004).

I use mixed method research in its very basic forms:

1. A questionnaire contains both quantitative and qualitative questions: *data is embedded.* (Paper V)
2. A quantitative pre-study is followed by more in-depth qualitative study: *data is connected.* (Paper III, IV)
3. Both quantitative and qualitative data form democratic results: *data is merged.* (Paper III)

(Creswell & Clark, 2007)

4.5.2 RQ2: Research

At the beginning of their university-level studies, most of our female freshers were in a transitional period from *received* to *subjective knowledge,* if we are using Belenky's model (Belenky, Women's ways of knowing: The development of self, voice, and mind, 1986). The transition period towards *subjective knowledge* is difficult if the teaching methods are teacher-centred[11], as is the traditional lecture-exercise-examination model. For example, in traditional mathematics courses:

1. Lecture: students sit passively in the lecture, taking notes.
2. Homework: students complete homework, preferably alone (to avoid suspicions of cheating).
3. Exercise: each piece of homework is demonstrated on the blackboard by a random student. A student gets points from every completed assignment (competition).
4. Examination(s): students can participate in either three tests during the period, or one larger-scale examination later on (competition).

This is a good example of a teacher-centred teaching process (chalk and talk): the teacher provides students with knowledge bit-by-bit, and students accomplish fixed assignments (alone). The above-mentioned is a good example of a competitive masculine learning environment, which is a typical form of study during the first two years of study. However, as earlier research depicts, women interrupt their studies during the freshmen and sophomore years more often than their male peers (Seymour, 1995) (Brainard & Carlin, 1998).

Whereas traditional competitive teaching methods are suitable for men, they do not motivate or encourage women into better performance (Seymour &

[11] Teacher-centred Learning: learning is transferring knowledge from teacher to student.

Hewitt, 1997). It has been stated earlier in this thesis that while women don't excel themselves in competing, they do in environments they find positive and supporting. Earlier studies (Brainard & Carlin, 1998) depict that support from the faculty, teacher and/or mother improves one's rating of math (perhaps any STEM subject). In my papers III and IV, I work on the research question RQ2: Can we help with the retainment of female students during their early studies in a cost and an admin-efficient way?

According to paper III, traditional teaching (lessons and exercises) can also be taught in a way that is profitable to female students with no extra costs, simply by dividing the training sessions into all-female, fifty-fifty and all-male groups. The main weakness in this course of action is that we reduce the freedom of choice and push students into something they do not necessary want to do. It is very understandable that neither faculty nor students want to do it that way for various reasons.

If the faculty doesn't support education methods favouring female students, as the current situation often fails to do, support can be given from separately funded projects or by individual teachers. In this case, the action towards better retainment figures for female students can be reached by small adjustments. Independent from faculty police, I aim to create a supportive climate, which is important for women's retainment figures.

I must not give a pessimistic view of the faculty: they have, for example, monetary pressure and inner conflicts on how to teach or study. Plus, gender-emphasised teaching is a very contradictory topic. However, one important issue for women's retainment figures is to create connections and interaction within the faculty. A very female-beneficial and widely used activity in many universities is the tutoring system. The operation is gender-neutral, however, as it favours women since their study methods are naturally dialogic and they benefit from the personal connection to a faculty member. The challenge of tutoring is that many students do not understand why they should take part in tutoring activities, since they don't directly assist their present-day courses.

On the other hand, what if we cannot teach traditional engineering in a better way: perhaps there is no money, or no will to shift the teaching focus from teacher-centred teaching models to more co-operative learning processes – well, we can still support students. I summarise methods of supporting students by an interdisciplinary course of literature in paper IV.

From a bigger perspective our teaching offering can be seen as marginal, since the amount of participants in our course is counted in small numbers (compared to mass courses). We don't deny this matter: our goal in this course was to help the people who benefitted from our teaching. We must emphasise that not all students want to participate in our course.

Supporting methods, both inside and outside of official teaching, have proven to be efficient in our study.

4.5.3 Paper III: Gender, Communication and Comfort Level in Higher-Level Computer Science Education – Case Study

4.5.3.1 Data Collection

I did a preliminary study in year 2003 (before my maternity leave[12]) and the primary study in year 2005 (after my maternity leave). This was my first research, so I wanted to be sure that the observations worked and the questionnaire would show the causality between variables (internal validity). External validity is more problematic, because this kind of study is bound to teaching substance, methods and culture. However, I state this method suitable for learning basic engineering skills like CS, programming, mathematics and physics.

The main data collection for this paper was done in autumn 2005 in the students' first mandatory CS course. I had external funding for the observers' salary. Data was collected from six groups. Each group had 6-14 members. Group types were all male, even gender and all female.

In this study I did not research the equality between genders. Emancipation is not discussed in this study. Gender is defined as it appears in a person's register.

4.5.3.2 Research

Women act as climate thermometers in study and work places. Even if their study performance is above average, they discontinue their studies easier than their male peers, and suffer more from a poor climate and/or poor teaching than their male peers (Klawe & Leveson, 1995) (Seymour, 1995). On the other hand, female students are easier to reach than their male peers: women excel themselves in friendly (formerly women-friendly) surroundings. The reason for the term 'women-friendly' is that a good climate affects women more than their male peers (Cuny & Aspray, 2002).

In this study I evaluated climate and the amount of communication there is in three different types of gender distribution: all-female, mixed groups and all-male. The study is conducted mainly by observation. Two observers sat in the back of the class in each exercise. Additionally, students filled out questionnaires (APPENDIX C). Questionnaires were based on student feedback material from earlier years, my own experiences of exercises as an assistant and other assistant feedback. I also tracked how many exercises one could carry out (i.e. how successful were the students at studying during the exercise). We observed the very first CS training sessions that students took in TKK. The research has a clear mixed-method nature represented in Figure 5.

[12] Maternity leave in Finland begins before child birth and lasts 105 weekdays. After maternity leave, starts parental leave, which lasts 158 days.

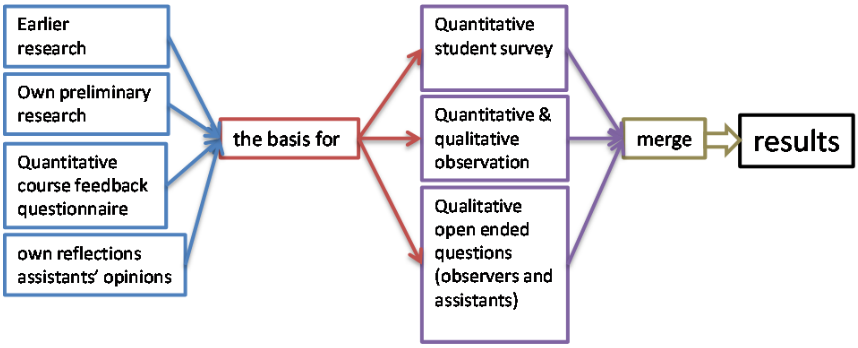


Figure 5 Mixing quantitative and qualitative data

I chose three types of exercise groups: all-male, even-gender and all-female. Two observers sat at the back of the class in order to take notes from each group. The two observers took notes of how much students speak (or have the floor), and evaluates the nature of communication (relevant for the exercise or not). Additionally, observers recorded their own views of the nature of the exercise. The idea behind putting two observers into each group was to ensure that the observation was precise. However, as we soon noted, the use of two observers was not needed, and one per group was enough.

As stated in paper III, observers had a map of the class, and each student scored as represented in the figure below.

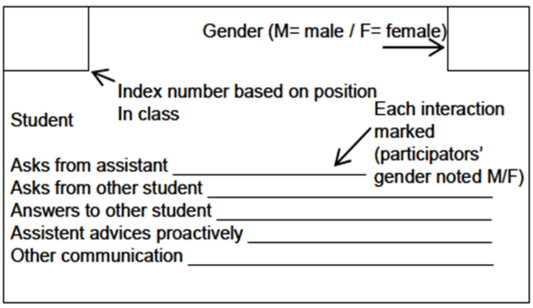


Figure 6: An observation form for a student in an exercise group: these were used to form a map of the class (from paper III)

Based on these markings, I counted averages and standard deviations for different kinds of communications. Noteworthy differences were found between groups: while the male students' performance was approximately even in spite of the gender distribution of the group, female students fared better both in even or female-only groups. The female students spontaneously used group or pair work when needed. In mixed gender groups, the common way of working was dependent on the distribution: if the distribution was close to even, the training sessions were described as casual and relaxed. Female students acted as initiators in most cases and they asked a lot from other students and the assistant.

Unlike the previous two group arrangements, in all-male groups no successful groups or pairs were formed. Students worked alone and did not communicate much. They searched for help from books, papers and the internet rather than from each other or the assistant. The atmosphere in all-male training sessions was described as quiet.

I sum up the amount (average and standard deviation) of communication in different groups in Table 2. Women are more active than their male peers in co-operation in each group. The best communication rates are in groups with a gender balance that is close to even. In the groups |M|>|F|, the amount of male students exceeded greatly the amount of female students.

Table 2: The amount of overall interaction related to the exercises in different groups

Group	Average	Standard Deviation
All-Female	9.30	9.94
Females, Mixed (|F| > |M|)	15.63	12.89
Males, Mixed (|F| > |M|)	15.50	14.06
Females, Mixed (|M| > |F|)	14.23	7.63
Males, Mixed (|M| > |F|)	5.91	5.73
All-Male	5.47	6.56

Observers also described the working methods and atmosphere on each group. Here are a few examples:

Observer Oona (all-male group): *The atmosphere in training sessions is peaceful and focused. Students don't ask help from the assistant, instead they search for help from handouts. One student did not ask help from anyone, even though he is clearly stuck on one exercise.*

Observer Mark (fifty-fifty group): *In this group students ask a lot from each other and the assistant. Female students talk also beside the point. A few quiet men and one woman work independently. Completing the exercises took more time for this group than the quiet ones, but I got a feeling they were done thoroughly.*

Observer Alice (all-female group): *The group was quite high-spirited. Students asked a lot from each other, but also from the assistants. Assistant was asked usually after students had negotiated the problem themselves. Some students asked mostly from the assistant.*

When male and female students were compared with each other, the male students completed more exercises than women. However, more than 10% of male students completed less exercises than any of their female peers. This might result from more modest interaction among the men, i.e. when a male student in an all-male group failed to accomplish a certain exercise by himself, he for some reason was not able or willing to ask for help in accomplishing the task at hand. Women felt the exercises more difficult than their male peers.

These three groups used knowledge in different levels of Belenky's five levels, (Belenky, 1986): in all-male groups, students worked on levels one (*silence knowledge)* and two *(received knowledge)*: there was no collective knowledge sharing or developing. Students developed their knowledge via materials. This is a very typical working method in the first two years of elimination pedagogy. Mixed and all-female groups worked on levels four (*procedural knowledge*) and five (*constructed knowledge*): they were willing to co-operate, assimilate their knowledge with others and authorities.

4.5.4 Paper IV: Beyond the Conventional Engineering Discipline – Teaching Prose

4.5.4.1 Data Collection

The course of literature was arranged six times during 2002-2006. The variation of group members varied between 7-17 students. Altogether 51 students, 18 women and 34 men took part in the courses from Autumn 2002 to Autumn 2006. I emailed my questionnaire (APPENDIX D) to all 51 students. I received 16 answers (6 female, 10 male), which means that the answer percentage was 31 percent. Hence the results are suggestive.

4.5.4.2 Research

The teaching of prose and lyrics started at the Department of Electrical and Communications Engineering at the Helsinki University of Technology in Autumn 2002 and the last course was held in 2007. The story of the course is familiar from many promising projects: since the course administration was project-based instead of faculty-arranged, the course was shut down while the project series (Paloheimo;Putila;& Simpanen, 2010) was over.

The idea of the course was to form 10-person (+- =7-17) groups and familiarise yourself with different kinds of literature, for example prose, short stories, science-fiction, poetry, causerie, aphorism, drama and radio plays. The teacher, who also listened to participants' own wishes, provided the material. Additionally, there was a possibility to produce your own text and get feedback from it. The course consisted of six meetings and corresponding homework.

The course was arranged in both autumn and spring semesters. Many students took the course two (or even three) times, as depicted in Table 3. One could obtain credits from both autumn and spring semesters. The course credits were either one or two, depending on the workload. The amount of credits was so small that we interpreted that students did not participate because of easy credits or other external reasons.

Table 3: An illustration of student profile in course: Year/term

Year / Term	Number of Participants	Second Timers	Third Timers
Autumn 2002	17	-	-
Spring 2003	16	8	-
Autumn 2003	7	2	1
Autumn 2005	13	1	-
Spring 2006	10	7	1
Autumn 2006	12	2	2

In my research I aimed to find out what kind of outcomes students got from this course of literature. In the TKK Department of Electronics and Communications Engineering, the use of course feedback questionnaires were highly recommended for all courses. Students evaluated the literature course as among the top three within electronics and communications study programmes for the years 2002, 2003 and 2005. The basic course evaluation form is represented in (APPENDIX B). The questionnaire had mostly quantitative, Likert-scale questions and one qualitative wordy question for further reasoning. It has to be noted that the questionnaire in (APPENDIX B) is made afterwards, since the original course evaluation form was in Finnish.

I started my research by studying basic-course feedback data (APPENDIX B), which was collected in the autumn courses of 2003, 2005 and 2006. I soon noticed that: the female percentage of course students were substantially higher than in the overall department: during 2002-2006, approximately 15% of students were women, whereas the average percentage of females in the literature course was 40%.

I started a deeper examination of the course and its impact on students. Based on earlier research, teaching arts alongside with technical courses offers remedies to commonly recognized social and motivational problems in engineering education. As a basic supporting act, teaching arts offers ways to communicate as well as networking tools and opportunities. This, in turn, creates a more balanced and supportive climate for learning. (Barker & Garvin-Doxas, 2004) (Leathwood, 2006)

Based on earlier research about diversifying the higher engineering education as well as the results of course feedback I made a post-course inquiry in 2006 and sent an email to all students who participated in the course during the years 2003-2006. Post-course inquiry can be found from (APPENDIX D). In the inquiry I elaborated on reasons for participating, features of the course, networking and one very wide question about the course, literature and life.

The questionnaire and questions were purposely wide letting the students to use stream of consciousness.

The students answered very thoroughly. I present two example answers:

Q1: (Elaborate on your reasons for participating in this course. In case you participated more than once, what were the grounds for a re-run?) "*During my studies in TKK, I have always searched for more intellectual courses or* *events, where standpoint is more wide-ranging than the traditional technological perspective.*

Years ago I used to visit Nyyti r.y.[13]*'s events, where psychologists gave guest lectures. I also took Esa Saarinen*[14]*'s lectures as well. This literature course offered me just the type of conversations (I was looking for), inspired by the writer (Kosti Sironen) and other participants." (***Edward)**

Q2: (In a longer temporal perspective, what were the best offerings on the course?**)** "*Great atmosphere, creativity; talking instead of being silent from morning to night. And all of this happens in TKK!!! This increased my motivation towards more traditional courses. Not joy of life, but energy and vibes for TKK work."* (**Ann**)

I want to highlight three features of course participants: firstly, the percentage of female students was notably higher than was in the overall department. Secondly, many participants were also keen on other humanistic studies: some had already taken courses from the Humanistic Faculty in the University of Helsinki, some were planning for more disciplinary studies. The third significant feature was that the age range of the students in the course was wider than in traditional courses.

According to my study, the course improved four areas of excellence: communication methods, innovative thinking, motivation for more traditional engineering studies and networking. All of these are very important skills for future engineers. This is also a very good example of offering support outside the faculty and creates possibilities for more personified learning.

The learning model in this course was dialogic: students and teachers structure knowledge together. I position the course's working methods between levels four (*Procedural knowledge*) and five (*Constructed Knowledge*) on Belenky's scale (Belenky, Women's ways of knowing: The development of self, voice, and mind, 1986). The course had many advantages: it gave the students tools to process knowledge and team-working skills, while on the other hand it provided students with a more personal experience when compared to mass courses: whereas many classes at that time were teacher-centred, the course of literature was guaranteed to be student-centred. The course was for small groups of students. However, the cost structure of the course was relatively small: the teacher was an author employed on an hourly wage.

However, this kind of teaching needs to break barriers: as represented above, teaching in traditional studies (mathematics, physics) is very teacher-centred: In Belenky's statistics we are talking about levels one (*Silence*) and two (*Received knowledge*), implying that students are used to passively following the authority. They don't understand their own role in producing knowledge and the validity of their own thoughts. A student who is used to following authorities unconditionally will be lost if there is no straightforward agenda, as one

[13] Nyyti ry was established in 1984. It aims to improve students' mental health and life management.

[14] Esa Saarinen is a very famous Finnish philosopher, company trainer and writer.

has to participate in creating the content. This is contradictory when compared to earlier experiences when the student doesn't appreciate herself as part of the learning process. If one doesn't consider herself as an active member of the group, one will not want to participate on the course. These kinds of students prefer mass lectures, since in that way they can hang on to their level one and two data acquisition.

4.6 RQ3: What are the early career prospects of female engineers that graduate from our university?

4.6.1 Research methods

Using Secondary Data

In both of my papers on this matter I use secondary data: secondary data is data collected for another reason and by someone other than the user. Using secondary data, a researcher saves time, money and manpower. One form of secondary data is to examine a non-scientific inquiry in a scientific way. One can also study the material from another angle than the original (Jarvenpaa, 1991).

The main weaknesses of the secondary data are shortage of research data or biases of data compared to new research. I use a ready-made, very large-scale quantitative questionnaire in paper V (presented in 4.5.1). I use qualitative material in paper VI that was originally collected for an extensive survey for development of a web community (weme.fi, not available anymore). In both cases the amount of data is extensive and wide-ranging. I consider the both data adequate for my thesis.

Interview

Interview studies are commonly classified as either structured (closed, forced-choice responses) or unstructured (open-ended responses). The latter category is then further subdivided into informal conversational interviews, the interview guide approach, and the standardized open-ended interview. The typical in-depth, semi-structured, or unstructured interview aims to elicit stories of experience. The active interview is framed as an interactional encounter. (Schwandt, 2007)

Focus Group Interview

Focus group interviews or discussions bring together a group of people to discuss a particular topic or range of issues and are commonly found in media and communication studies, evaluation research, and organizational research. (Schwandt, 2007)

The moderator has two important tasks: firstly to create a nonthreatening and non-evaluative environment in which group members feel free to express themselves openly and without concern for whether others in the group agree with the opinions offered. Secondly the moderator has to keep the discussion on track. (Stewart & Shamsadani, 2006)

4.6.2 RQ3: Research

Women face many challenges in their working life when compared to their male peers. The key term is underestimation: women have to continuously prove their competence. Earlier research depicts that women as a group are worse negotiators than their male peers. Women are less eager to take risks, whereas men are more competitive. To get something out of this phenomenon, we should admit that there are notable differences in women's and men's leading skills: female engineers emphasise group work and deliberative methods, whereas men outperform women in competitive environments (Kray;Thompson ;& Galinsky, 2001) (Kray & Thompson, 2002) (Kray & Thompson, 2004).

One big question regarding careers is family leave: despite actions, women take substantially longer family leave and spend substantially more time in childcare and/or household work than their male peers. Usually women continue to be the ones who interrupt their careers, take more days off, and – if needed – work part-time. As a result, they have fewer years of job experience and fewer hours of employment per year, which slows their career progress and reduces their earnings.

Wage gaps exist inside STEM fields. In the US, hourly earnings in 2009 within the STEM sector had a 14% gap between male and female workers in favour of men (compared to a 21% gap in non-STEM fields). Estimates are for full-time, year-round private wage and salary workers age 16 and over. Among college-educated STEM workers, engineering has the smallest pay gap (7%) and computer and math the biggest (12%). These figures are calculated from full-time, year-round private wage and salary workers aged 25 an over. (Beede;Julian;Langdon;McKittrick;Khan;& Doms, 2011)

It is difficult to gain information of female and male engineers' inexplicable salary gap in Finland. In 05/2015, the Finnish labour market organisation's specialist, Tarja Arkio, evaluated that the inexplicable gap is 5-6% in favour of men.

4.6.3 Paper V: Less is Not More - Female Engineers' Career Paths Five Years from Graduation

4.6.3.1 Data Collection

A career and employment survey completed five years after graduation was conducted for the sixth time in 2010. 13 universities in Finland took part in this survey. The survey was designed in co-operation between universities. The co-ordination unit was the recruitment services of the University of Tampere.

In 2005, 1,017 architects and landscape architects graduated from TKK as Masters of Science in Technology. The questionnaire was sent by post for 989 persons, whose address was found from the Population Register Centre. 522 persons answered to the questionnaire, with a response rate of 51.3. Female engineers' response rate was higher (58.3%) than their male peers (48.7 %) The English questionnaire form is represented in APPENDIX E.

4.6.3.2 Research

In this research, I studied the early career paths of engineers who graduated from TKK in 2005: In 2005, 1,017 architects and landscape architects graduated from TKK as Masters of Science in Technology. The proportion of female respondees was 27%. In year 2005, 24,7 % of accepted higher education engineering students were female students. The percentage of female students was 20 %. The proportion of female graduates was approximately 27%.

My research uses Academic Career Service (ACS) data, which was collected in 2010 as part of a large-scale research involving 13 universities around Finland. Aarresaari (aarresaari.net) is a network of Academic Career Services representing 12 Finnish Universities. The network offers services for university students, graduates and employers, as well as for the universities themselves.

The Aarresaari network actively monitors the employment of academic graduates. The data collected in career monitoring surveys is primarily utilised in quality assurance, teaching development and student counselling by the universities. Questionnaires target Master's and Bachelor's degree graduates (Master's degree career monitoring) who have completed their studies approximately five years earlier, as well as doctoral degree graduates who have completed their studies 2–3 years earlier. Nationwide career monitoring surveys are implemented as a collaboration project of the universities. Aarresaari data is collected from Finnish tertiary education, as depicted in Figure 7

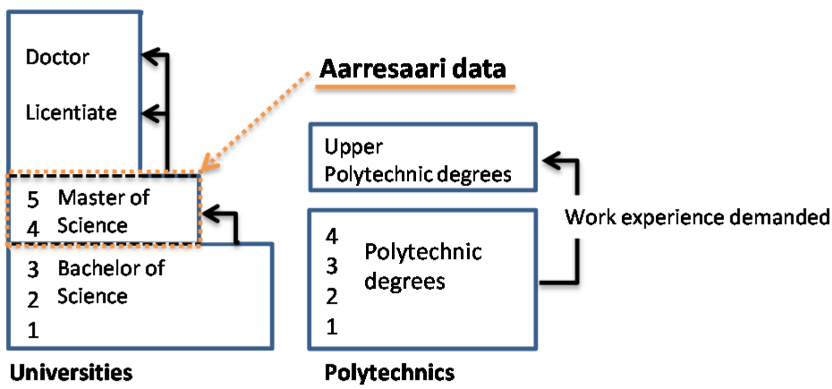


Figure 7 Finnish tertiary education system and Aarresaari data used in this thesis. The numbers presented are years in which one should complete one's studies.

Career monitoring data has been collected for approximately 10 years and almost all universities in Finland have participated in it. Regular data collection enables the monitoring of changes that have occurred in education and labour markets. The data collected will be primarily utilized in quality assurance, teaching planning and development by the universities, as well as in student counselling. Studies have been conducted based on the materials and they have provided varied knowledge to the educational policy debate. Career monitoring survey data is also utilized in the töissä.fi web service (Career monitoring, 2015).

The questionnaire used in this study (APPENDIX E) included 38 questions, which consisted of multiple choice, Likert-scale and short, open questions. The questionnaire was divided into five sections: education and work history, situation at the time of graduation, first job after graduation, current situation, and the significance of university education. The long traditions, co-operation and prestige of work act as a guarantee of the quality of questionnaire. However, I would generalize my part of study only in other technical universities: For my research I calculated basic figures based on Aarresaari -data and the statistics of female graduates and students in our university.

The survey was sent by mail to graduates of the class of 2005, and an internet form was also provided as an alternative. 1,017 students graduated in our technical university in 2005. The questionnaire was sent to 989 participants, 521 answered with a response rate of 51.3%. Female engineers' response rate was higher (58.3%) than their male-peers (48.7%). However, since the response rate is somewhat modest, the sample is biased in favour of those who are active in answering questionnaires. Hence, the results are approximate.

I calculated basic figures based on Aarresaari -data and the statistics of female graduates and students in our university. Based on this analysis I present in my paper the vertical career development from a gendered point-of-view, for example the nature of work agreement, position at work and family leaves. I also represent the salary gap between female and male engineers after five years of work. Outside the research paper, I investigated the salaries in more detail.

As a result of investigating engineers' career development, I conclude that engineers are, on average, satisfied with their career: they find their job interesting and it offers them multiple career possibilities. However, when looking at the figures closer, we find differences that start from the beginning: at the time of graduation, 85% of male and 82% of female engineers were employed. The first position was permanent for 67% of male and 57% of female engineers. During the five years after graduation, 12% of male engineers and 23% of female engineers had been unemployed.

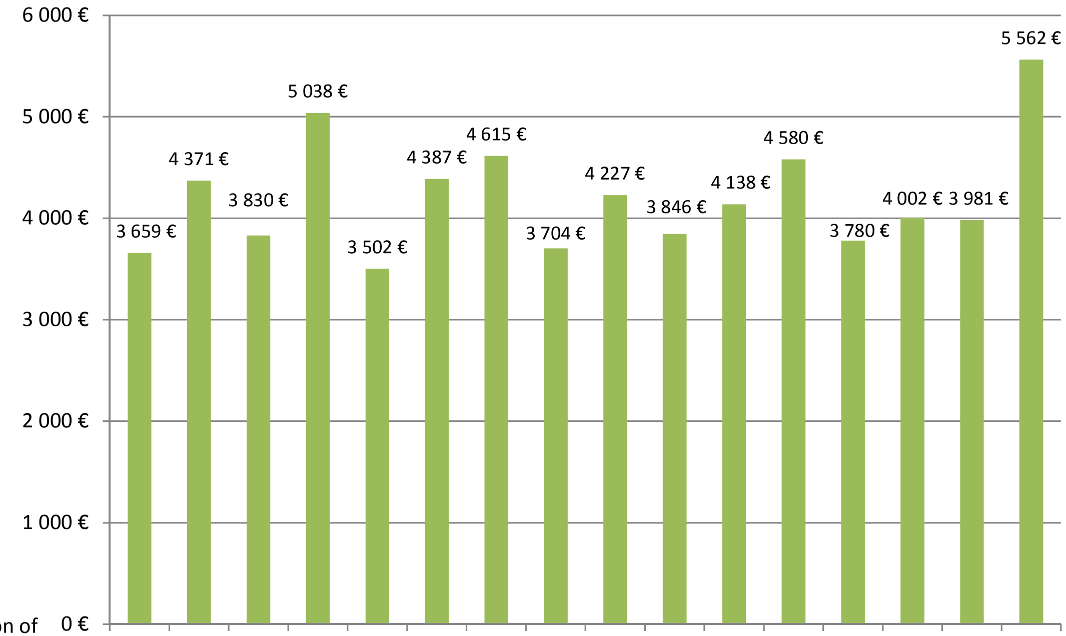
On the other hand, 45% of female and 28% of male engineers had been on family leave during the first five years of their careers. However, in Finland we have a parental leave model that allows fathers to have up to two months off from work. More descriptive results were got when comparing the length of these absences, as follows: 69% of female engineers were absent from work for more than a year, whereas 5% of their male peers had more than one year of parental leave.

Family leave is one interpretative factor in women's worse career development (substantially less women in manager positions), but it does not explain the notable difference in salaries: five years after graduation, male engineers' monthly gross salary (regular allowances, tax value of benefits in kind and overtime pay included), was €4,273, while female engineers' salary (similarly counted) was €3,784.

4.6.4 More details of the salaries

Outside our paper, I examined salary circumstances a further five years after graduation. The salary development of each study programme is represented in **Error! Reference source not found.**. Here the percentage of female graduates is marked below each study programme. Abbreviations of study programmes are represented in Table 4. When interpreting these figures, we must keep in mind that women were more active in answering the questionnaire. Hence the actual percentages of females in study programmes are lower than they appear in our figures.

In Figure 9 we represent the salary-gender ratio. This figure aims to give a bigger picture of this phenomenon: we start with a study programme that is mostly male dominated, Electronics Engineering (old version), and move along to the most female-dominated programme, Information Networks. The percentage of female respondents is multiplied by 1000 to create a visible graphic. We used scatter diagrams to confirm that there was no correlation between female percentages and certain study programmes of monthly-average salaries. This indicates that the difference of monthly salaries between female and male respondents also takes place inside the field of work.



Abbreviation of study program →	A	AS	EE(n)	INF	CHE	ME	REIF	GEO	MSE	FTP	CEE	EE(o)	PH	CS	CE	IE
Percentage of women respondents →	45%	16%	21%	82%	67%	30%	57%	27%	60%	52%	59%	3%	15%	7%	26%	18%

Note: EE(n) is a new version of electronics engineering
EE(o) is old version of electronics engineering

Figure 8 Average monthly salaries in study programmes after five years of career. The percentage of female repondents in each programme is presented in the lowest line.

Table 4: Abbreviations of study programmes

A	Architecture
AS	Automation and Systems Technology
CE	Communications Engineering
CEE	Civil and Environmental Engineering
CHE	Chemical Technology
CS	Computer Science
EE(n)	Electronics Engineering (new)
EE(o)	Electrical Engineering (old)
FPT	Forest Products Technology
GEO	Geoinformatics
IE	Industrial Engineering and Management
INF	Information Networks
ME	Mechanical Engineering
MSE	Materials Science and Engineering
PH	Physics
REIF	Real Estate Economics

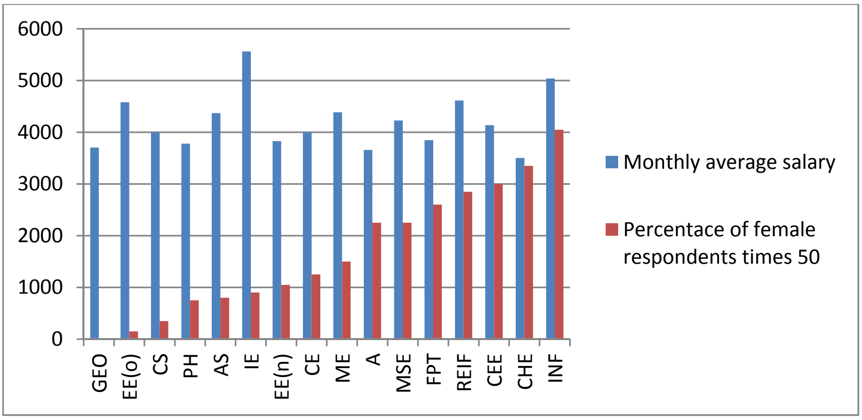


Figure 9: Proportion of female respondents in study field vs monthly average salary. The percentage of female respondents is multiplied by 50 in order to achieve better readability.

4.6.5 Paper VI: Managing the challenges – introducing the female minority in technical research society

4.6.5.1 Data Collection

A user survey for weme.fi, an internet community for women, was conducted in 2005 by Johanna Leppävirta, Maria Hyytiäinen, Johanna Kukkanen and Kirsti Keltikangas. The methods used in that project were theme interviews, diary methods a focus group interview. Themes in interviews were work and leisure. 24 theme interviews were conducted: 18 researchers and 6 entrepreneurs. Diary methods were used one week prior to the interview: in this case, diary one describes the events and emotional states of the events during the day. The diary was used as a basis for the interview.

Two focus group interviews took place: one for female research scientists and another for female workers in technical fields.

Altogether, 45 women participated for user survey. Age and education variations are represented in Table 5.

Table 5 Age and education variation of study participants

		n.o. participants
Age	20-30 years	23 (52%)
	31-40 years	13 (29%)
	41-50 years	8 (18%)
Education	Student	5 (11%)
	M.Sc	23 (51%)
	Licentiate	8 (18%)
	Doctor	9 (20%)

Persons in this project were not allowed to do research, which was the reason for my work. I used the interview transcriptions of 18 female researchers, diaries and one group interview for my study. The user survey was so extensive that using material for research was quite straightforward. However, the user survey was intended as a basis for an internet society to support women in their work, career and family challenges: the interviews were biased to search for women's problems and survival strategies.

4.6.5.2 Research

This study is based on an extensive survey conducted in a three-year project (2005-2007), WomEqual. WomEqual's objectives were to support women's career development, especially in the field of technology; promote women's innovation activities and entrepreneurship; as well as to create and implement a tool for women's networking.

In my analysis, I mapped work and family circumstances of female research scientists and scholarship graduate students. In the research, I used secondary data: I got transcriptions of interviews of 18 female research scientists and one eight-person focus group conversation. Additionally, I received their diaries. The majority of researchers were early in their scientific career. I research the data by means of content analysis.

The female research scientists experienced their work as interesting, versatile and multifunctional. They felt creative and independent and had fair possibilities to affect their work, schedules and the completion of their duties. Additionally, the constant learning and self-development processes were seen as great advantages. Female research scientists with children considered their balance between work and family life to be satisfactory to good.

The most significant problems experienced by the examined female research scientists were related to a lack of support and contacts, loneliness, isolation from society and fixed-term employment. These problems were most substantial among beginners and were related to situations where women were never, or at least rarely, involved in a gender-balance that was strictly male dominated.

Q: Do you get support for your work?
"*I get no support. Our team works to further our project, but there is no technical or social support. Sometimes I wonder if it pays to continue. … However, I feel it is important to keep on working."* (**Lisa, 29** years doctorate, children 9, 5, 3 years)

However, despite the above mentioned problems, many women working in an uneven gender-balanced society (in favour of men) considered working in a male dominated field as a positive aspect in their working circumstances.

Q: Is your work community male dominated? If it is, tell how it feels to work with your male colleagues.

"Personally I find it easier to work with men than to work with women. There is no doubt of that. In my hobby (X) I am around other women and the communication is substantially more complicated. Men are more straightforward in their communication, easier, no-one will talk behind your back. … Men, who have started to work same time in my team have a sauna-evening, in which they haven't invited me. I don't know if I had the time to go there, but.. in principle.. " (**Mary** 28 years, no children)

The skill pallet for women in technical research society covers both technical and soft skills. For example some told that independent initiative is an important skill (because the superior isn't there or doesn't care). Other skills mentioned in interviews were self-directed working methods and discipline.

Q: What kind of skills your job requires?
"Analytical thinking, communication skills, courage, trust in oneself, imagination, self-discipline (because of the high rate of freedom in work)." (**Helen** 30 years, post-doc)

"Basic technical knowledge, managing skills and customer service. Lots of communication skills. And definitely most important of all skills one has to be capable for autonomous and disciplined work. And research methods are important too. This is a million skills work." (**Stephenie** 22, 1 child)

Many researchers depicted that the combination of teaching and researching activities was an asset in their work. The teaching activities were seen invariable as positive. Some women had experienced loneliness in their research work.

Q: What are the best parts of your job?

"Research and teaching, as a combination. Nicest to see people learning and having inspiration. Supervising master's theses is very motivating. In research best is to be able to argument convincing and bring out the essential. Inspiration" (**Annie** 30)

To socialise one's work many women had created solutions (for example, unofficial networks and peer groups) making them less vulnerable towards the problems represented above. Something noteworthy was that two researchers in the middle of their careers commonly had networked geographically, and seemed to consider that solution as being easier than approaching colleagues in the same unit. Most of the women that were researched emphasised the importance of communication and interaction skills. These skills were actively used when constructing research networks to survive on-field.

As much as 40% of females considered their academic career as only an intermediate phase in their working career. This is a very important phenomenon, and it fits very well into the concept of the shrinking pipeline (Camp, 1997). A concept of 'real work' (in Finnish 'oikeat työt') occurs in interviews, meaning work outside of university:

Q: What do you expect from your future? (Family/work?)

"I kind of hope to get away from TKK one day. However, as long as my children are young I am happy to work here. I am a bit terrified that when I will search for 'real work', I might not find it in my subject field..." (**Ann** 22 years, 2 and 4-year-old children)

4.7 Summary

In this chapter I described my research and main findings. Research results are represented according to each question.

RQ1: What are women's paths to our university of technology?

In traditional engineering programmes with a strong majority of men (more than 89% of students), the most common reason for engineering studies was the possibility to apply traditional natural science into something concrete. Other central points were the belief of our university's better quality compared to other universities and the better career prospects than in other fields.

In study programmes with a relatively high concentration of female students (44-53% of students), many expressed an interest in using their engineering education as a tool for future interdisciplinary work life. Women expressed interest in socially-oriented studies, multidisciplinary studies and environmental and protection.

RQ2: Can we help with the retainment of female students during their early studies in a cost and admin-efficient way?

I represent two methods to support and retain female students' studies in higher engineering education:

Firstly, I present a simple group division for better study success: we should divide our training groups into all-female, even-gender and all-male. In that way women, who profit from student activation methods and a good atmosphere in class, can accomplish more assignments during exercises. However, it is predictable that female students will not go for all-female exercises, so a more realistic division would be fifty-fifty and all-male.

Secondly, I introduce a small course of literature. In this course, students learned literature in dialogic learning models. The teacher in this course was an author outside our university, working on an hourly basis. This easily-organised course developed certain skills, such as communication methods and innovative thinking. Besides this, the course acted as motivation for more traditional engineering studies. The percentage of women in this course was notably higher than in the overall department.

RQ3: What are the early career prospects of female engineers that graduate from our university?

However bright young women see their career in technical fields, it has to be noted that their early career aspects are not as good as their male peers. The research of public career monitoring data in TKK reveals that, at the time of graduation, a higher percentage of men had permanent positions in comparison to women. During early years, men have less unemployment periods than their female peers. And, five years after graduating, men's salary is €478 higher than their female peers. However, one decisive factor for the pay differences is the family leave, which women take substantially more of than their male peers.

5. Discussion

5.1 Introduction

In this chapter, I further explore my findings and share insights on the fields of my research questions. I propose improvements to the existing student application process, as well as the application of more female-friendly teaching methods.

Firstly, I talk about student recruitment: a most cost efficient recruitment policy for women are those directed to upper-secondary school students who have already chosen STEM courses. For this kind of activity we should further study the reasons for women not applying to study engineering. (This would be a reverse angle for my study in this thesis.)

Secondly, I talk about reaching out to the masses. We can use different methods to reach out for the girls: a popular method is to use internet and social media. The downside of these is that gaining publicity is a very difficult and unpredictable task. Our other possibility is co-operation: with our school student recruitment unit, with study advisors and with STEM teachers.

Thirdly, I talk about women-friendly education, for example interdisciplinary studies, soft skills, collaborative working methods and education, all of which help to raise women's technical self-esteem. Despite the term women-friendly, this education profits both sexes. It is also very advisable in the way of preparing students for futures in the engineering work field.

Lastly, I briefly talk about women's early career path and support. Many women are very satisfied with their work career. However, their career expectations are lower than their male peers. Commonly, women have more family responsibilities than their male peers. Flexibility and possibilities of remote work are advantages of a vacancy.

5.2 Recruitment

5.2.1 The Women Who Choose Different

I examined reasons for women entering engineering education in papers I and II. I found similarities (support of family or acquaintance) and differences between programmes that had a low concentration of women (interests in applied mathematics) and a high concentration of women (emphasise humane and societal values).

To be an eligible candidate for engineering studies, a woman has to master STEM subjects in upper-secondary school. However, many women choose differently in the critical final years: for an efficient recruiting process, we should concentrate on those women who master STEM subjects, but still choose differently: the women who take extra mathematics and physics classes in upper-secondary school, but choose university study fields other than engineering. They have clearly beaten the basic obstacles like the system pushing them to other directions (Hill;Corbett;& St Rose, 2010)a shortage of support in STEM classes (Seymour, 1995), stereotype threat (Spencer;Steele;& Quinn, 1999) – and most importantly, their own beliefs of not be able to perform well in mathematics (Brown & Josephs, 1999).

These women have proved their capabilities in STEM, but they do not apply for technical universities, but other fields. We could assume that our most significant competitors are both the School of Medicine and STEM teacher education: medicine answers to women's altruistic aims of healing people, while education to the raising of children; both professions are considered more social than the old-fashioned image of engineering (Sagebiel & Dahmen, 2006). I represented how women emphasised humane and societal values in their study place selection process in paper II. A group of women also found these values in higher engineering education. Earlier study in CS field depicts us to ensure the content of recruitment events goes beyond "interesting and fun" to showing girls that IT career choices can help them make a difference in the lives of others (Cohoon & Aspray, 2006). This would appeal to women's altruistic goals (healing patients, nature or the world). We could study this behaviour closer and develop our recruiting materials further.

The entrance examination for the School of Medicine contains areas of physics, chemistry and biology. It has similarities to the higher engineering education entrance examination, which – in most study programmes - includes mathematics, physics or chemistry. The learning strategies for both medicine and engineering are the same in upper-secondary school: wide-ranging STEM subjects.

Other interesting and competitive study fields are STEM faculties in University of Helsinki (UH). In my study, students wrote that they had applied for both University of Helsinki and TKK, but chose TKK. It would be interesting to research whether the UH freshers had applied for our school as well, but choose differently.

To study these phenomena closer we should look to upper-secondary schools and interview girls about their future plans. However, to get valid results, we have to answer to the challenge of diversity of both content and teaching in upper-secondary schools. When I went through the material for papers I and II, I found out that the background of students was very diverse. The four most common arrival qualifications directions were:

- Basic Finnish upper-secondary school.
- STEM oriented Finnish upper-secondary school.

- International Baccalaureate in Finnish upper-secondary school.
- Upper-secondary school abroad.

In light of previous research, I recommend a study in the form of student interviews in either basic Finnish upper-secondary schools or STEM-oriented Finnish upper-secondary schools. We should discuss with the girls about their future plans: schools and profession. Based on these interviews, we could make suggestions into the recruiting material of our Aalto Technical Schools[15] (formerly TKK).

5.2.2 Achieving Effectiveness

The most significant problem in recruiting girls within engineering is to reach target groups and provide them with material that breaks prejudices and misbeliefs. Perhaps our most challenging problem is that a large amount of schoolchildren, teachers and parents ‘know’ that reading is for girls and mathematics for boys, which is not true (Finland's Ministry of Education and Culture, 2015). This is a very important phenomenon since the latest results in PISA evaluations (2013) show that girls slightly outperform boys in mathematics (OECD, 2015). Women suffer from a belief that they are not good in mathematics (Spencer;Steele;& Quinn, 1999). This is a vicious circle, since if girls don’t believe in their capabilities, they subsequently perform worse and choose very few STEM subjects when it is possible to choose otherwise.

To fight against that tendency, we have to create and deliver a positive image of engineering that appeal to our target groups. The image can vary between groups, but it has to have an influence. As I will later represent, the ‘cool’ content is not enough if it doesn’t reach the audience. Since the dimension of a typical gender project in technical universities is very limited, we need co-operation with other parties. Our most significant challenge is mainstreaming: it is easy to concentrate on high-quality content, while leaving the mainstreaming strategies in the background. As I will represent later on, the cool content is not enough and social media is a difficult and unpredictable tool.

Co-operation is vital for our work success. A gender project is such a small unit that we should co-operate closely with other parties. Instead of trying to reach each party ourselves, we should form indirect-influence chains. In recruiting, the closest operator is admission services personnel in TKK, which have channels to influence other parties in the field. The big advantage is that admission services are ‘female-friendly’: the illustration of their material represents an even amount of female and male students/engineers in their work.

In Figure 10, the number of each partner in our recruitment pool is represented. As we can see, the number of girls who we want to affect is counted in tens and hundreds of thousands, whereas mathematics teachers in thousands and study counsellors in hundreds. If we can establish a functional chain, each party can be reached inside their comfort zone. Important in this figure is the indirect influence chain:

[15] School of Chemical Technology, School of Electrical Engineering, School of Engineering, School of Science

No. of school girls in primary or lower secondary schools	264845
No. of teachers in primary or lower secondary school	39 041
No. of mathematics teachers in lower secondary school	1803
No. of study advisors in primary or lower secondary	668
No. of school girls in upper secondary schools	61701
No. of mathematics teachers in upper secondary school	1038
No. of study advisors in upper secondary schools	387
Admission Services personnel in TKK	16
Personnel in an imaginary gender project at TKK	4
Voluntary activists	n/a

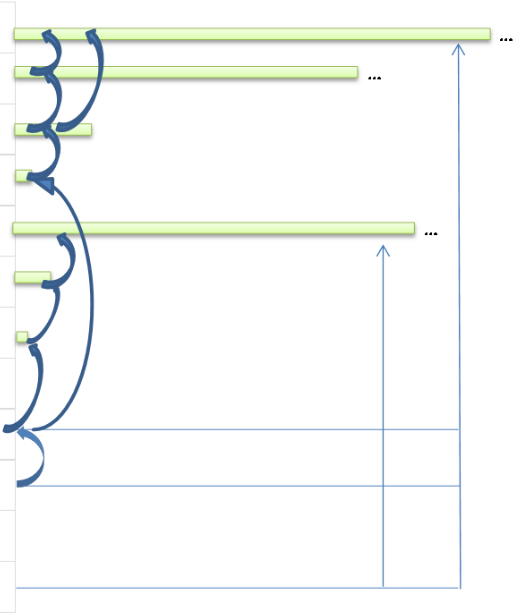


Figure 10: Number of parties in recruitment pool: since the amount of girls is great, we need to have strategies for both via Indirect and direct influencing channels.

An effective way to influence children is to create a CS exercise, or a series of exercises that creates a positive image of STEM and careers in the technology industry. Even if school children don't officially have information technology as a school subject, it is incorporated in subjects like languages and mathematics. We could offer our series of exercises either via

We could offer a series of interesting exercises that are "cool" enough to attract young women in graphical environment. For example Microsoft Research has been developing a Kodu coding environment for school children: Kodu is a visual programming language made specifically for creating games. It is designed to be accessible for children and enjoyable for anyone. You can program in Kodu either via an Xbox console or mouse and keyboard (Microsoft, 2015).

Here we could make use of the indirect chain of influence. Important in this chain is that teachers should be given a small, easily executable package, which doesn't significantly raise their workload: it is much easier to give a ready-made exercise for children's CS lessons than read material of gender-equality teaching practices and develop one's own course of action. Our key words are 'small steps, small loads for teachers'.

Our most significant focus must be on lower-secondary schools: to reassure girls that choosing STEM subjects in upper-secondary school is profitable. This is a very tricky question, since earlier research (OECD, 2015) depicts that girls suffer from a very severe lack of self-confidence in this field. To compete with this we could create a IT club in which IT is represented as 'cool'. We would create hands-on material for teachers and make this IT club to be 'girls only'. It is very important to keep the club 'girls' only' because earlier research depicts that boys are more aggressive learners in IT and thus they have usually better pre-knowledge on subject, they easily occupy both teacher and equipment (Cohoon & Aspray, 2006).

For both genders, exhibition visits are advisable. However, they require either an active student, teacher or study advisor. Yet again we should use the indirect chain of influence: such as other channels, which are aimed at a smaller proportion of lower-secondary schoolgirls' CS clubs and study visits.

This latter way has a weakness: if a girl should visit an exhibition herself, she is already interested in technology. To use the indirect chain of influence, us/the admission services should activate study advisors and pass this onto the STEM teacher. The STEM teacher's contribution is the most important factor in this chain.

When we are talking about the indirect chain of influence in upper-secondary schools, we must talk about the age structure of personnel: upper-secondary school teaching personnel are older than their peers in primary and lower-secondary schools. 41% of upper-secondary schoolteachers and principals are over 50 (Kumpulainen, 2014). We must proceed with open eyes, but we must be prepared that there might be age-related challenges, for example prejudices, resistance to change and old misbeliefs.

Traditionally, one milestone in lower-secondary school was to encourage girls to choose STEM subjects in upper-secondary school. However, it is still possible to correct one's choice in both directions: towards more or less STEM courses. This is why all classes have a strong influence. Besides, my research (papers I and II) depicts that the majority of girls applying to the Technical Schools of Aalto University[16] decide their study field one or two years before their matriculation examinations.

5.2.3 Direct Influence – Examples from Our Projects

Direct influence is often problematic due to the low number of project people in universities. However a small project can still achieve big publicity. (Web 2.0 technologies enable anyone to be a content provider). However, gaining publicity is a very difficult and unpredictable task. In our projects (Paloheimo;Putila;& Simpanen, 2010), the basic websites were created by professionals who specialised in creating content. Besides basic websites, there were two self-contained units:

Tina's survival guide (to technical studies): the idea behind this guide was to answer questions related to studies in TKK. This was a relatively small website; it was made in co-operation with M. Sc. Tech, electronics students and a usability student. The content provider, Nicefactory Oy, created the site's appearance and illustrations. This was a small, cute site. However, to get publicity it should have been strictly linked to the faculty and university website, or had an active information campaign.

DinaNet: a network mentoring service targeted at lower-secondary and upper-secondary schoolgirls interested in technology. DinaNet was wider than

[16] Former Helsinki University of Technology

the survival guide, and it contained cool functions such as career stories and blogs, problem-solving columns and so on. The idea was that both female students and alumnae would provide content for the site. However, the number of yearly visitors was calculated to be in the thousands, which was not found to be satisfactory and, after a few years, the site was shut down. Yet again we realise that social media is unpredictable.

In our projects (Paloheimo;Putila;& Simpanen, 2010), the last project's main task was to spread the word in a traditional way: two very good leaflets were made and shared out to academies. What their relevance was is hard to tell.

5.3 Teaching to Attract Women

The one crucial result in my research was that engineers raise engineers. As stated in papers I and II, the most significant factor for a girl in choosing engineering was the support of her family (engineers), and, even more so, her mother. While children commonly have motivation problems towards STEM subjects, students with family backgrounds in STEM are the ones most likely to make their way through STEM studies into upper-secondary school and apply for an engineering education. These women are the ones 'we already have': they don't need extra recruiting efforts or materials. However, this is a small population, and our challenge is to reach a larger pool.

We aim for women who are talented in STEM subjects, but have decided to pursue something else. As examined in paper II, women are eager to form social connections: the key words for fields of study with a high concentration of women are socially-oriented studies, multidisciplinary studies and environmental influencing and protection. This is in accordance with the earlier research (Seymour, 1995) that determines women are more altruistic than men in their career goals, and are more likely to switch studies to something that provides a more humanitarian or personally satisfying sense of work.

One very successful study programme, Information Networks, includes a lot of socially-oriented teaching. It has been stated in recruiting materials that the program is both interdisciplinary and socially oriented. The women perform well during studies and their early working career, and the monthly salary five years after graduation is the second best in TKK (paper V).

The other popular study programme, Bioinformatics, is more interesting: Bioinformatics is promoted as interdisciplinary and close to medicine – and it is. However, this program is technically very challenging and some studies are conducted with a traditional model of elimination pedagogy. Here we cannot underestimate the power of image: since women know that they are studying something close to medicine, they approach their studies with better self-esteem and, in turn, perform well. According to the study administration in the Aalto University School of Electronics, the study success in Bioinformatics is substantially better than its sibling study programs: Electronics and Electrical Engineering, and Communications Engineering. However, the problem with the Bioinformatics degree programme is a high percentage of study discontinuance: since the programme is often the second choice, after medical school, many students will apply again after their first or second year, and – if accepted – discontinue studies in our study programme.

During studies we must influence female students in supporting acts with a low profile: many male and female students and faculty members in the field have a strong resistance towards supporting acts for females. This is a continuum of the schooling system, from kindergarten to primary, secondary and upper-secondary schools, where both teachers and schoolchildren 'know' that boys are better in STEM subjects – period. This misunderstanding culminates in the PISA[17] assessment program: even if girls are a little superior when compared to boys, they suffer from very low self-esteem towards their capabilities in natural sciences (Finland's Ministry of Education and Culture, 2015).

Earlier research (Wolfe & Powell, 2009) depicts that female engineering professionals are more androgynous than their peers in economics and nursing. These women easily 'try hard to be one of the boys'. This is one reason why they are subsequently adverse to possible 'women-friendly' arrangements in fear of missing something important. This is a complicated arrangement, since without some guidance women are likely to be the only ones in their exercise groups in the most male-dominated study programmes. This is a difficult situation: as represented in paper III, a lonely woman will easily be isolated from the rest of the group. She will have less peer support and will suffer from it more than her male peers.

As stated in paper III, women do benefit from some arrangements in these courses: women outperform themselves in comfortable environments, whereas men excel in competitive environments, hence they profit from elimination pedagogy. A comfortable environment would either be an even or female-only exercise group. In the mentioned groups, female students spontaneously use student-centred and teamwork methods – and fare well. On the other hand, when there is only one woman in an otherwise all-male group, women perform below their average. Male students' performance was approximately even, regardless of the gender distribution of the groups. To gain the optimal study success for female students, we should use these small (women-) friendly actions. Even if we work in the way of elimination pedagogy (lectures, exercises and examinations), we can help women in small adjustments: if we design the classes and timetables in a way that women are collected together in exercise groups in an all-women or even-gendered way, female students will feel comfortable and their performances would improve. Even-gendered groups might be the most appropriate of these options. However, we must keep in mind that many women do not want to work in female-only groups.

In the ideal situation, we would develop women-friendly education with university teachers and lecturers. However, this would most probably prove unsuccessful due to a lack of interest and loss of time from all parties. On a smaller scale, we can offer female-friendly education via arranging courses to support female students in their studies. As in our experience, the support for

[17] Program for International Student Assessment

conducting studies can be small if it is allocated wisely. We used three[18] 'outside-faculty' courses for students: a course of practical electronics, a course of teamwork and a course of literature (paper IV) (Paloheimo;Putila;& Simpanen, 2010). While the electronics course was female-only, the literature course was for both genders and the gender distribution was roughly fifty-fifty during the years.

The female-only electronics course was intended to narrow the gap between female and male students' technical know-how. (Paper I: Men had more technical prior knowledge than their female peers.) The course got very good feedback from attendees. Students were under the impression that they learned a lot about electronics. However, the course was so narrow (six sessions) that it could not have been a very deep review of electronics. The more important outcome of the course was the increase in women's self-esteem. Course topics are listed below:

- Information lecture
- Household electricity work
- Simulation and circuitry
- Measurement and soldering
- Finishing the circuit
- Connecting a computer to the local area network

Students worked in pairs, however both created an individual circuit. The funding was project-based and teachers came from different laboratories. The course fell into administrative (there was not a single laboratory to take responsibility for this course) and monetary problems (project-based funding). To create a successful course, we should have a constant funding and a responsible teacher/unit.

The above proves that we can affect students' self-esteem via a technical course. The same idea is repeated in our literature course: besides learning literature, students met people, interacted and shared ideas, got peer support and so on. The course provided students with female-friendly teaching models and better female-to-male ratios when compared with other courses in the electronics and communications engineering study programs.

It is very important for many reasons, from personal perspectives to national economy, to find the means to support women both in their studies and working life. As researched, women and men excel themselves in different situation: for women, the good climate is a key factor whereas men outperform themselves in competition. As the 21st century engineering education reform aims towards more student-centred methods and constructivism, will female students have it any easier?

5.3.1 Supportive Education

Earlier research (Brainard & Carlin, 1998) (Cuny & Aspray, 2002) (Sagebiel & Dahmen, 2006) depicts that women discontinue their studies most often in

[18] We had a third course, which taught teamwork skills, but this course wasn't successful and it was signed off after one test round.

the first or second study years. This is often because of both poor teaching and poor climate: unlike their male peers, women blame themselves if the teaching is of a poor quality. This is regrettable, as the women who quit are usually average or above average in their study success (Seymour, 1995).

The change from traditional teacher-centred education methods to student-centred learning strategies is a process that is beneficial for female students because many of them are socially active and interdisciplinary oriented (Papers I and II) and profit from teamwork (Papers III and IV). Traditionally, the first two years of teaching is often regrettable because of its teacher-centred nature. Additionally, the old system unintentionally pushes students to work alone for fear of being accused of plagiarism.

In recent years, in our technical schools of Aalto University, the teaching personnel in mathematics and physics have created more co-operative learning methods, such as interactive exercises and peer review. The basic working method is that a course has both interactive exercises (students calculate and assistants assist) and traditional exercises (students calculate at home, assistants choose a student to represent one's solution). However, the teaching varies greatly from course to course.

Perhaps the form of traditional support method that gains the most publicity is tutoring. The idea is that tutoring will encourage students to get through their first two years of teacher-centred elimination pedagogy. A tutor can play a very central role in improving female students' technical self-esteem. However, there is a risk within the tutoring system that might cause students to not realise its meaning and importance, since students do not get credits from participating in tutor meetings.

In paper III, I represent group-arrangement methods to support women's studies: we divide exercise groups into female-only, fifty-fifty and male-only. When groups are divided by gender, women use their natural facilities of informal teamwork and pair work: the group division enabled women to work at Belenky's levels of (Belenky, Women's ways of knowing: The development of self, voice, and mind, 1986) four and five: they internalise information from multiple sources and share their knowledge with authorities.

Also, as represented in section 5.3.1, a soft skill course can be a supportive activity in the middle of traditional, teacher-centred technical studies. Soft skill courses are often social and interdisciplinary: both characteristics that women value, are interested in and good at (paper I, II, III, IV). Since they are courses and not external support actions, they do not provoke criticism compared to many other supporting methods for women.

5.3.2 Teaching Soft Skills

Traditionally, higher engineering education has concentrated on technical skills. However, the rising complexity of projects and the rapid changes in technology require so-called soft skills[19] (Schultz, 2008). Since the information

[19] The term 'soft skills' illustrates the character traits and interpersonal skills that characterise a person's relationships with other people. In the workplace, soft skills are

systems become more and more complex, skills like communication, teamwork, negotiation and management become crucial for software project success.

The personnel of a typical technological project consist of many other experts and engineers. Figure 2 on page 25 illustrates rates the structure of programming project personnel. To master projects these days, engineers need soft skills and other supporting skills to work in interdisciplinary teams and to narrow the gap between practitioners and their clientele (Chubin;May;& Babco, 2005). As depicted in Paper II, this is all good news for women, who value interdisciplinary and socially-oriented studies.

In conventional teaching we can divide higher engineering studies into soft skills (communication, teamwork, languages, human relations skills, etc.) and hard skills (STEM). In paper IV, I represent an example of teaching soft skills in the form of a separate course. This is a good way to get your own ideas into action: a separate small-scale course is lightweight and agile. Also, when in need of a teacher outside our own university, it is easy to employ one on an hourly wage.

Dividing students into interdisciplinary teams and giving them a wide-ranging task is not enough: teamwork and soft skills are complicated kinds of expertise that need to be supervised and taught by professionals. To create truly functional team projects is hard work and requires breaking prejudices from both students' and study personnel's point-of-view. Soft skills are crucial in engineering fields and they must be taught as part of an engineering curriculum, both in separate courses and built-in technical courses. However, teaching built-in soft skills is very demanding for both personnel and students, and it does not appear to be taking place within our university in the near future. Perhaps the most significant obstacle for large-scale interdisciplinary projects is that both students and faculty members have other engagements at the same time and are not willing to commit to the course in its full extent.

Outside large-scale arrangements, we can continue to teach soft skills and interdisciplinary skills in relatively small-scale and cost-efficient, separate courses. However, as stated in Paper IV the communication and advertising of such an experimental course can be a challenge. (The same problem occurs in the technical courses of changing content).

5.3.3 Teaching the Girls: Geek is Chic!

TiNA projects (Paloheimo;Putila;& Simpanen, 2010) in TKK worked to improve girls' self-esteem and interest regarding technology: projects arranged study visits to the Department of Electronics and Communications Engineer-

considered a complement to hard skills, which refer to a person's knowledge and occupational skills. Sociologists may use the term soft skills to describe a person's "EQ" or "Emotional Intelligence Quotient" (as opposed to "IQ").
http://www.investopedia.com/

ing. These study visits were for girls only. (That way we avoided the phenomenon where boys do and girls wait). During study visits girls did some easy electronics exercises. Among them were, for example, those classics like 'how to light a light-emitting diode with a potato', and 'how to make a magnet out of a nail'. Besides the hands-on exercises, the students got a laboratory visit in some of our units. The girls who attended were quite pleased with the package (Paloheimo;Putila;& Simpanen, 2010).

Today, the facilities of student visits are good, as in recent years an exclusive STEM laboratory (LUMA Centre at Aalto University, 2015) has been built to serve upper-secondary school students. The LUMA centre is equipped with many kinds of machinery for science and technology learning. It has many tools for hands-on exercises in electronics, biology and chemistry. At the moment there are no girls-only activities.

A current science education and taster event for young children in Finland is 'koodikoulu' (code school), which started in the beginning of 2014 and is an event where children and adults code together with some easy programming (Reaktor, 2014). The events are aimed at 4-9 year-old children and their parents, and last two hours each. This has been a very popular operation model and the events have been filled soon after being announced. Another science event for children is Mehackit (http://mehackit.org/), in which children do cool stuff in the areas of programming and electronics.

TiNA-projects' operation models aim to remove girls' negative preconceptions of technology and engineering. The koodikoulu and mehackit rely on active parents who already encourage their children to interact with technology. We aim to tackle those with less support from their family:

Looking to provide nice events to girls, TiNA-projects arranged an experiment for our 'all-girls' compute science (CS) clubs that was arranged for primary school sixth-grade to lower-secondary school ninth-grade girls. The operations model was to get together a few times and do some hands-on exercises on the fields of CS and information technology (IT). This was a very successful course of action: the courses filled up quickly and girls were satisfied with the teaching.

A crucial point in our courses was that while the participating schools also had their own voluntary computer classes, there were no girls that were currently involved in those classes. Our 'girls-only' CS club is a working model that deserves mainstreaming: we could chop and change our teaching and spread it into four sessions. This would be profitable for girls, since the activities could be right after the school day, within the school accommodation. In the long run, the older girls could co-teach the younger ones and we could bring about a permanent arrangement. Below are four principles for a successful club:

- The course load has to be minimal.
- We need to engage at least one adult from the education institute for administrative issues.
- There has to be a person in charge from a higher engineering education unit.
- A summer trainee should be available to update the materials yearly.

5.3.4 A Few Words of Interdisciplinary Teamwork

To truly succeed in the mission of overcoming segregation we must be willing to co-operate between disciplines and boundaries. Overcoming segregation does not have to be the aim in our working models, but it is more of a result of high-grade teamwork methods in complicated projects. We no longer have technology just for the sake of technology, but we use technical advancements to serve the society – and people. In that way we always have at least two dimensions to our work: technology and human. We are talking about human/machine interaction. Our customers are no longer interested in assimilating technology, but they demand technology to adjust to their needs.

It is a necessity to have interdisciplinary teams to also accomplish desired results in technical fields. One step towards wider studies and collaboration across boundaries was the creation of Aalto University in 2010, which merged three existing Finnish universities: the Helsinki School of Economics, Helsinki University of Technology and University of Art and Design Helsinki. Aalto is aiming towards student-centred and interdisciplinary learning methods.

According to this mental structure we have two goals: to persuade women into pursuing technical fields, and to create multicultural teamwork methods where women – and men – from other fields can also participate in an equal way. The thread in future engineers' working life is to understand that they are part of a bigger ensemble, where, for example, programming is one task. No more or less important than the other parts (see Figure 2 Example of programming project governance). We have to appreciate other fields than our own.

Women have many characteristics suitable for working in interdisciplinary teams. Women are less aggressive than their male peers, which makes them better team players. They are also not afraid of asking questions, which is a very good feature in working life. However, the case is not this simple: since women are indicators of workplace climate, they can excel themselves, do average or go below their natural level, depending on their feelings of comfort and respect. Hiring a female employer is a tricky question. How shall we create a confidential environment, where everyone feels comfortable and respected? This would, of course, be beneficial for both genders. On the other hand, the very same qualification that makes women good team players creates obstacles in competitive situations.

5.4 Getting Ready for Career

The nature of female engineers' career paths means a permanent reaffirming of one's expertise at all levels (Kray;Galinsky;& Thompson, 2002) (Eagly & Carli , 2003). Women usually negotiate lower starting salaries than their male peers, and the gap easily grows (Stevens;Bavetta;& Kahn, 1993). When it comes to negotiations during entire careers, women might even be the better negotiators, since they are capable of asking questions and avoiding unnecessary risk taking (Bass & Avolio, 1994) (Byrnes;Miller;& Schafer, 1999) (Croson & Gneezy, 2009). However, in technical fields, masculinity and a competitive attitude are easily overvalued and risk-taking is considered as a favourable attribute of masculine psychology (Byrnes;Miller;& Schafer, 1999) (Eagly & Carli , 2003). Many men do enjoy the competition (Gneezy;Niederle;& Rustichini, 2003) and risk-taking, whereas women benefit from a workplace's good atmosphere. These trends are not always the case, however, as women can also be competitive and men can benefit from an enjoyable work climate.

Salary is one indicator of women's early career paths. I introduce other measures of women's early careers in paper V:

- At the time of graduation, more men than women were employed.
- At the time of graduation, more men had permanent jobs than women.
- During the first five years, more women than men had an unemployment period.
- During the first five years women had taken significantly more and longer family leaves than their male peers.
- During the first years, men achieve more managerial positions than their female peers.

For women, the early career path is a rocky road. However, we can help to alleviate this by, for example, career coaching and mentor programmes. For young engineers it is important to understand two important issues of modern engineering work. Firstly, the working career is not a sprint, but lasts for decades. Secondly, work means constant learning (both technical and soft skills).

Another important aspect is the satisfaction gained from one's work. As stated in papers V and VI, women in general are satisfied with their work: they describe their job as interesting, creative and independent. They see their career prospects as good. However, a significant finding in paper VI is that many female graduate students do not plan on having a career in the academic field, but consider that an intermediate phase of their working life: they direct their energies away from the academic world, where they hope they can utilise their full potential and receive appreciation for their efforts. This is part of the shrinking pipeline phenomenon (Camp, 1997): the percentage of women diminishes during each hierarchical step in the academic world. Earlier research (Rees, 2001) aims to fight this phenomenon with a three-step strategy:

- Equal treatment.
- Career guidance, counselling and childcare facilities with family-friendly hours.
- Mainstreaming.

5.4.1 Family and Work

Since women have the burden of baby and household taxes (Blau & Kahn, 2000) (Coltrane, 2000) (Gürer & Camp, 2002) (Eagly & Carli , 2003), it is stated in earlier research that to entice women into engineering we should make sure that the work can be done within a reasonable amount of hours. Flexible working hours are also considered as an asset (Hewlett & Luce, 2005). However, when climbing up career ladders the work becomes more and more demanding. At some point one has to do the maths: more working hours or less aggressive career development? Since women traditionally have more responsibilities at home, they can easily take a step back.

As stated in my paper V women have more family leaves during first five work years (45% of female and 28% of male engineers had been on family leave). This difference is not alarming. However, we get more descriptive results when comparing the length of these absences, as follows: 69% of female engineers were absent from work for more than a year, whereas 5% of their male peers had more than one year of parental leave.

One important way of supporting women's career is to create intervention programs to support one's returning work after a longer absence, family-related or other. Earlier research Panteli, N. (2012) present an intervention project, Equalitec, which was to assist women returners in IT: to define, align and adjust their attitudes, aptitudes and aspirations making them well-equipped to enter the labour force. - And feel comfortable and welcome.

5.5 Prejudices

All the way from kindergarten to university studies, girls and women have an illusion of boy/men superiority. This has roots deep within our society. (Women have always been the "weaker sex"). Women form clear majorities in fields that have low career prospects, compared to engineering, which promises (at least in our minds) a successful career.

For example, school teachers form a female-dominated group without special career expectations. The life is quite secure and riskless – and since they have chosen the riskless path, they might transfer their own fears and prejudices to the girls: this could be the basis for school personnel to 'raise' girls into 'female professions', and boys to technology and engineering.

One obstacle in women's studies is the resilient belief of men's superiority. For example in CS, where the challenges in the first two years vary greatly depending on one's preliminary talents in programming. The beginning is hard if one has no pre-programming skills, but the personnel assure students that in the two years it is possible to catch up with those that have a programming background. This is a classic example of a situation where women can easily think that their male peers have some special talent that they do not have, and that is why women will never learn to program – at least not as well as men. Women tend to ignore or forget about the amount of work their male peers have had to put into learning programming.

Women think somewhat similarly towards deficiencies in engineering education: during studies in higher engineering education, the educational methods vary a great deal. For example, we have the traditional lecture and exercise teaching, projects, practical work and so on. Since teaching staff doesn't have a uniform pedagogical training, the level of teaching varies from course to course. When the quality is poor, women and men react differently: men find the teaching poor, whereas women accuse themselves of not understanding the teaching. This could be one reason why women with average or above-average study success interrupt their studies (Seymour, 1995).

5.6 Summary

This chapter presented wider perspective on my research. What is the larger scale environment of my research? How does the environment affect women in higher engineering education? Can we conduct actions based on my research? In this chapter I discuss possibilities in recruiting, teaching and career training based on my research.

I presented different angles of recruitment processes, for example recruiting young women from upper-secondary school STEM classes or reaching primary and secondary school girls via their study advisers and STEM teachers. I also present recruitment via internet and social media, but with the warning that the conversion rates in those media is unpredictable.

I also talked about higher engineering education being profitable for women. This education also serves male students well. Women-friendly education can contain, for example, interdisciplinary studies, soft skills and collaborative learning methods.

I described a few aspects of female engineers' early career, like satisfaction on one's career and some basic gender differences in engineers' early career. Lastly I discuss common prejudices and obstacles in women's path from day care to an engineering career.

6. Conclusions

6.1 Introduction

My thesis has presented new findings regarding women in higher engineering education. My research was based on the fact that women are strongly underrepresented in most of the engineering programmes, both in Helsinki University of Technology and around the world. I also briefly present gender statistics from my university after my work (2011-2014). The proportion of women has not risen.

6.2 Conclusions

In this research, I had three research questions:

RQ1: What are women's paths to our university of technology?

I discovered connective categories for freshers' reasons for choosing engineering as a study field. For future recruitment I emphasise the following guidelines.

Women are interested in interdisciplinary studies. While a certain proportion of female applicants chose to study in TKK because of their interest in applied mathematics, the majority expressed an interest in using their engineering education as a guarantee for their future interdisciplinary working life. Women favour social studies and human values.

A step towards an interdisciplinary direction has been taken in the creation of Aalto University: it was created by a merger of the Helsinki School of Economics, Helsinki University of Technology and the University of Art and Design Helsinki in 2010. This has two clear advantages: it can broaden a student's studies in the directions outside of traditional technology education, while on the other hand it can broaden work in interdisciplinary teams during studies. However, it is yet to be seen if this works. There have been teething problems during the process of taking courses outside of one's own school.

RQ2: Can we help with the retainment of female students during their early studies in a cost and admin-efficient way?

I discovered means to support women during studies. Most important was a dialogue between personnel and other students. If we have the means to arrange our course's exercise groups in the form of female-only, fifty-fifty or male-only groups, we should do so: women benefit from a good climate and group work. If we cannot influence courses' teaching methods, we can at least support female students outside compulsory education.

In this thesis I present a course of literature to help women to succeed in their studies.

Course of literature: to keep this course alive, we need one part-time teacher from the faculty to take responsibility of the course and communication channels, so students can be informed about the course. Teaching of the course can be outsourced to a literary expert. The course structure for this course is represented in paper IV. This course improves the following skills: communication methods, innovative thinking and bringing students motivation towards more traditional engineering studies. However, as clear and efficient as this course is, it needs a staff member as a coordinator.

RQ3: What are the early career prospects of female engineers that graduate from our university?

Traditionally, we are eager to debate the work and salaries between traditional female and male occupations. However, as stated in paper V, we also have different career and salary development inside the same field (engineering). This is explained by studies that claim women are the weaker sex and worse (salary) negotiators (Gerhart & Rynes, 1991) (Stevens;Bavetta;& Kahn, 1993) (Kray;Thompson ;& Galinsky, 2001)**.** However, I must emphasise that, in the long run, a working career is not so much a competition but an essential part of one's life.

Quite often in the beginning of one's career, women usually have a bigger burden in the household and with child upbringing than their male peers. Already in the five first years after graduation, male employees get more promotions and a better salary that is only partly **explained** by 'baby tax'.

Despite career differences in favour of men, women consider their working life satisfactory.

6.3 Student Enrollment Statistics After My Study

My data collection is dated between 2003 and 2011. However, to see the big picture, we have to take a look at figures all the way to nowadays. The percentage of female students in our technical schools has not risen during the years 2005-2014. The figures have to be researched carefully, since during my timeframe two important administrative shifts were made:

1. 2010: Aalto University was created by a merger of the Helsinki School of Economics, Helsinki University of Technology and the University

of Art and Design Helsinki. The name of the old TKK was changed to Aalto University School of Science and Technology.

2. 2011: Aalto University School of Science and Technology was split into four schools:
    - School of Chemical Technology
    - School of Electrical Engineering
    - School of Engineering
    - School of Science

The percentage of female freshers in bachelor's degrees (BS) lowered from 24.5 to 22.4 % between 2011 and 2014. During 2011-2014 the percentage of female students in bachelor's degree programmes in our Technical Schools has lowered from 17.8 to 17.3%. This difference is not alarming, but the overall small portion of female students in bachelor's degree programmes is. The percentage of female students in master's degree programmes in our Technical Schools has lowered from 26.0 to 23.3%. These figures are paralleled in U.S. research (Nelson, 2014), where 13.3% of BS degrees and 28.7% of Master of Science (MS) in CS were awarded to female candidates.

The above figures present a few basic phenomena:

- Women form a clear minority in applicants for engineering degrees in our university.
- The proportion of female students has not risen despite efforts.
- Women form a clear minority in higher engineering education study programmes in our university, especially in bachelor level programmes.
- Women discontinue their studies more often than their male peers in our university.

6.4 Future Work: Survival Strategies

In 2012 I started a longitudinal study on female students' study strategies during their studies in our Technical Schools. I started to collect data from female freshers from two study programmes: electronics and chemistry. The study programs were chosen based on two things. First: electronics had a low proportion of female students, whereas chemistry had a higher proportion of female students. Second: the study programmes had approximately even admission scores. The yearly data collection method has been an interview and a transcript of recordings. The fee from interviews was either a €20 voucher for Stockmann[20] or two movie tickets.

In the interviews my assistant collected data from three categories:

1. Basic questions: satisfaction towards studies and place of study, the expectations, study success, etc.
2. The big picture: evaluation of teaching in one's study programme (pros and cons), impressions of one's discipline, etc.
3. Communal questions: feeling at home in student departments, climate issues, etc.

[20] Popular department store in Finland

4. How the climate is in regards to fellow students, departments, etc.

I have not analysed the data yet, but this will be my future research.

6.5 Finally

The last thing to remember is that even small actions can make a difference: one visit to our stand in the student expedition could give a girl an idea of engineering studies. One role model found from the internet: something that assured me that engineering is also for women. A tutor discussion where a student displays the courage to express her uncertainties regarding her studies could save one woman from discontinuing her studies. Mentoring (and sponsoring) systems can play a significant role in the career development of female engineers.

References

Aalto. (2015). *Aalto University*. Retrieved 11 09, 2015, from Aalto University: http://www.aalto.fi/fi/

Adelman, C. (1998). Women and Men of the Engineering Path: A Model for Analyses of Undergraduate Careers. *US Government Printing Office, Superintendent of Documents*.

Adya, M.;& Kaiser, K. M. (2005). Early determinants of women in the IT workforce: a model of girls' career choices. *Information Technology & People, 18(3)*, 230-259.

Amelink, C. T.;& Creamer, E. G. (2010). Gender differences in elements of the undergraduate experience that influence satisfaction with the engineering major and the intent to pursue engineering as a career. *Journal of Engineering Education, 99(1)*, 81-92.

Anderson, N.;Lankhear, C.;Timms, C.;& Courney, L. (2008). Because it's boring, irrelevant and I don't like computers': Why high school girls avoid professionally-oriented ICT subjects. *Computers & Education 50(4)*, 1304-1318.

Bannerot, R. (2003). Who Are the Good Team Players? *Proceedings of 2003 Annual Conference of ASEE Gulf Southwest Section*. ASEE.

Barker, L.;& Garvin-Doxas, K. (2004). Making visible the behaviors that influence learning environment: A qualitative exploration of computer science classrooms. *Computer Science Education*, 14(2), 119-145.

Bass, B. M.;& Avolio, B. J. (1994). Shatter the glass ceiling: Women may make better managers. Human resource management. *Human resource management*, 33(4), 549-560.

Becker, J. (1995). Women's ways of knowing in mathematics . *Equity in mathematics education: Influences of feminism and culture*, 163-174.

Beede, D.;Julian, T.;Langdon, D.;McKittrick, G.;Khan, B.;& Doms, M. (2011). Women in STEM: A gender gap to innovation. *Economics and Statistics Administration Issue Brief*, 4-11.

Belenky, M. F. (1986). *Women's ways of knowing: The development of self, voice, and mind.* Basic Books.

Beraud, A. (2003). A European research on women and Engineering Education. *European journal of engineering education*, 28(4), 435-451.

Bernstein, D. R. (1991). Comfort and experience with computing: Are they the same for women and men? *ACM Sigcse Bulletin*, 23(3), 57-60.

Bianchi, S. M.;Milkie, M. A.;Sayer, L. C.;& Robinson, J. P. (2000). Is anyone doing the housework? Trends in the gender division of household labor. *Social Forces 79(1)*, 191-228.

Bilimoria, D.;Joy, S.;& Liang, X. (2008). Breaking barriers and creating inclusiveness: Lessons of organizational transformation to advance women faculty in academic science and engineering. *Human resource management, 47(3)*, 423-441.

Blau, F. D.;& Kahn, L. M. (2000). Gender differences in pay. *National Bureau of Economic Research, No. w7732.*

Blickenstaff, C. (2005). Women and science careers: leaky pipeline or gender filter? *Gender and education, 17(4)*, 369-386.

Borrego, M.;& Newswander, L. (2008). Characteristics of Successful Cross-disciplinary Engineering Education Collaborations. *Journal of Engineering Education*, 97(2), 123-134.

Brainard, S.;& Carlin, L. (1998). A Six-year longitudinal study of undergraduate women in engineering and science. *Journal of Engineerin Education, 87 (4).*

Brown, R. P.;& Josephs, R. A. (1999). A burden of proof: Stereotype relevance and gender differences in math performance. *Journal of personality and social psychology, 76(2)*, 246.

Buzzetto-More;Ukoha, O.;& Rustagi, N. (2010). Unlocking the barriers to women and minorities in computer science and information systems studies: results from a multi-methodolical study conducted at two minority serving institutions. *Journal of Information Technology Education, 9(1)*, 115-131.

Byrnes, J.;Miller, D.;& Schafer, W. (1999). Gender differences in risk taking: A meta-analysis. *Psychological bulletin 125(3), 367.*

Cago, M. J.;Ziman, J.;Caro, P.;Constantinou, C.;& Davies, G. (2004). *Europe needs more scientists*. High Level Groupon Increasing Human Resources for Science and Technology in Europe.

Camp, T. (1997). The incredible shrinking pipeline. *Communicatins of the ACM 40(10)*, 103-110.

Career monitoring. (2015). Retrieved 06 25, 2015, from Aarressaari - akateemiset rekrytiontipalvelut: https://www.aarresaari.net/home

Carnes, W. J.;& Radojevich-Kelley, N. (2011). *Te effect of the glass ceiling on women in the workforce: Where are they now and where are they going?* Review of Management, Innovation & creativity, 4(10).

Chang, J. C. (2002). Women and minorities in the science, mathematics and engineering pipeline. *ERIC Digest*.

Chemers, M.;Hu, L.;& Garcia, B. (2001). Academic self-efficacy and first year college student performance and adjustment. *Journal of educational Psychology, 98(1)*, 55-64.

Chubin, D. E.;May, G. S.;& Babco, E. L. (2005). Diversifying the engineering workforce. *Journal of Engineering Education, 94(1)* , 73-86.

Chung, W. T.;Husman, J.;Stump, G.;Maez, C.;& Done, A. (2009). Connecting to the future: How the perception of future impacts engineering undergraduate students' learning and performance. *Frontiers ion Education Conference* (ss. 1-5). San Antonio: Frontiers in Education Clearing House.

Clayton, K. (2007). *The influence of metropolitan Brisbane middle-school ICT experiences on girls' ICT study and career choices (Doctoral dissertation)*. Griffith University.

Clewell, B. C. (1992). *Breaking the Barriers: Helping Female and Minority Students Succeed in Mathematics and Science*. San Francisco: Jossey-Bass Education Series. Jossey-Bass Inc., Publishers.

Cochran, D. B.;Wang, E. W.;Stevenson, S. J.;Johnson, L. E.;& Crews, C. (2011). Adolescent occupational aspirations: test of Gottfredson's theory of circumscription and compromise. *The Career Development Quaterly, 59(5)*, 412-427.

Cohen, L.;Manion, L.;& Morrison, K. (2000). *Research Methods in Education*. London: Routledge Farmer.

Cohoon, J. M. (2002). Recruiting and retaining women in undergraduate computing majors. *ACM SIGSE Bulletin, 34(2)*, 48-52.

Cohoon, J. M.;Nigai, S.;& Kaye, J. J. (2011). Gender and computing conference papers. *Communications of the ACM, 54(8)*, 72-80.

Cohoon, J.;& Aspray, W. (2006). *Women and information technology: Research on underrepresentation* . The MIT Press.

Colaco, H. M.;Myers, P.;& Nitkin, M. R. (2011). Pathways to leadership: Board independence, diversity and the emerging pipeline in the United States for women directors. *International Journal of Disclosure and Governance, 8(2)*, 122-147.

Coltrane, S. (2000). Modeling and measuring the social embeddedness of routine family work. *Journal of Marriage and Family, 62(4)*, 1208-1233.

Connelly, F.;& Clandin, D. (1990). Stories of experience and narrative inquiry . *Educational researcher*, 2-14.

Cotter, D. A.;Hermsen, J. M.;Ovadia, S.;& Vanneman, R. (2001). The glass ceiling effect. *Social Forces 80(2)*, 665-681.

Creamer, E. G.;Amelink, C. T.;& Meszaros, P. S. (2010).). Individual and environmental factors that significantly impact short-and long-term interest in engineering. *Proceedings of Frontiers in Educaton Conference* (ss. T2H-1). Washingont D.C.: IEE Xplore.

Creswell, J.;& Clark, V. (2007). *Designing and conducting mixed methods research*. SAGE Publications.

Croson, R.;& Gneezy, U. (2009). Gender differences in preferences. *Journal of Economic Literature*, 448-474.

Crump, B. J.;Logan, K. A.;& McIIroy, A. (2007). Does gender still matter? A study of the views of women in the ICT industry in New Zealand. *Gender, Work & Organization, 14(4)*, 349-370.

Cuny, J.;& Aspray, W. (2002). Recruitment and retention of women graduate students in computer science and engineering: results of a workshop orgaized by computing research association. *ACM SIGSE Bulletin 34(2)*, 168-174.

Dow, W. (2006). The Need to Change Pedagogies in Science and Technology Subjects: a European Perspective. *International Journal of Technology and Design Education*, 307-321.

Dym, C.;Agogino, A.;Eris, O.;Frey, D.;& Leifer, L. (2005). Engineering design thinking, teaching and learning. *Journal of Engineering Education*, 103-120.

Eagly, A. H.;& Carli , L. L. (2003). The female leadership advantage: An evaluation of the evidence. *The leadership quaterly* , 14(6), 807-834.

Eagly, A. H.;& Carli, L. L. (2007). Women and the labyrinth of leadership. *Harvard Business Review, 85(9)*, 62.

England, P. (2010). The gender revolution uneven and stalled. *Gender & Society, 24(2)*, 149-166.

Erdil, E.;& Bilsel, A. (2005). Curriculum design to revitalise electrical engineering education at Eastern Mediterranean University. *International Journal of Electrical Engineering education*, 234-246.

Finland's Ministry of Education and Culture. (2015). *Finland's Ministry of Education and Culture*. Retrieved 11 09, 2015, from Finland's Ministry of Education and Culture: http://www.minedu.fi/OPM/?lang=en

Fox, M. F. (2001). Women, science, and academia Graduate Education and Careers. *Gender & Society, 15(5)*, 654-666.

Gerhart, B.;& Rynes, S. (1991). Gerhart, B., & Rynes, S. (1991). Determinants and consequences of salary negotiations by male and female MBA graduates., 76(2), 256. *Journal of Applied Psychology 76(2)*, 256.

Gneezy, U.;& Rustichini, A. (2004). Gender and competition at a young age . *American Economic Review*, 377-381.

Gneezy, U.;Niederle, M.;& Rustichini, A. (2003). Performance in competitive environments: Gender differences. *The Quarterly Journal of Economics 118(3)*, 1049-1074.

Gürer, D.;& Camp, T. (2002). An ACM-W literature review on women in computing. *ACM SIGSE Bulletin, 34(2)*, 121-127.

Hewlett, S. A.;& Luce, C. B. (2005). Off-ramps and on-ramps: keeping talented women on the road to succes. *Harward business review, 88(3)*, 43-6.

Hill, C.;Corbett, C.;& St Rose, A. (2010). *Why So Few? Women in Science, Technology, Engineering, and Mathematics*. Washington DC: American Association of University Women.

Hill, E.;Märtinson, V. K.;& Baker, R. Z. (2004). Beyond the mommy track: The influence of new-concept part-time work for professional women on work and family. *Journal of family and economis issues, 25(1)*, 121-136.

Holly, E. (2014). Engineering Degrees Still not Appealing to Women. *Times Higher Education*.

Holmengaard, H. T.;Ulriksen, L.;& Möller Madsen , L. (2010). Why students choose (not) to study engineering. *Proceedings in SEFI Annual Conference* . . Trnava (Slovakia): SEFI European Society for Engineering Education.

Ibarra, H.;Carter, N. M.;& Silva, C. (2010). Why men still get more promotions than women. *Harward Business Review, 88(9)*, 80-126.

Jamieson, L. (2007). Engineering education in a changing world. *IEC DesignCon*. Chicago: International Engineering Consortium.

Jarvenpaa, S. (1991). Panning for gold in information systems research: second-hand data. *Information Systems Research: Contemporary Approaches and Emergent Traditions*, 63-80.

Jhon, G. J.;Hee, L. S.;& Lee, K. W. (2006). *Advancement of women in sciene and technology: a case study of Korea*. Ewha Womans University Press.

Johnson, B.;& Christensen, L. (2004). *Educational research: Quantitative, qualitative, and mixed approaches*. Sage.

Klawe, M.;& Leveson, N. (1995). Women in Computing: Where are we now? *Communications of the ACM, 38(1)*, 29-35.

Klawe, M.;Whitney, T.;& Simard, C. (2009). Women in computing---take 2. *Communications of the ACM, 52(2)*, 68-76.

Kray, L. J.;& Thompson, L. (2002). Reversing the gender gap in negotiations: An exploration of stereotype regeneration. *Organizational behavior and human decision processes, 87(2)*, 386-420.

Kray, L. J.;& Thompson, L. (2004). Gender stereotypes and negotiation performance: An examination of theory and research. *Research in organizational behavior*, 103-182.

Kray, L. J.;Galinsky, A. D.;& Thompson, L. (2002). Reversing the gender gap in negotiations: An exploration of stereotype regeneration. *Organizational Behavior and Human Decision Processes*, 87(2), 386-410.

Kray, L. J.;Thompson , L.;& Galinsky, A. (2001). Battle of sexes: gender stereotype confirmation and reactance in negotiations. *Journal of personality and social psychology*, 80(6), 1942.

Kuenzi, J. J. (2008). *Science, technology, engineering, and mathematics (stem) education: Background, federal policy, and legislative action*.

Kuenzi, J. J.;Matthews, C. M.;& Mangan, B. F. (2006). *Science, technology, engineering, and mathematics (STEM) education issues and legislative options*. Washington DC: Library of Congress Washington DC Congressional Research Service.

Kumpulainen, T. (2014). Opettajat Suomessa 2013 - Lärarna i Finland 2013. *Opettajat Suomessa 2013 - Lärarna i Finland 2013*. Finnish National Board of Education.

Leathwood, C. (2006). Gender, equity and the discourse of the independent learner in higher education. *Higher Education*, 611-633.

Lieblich, A.;Tuval-Mashiach, R.;& Zilber, T. (1998). *Narrative research: Reading, analysis and interpretation*. Sage.

Lincoln, Y.;& Guba, E. (1985). *Naturalistic inquiry* . Sage.

Lindsey, E. H.;& Homes, V. (1987). Key events in executives' lives. *Center for Creative Leadership*.

Liukas, L. (2015). *Rails Girls*. Retrieved 06 25, 2015, from Rails GIrls: http://railsgirls.com/

Loufti, M. F. (2001). *Women, Gender and Work: What Is Equality and How Do We Get There?* Washington DC: International Labour Office.

LUMA Centre at Aalto University. (2015). Retrieved 11 09, 2015, from LUMA Centre at Aalto University: http://luma.aalto.fi/en/

Maher, F.;& Tetreau, M. (1996). Women's ways of knowing in women's studies, feminist pedagogies, and feminist theory. *Knowledge, difference and power*, 148-174.

Margolis, J.;Fisher, A.;& Miller, F. (2000). The anatomy of interest: Women in undergraduate computer science. *Women's Studies Quarterly*, 104-127.

McAlpine, L.;Gandell, T.;Winer, L.;Gruzleski, J.;Mydlarski, L.;Nicell , J.;ym. (2005). A collective approach towards enhancing undergraduate engineering education . *European Journal of Engineering Education*, 377-384.

Meyerson, D. E.;& Fletcher, J. K. (2000). A modest manifesto for shattering the glass ceiling. *Harward Business Review, 78(1)*, 126-136.

Microsoft. (2015). *Kodu*. Haettu 09. 11 2015 osoitteesta Microsoft Research: http://research.microsoft.com/en-us/projects/kodu/

Miliszewska, L.;& Moore, A. (2010). Encouraging girls to consider a career in ICT: A review of strategies. *Journal of Information Technoloy Education, 9*.

Morrison, A. M.;White, R. P.;& Van Velsor, E. (1987). *Breaking the glass ceiling: Can women reach the top of Amerca's largest corporations?* Addison-Wesley.

Nelson, B. (2014). The Data on Diversity: It's not just about being fair. *Communications of the ACM, 57*(11), 86-95.

Newton, P. (1987). Who Becomes an Engineer? Social Psychological Antecedents of a Non-traditional Career Choice. *A Man's World: Essays on Women in Male-Dominated Professions*, 182-202.

Niederle, M.;& Vesterlund, L. (2011). Gender and competition. *Annu Rev. Econm 3(1)*, 601-630.

OECD. (2015). *Programme for International Student Assesment (PISA)*. Retrieved 06 25, 2015, from Programme for International Student Assesment (PISA): http://www.pisa.oecd.org/

Osborne, J.;& Dillon, J. (2008). *Science education in Europe: Critical reflections*. London: THe Nuffield Foundation.

Paloheimo, A.;Putila, P.;& Simpanen, P. (2010). Recruiting and Retaining Women in Electrical and Communications Engineering. *Proceedings in SEFI Annual Conference*. Trnava: SEFI European Society for Engineering Education.

Panteli, N. (2012). A community of practice view of intervention programmes: the case of women returning to IT. *Information Systems Journal, 22(5)*, 391-405.

Papastergiou, M. (2008). Are computer science and information technology still masculine fields? High school students' perceptions and career choices. *Computers & Education, 51(2)*, 594-608.

Parker, K. (2009). *The harried life of a working mother*. Washington: PewResearchCenter.

Putila, P. (2007). *Tinataan*. Retrieved 11 09, 2015, from Tinataan: http://tina.tkk.fi/

Reaktor. (2014). *Lasten koodikoulu*. Retrieved 11 09, 2015, from Lasten koodikoulu: http://koodikoulu.fi/

Rees, T. (2001). Mainstreaming gender equality in science in the European Union: The 'ETAN Report'. Gender and Education, 13(3), . *Gender and Education, 13(3)*, 243-260.

Rich, L.;Perry, H.;& Guzial, M. (2004). A CS1 course designed to address interests of women . *ACM SIGCSE Bulletin* , 190-194.

Roberts, E. S.;Kassianidou, M.;& Irani, L. (2002). Encouraging women in computer science. *ACM SIGSE Bulletin, 34(2)*, 84-88.

Rosser, S. V. (1995). *Teaching the Majority: Breaking the Gender Barrier in Science, Mathematics, and Engineering*. New York: Teachers College Press, Columbia University.

Ruicargia, A.;Felder, R. M.;Woods, D. R.;& Stice, J. E. (2000). The future of engineering education I. A vision for a new century. *Chemical Engineering Education, 34(1)*, 16-25.

Sagebiel , F.;& Dahmen, J. (2006). Masculinities in organizational cultures in engineering education in Europe: results of the European Union project WomEng. *European Journal of Engineering Education*, 31(01) 5-14.

Sanders, M. (2009). Stem, stem education, setemmmania. *Teh Technology Teacher, 69(4)*, 20-26.

Schultz, B. (2008). The importance of soft skills: Education beyond academic knowledge. *Journal of Language and Communication*.

Schwandt, T. (2007). *The Sage dictionary of qualitative inquiry*. Sage.

Seymour, E. (1995). The loss of women from science, mathematics, and engineering undergraduate majors: An explanatory account. *Science Education, 79(4)*.

Seymour, E. (1999). The role of socialization in shaping the career-related choices of undergraduate women in science, mathematics, and engineering majors. *Annals of the New York Acadey of Sciences, 869(1)*, 118-126.

Seymour, E. (2002). Tracking the processes of change in US undergraduate education in science, mathematics, engineering, and technology. *Science Education, 86(1)*, 79-105.

Seymour, E.;& Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.

Shafer, E. F. (2011). Wives' Relative Wages, Husbands' Paid Work Hours, and Wives' Labor-Force Exit. *Journal of Marriage and Family, 73(1)*, 250-263.

Sidle, S. D. (2011). Career Track or Mommy Track: How Do Women Decide? *The Academy of Management Perspectives, 25(2)*, 77-79.

Spencer, S. J.;Steele, C. M.;& Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of experimental social psychology, 35(1)*, 4-28.

Stewart, D.;& Shamsadani, P. (2006). *Focus groups. Theory and practice* . Sage Publications.

Stevens, C. K.;Bavetta, A. G.;& Kahn, L. M. (1993). Gender differences in the acquisition of salary negotiation skills: the role of goals, self-efficacy, and perceived control. *Journal of Applied Psychology 78(5)*, 723.

Stone, P.;& Lovejoy, M. (2004). Fast-track women and the “choice” to stay home. *Tne annals of the american academy of political and social science, 596(2)*, 62-84.

Stuhlmacher, A. F.;& Walters, A. E. (1999). Gender differences in negotiation outcome: A meta-analysis. *Personnel psychology, 52(3)*, 653-677.

Sutter, M.;& Rützler, D. (2010). Gender differences in competition emerge early in life. *Working Papers in Economics and Statistics*, 2010-14.

Tonso, K. L. (1996). The Impact of Cultural Norms on Women. *Journal of Engineering education 85(3)*, 217-225.

Tonso, K. L. (2006). Teams that work: Campus culture, engineer identity, and social interactions. *Journal of engineering education 95(1)*, 25-37.

Weimer, M. (2002). *Learner-centered teaching: Five key changes to practice*. John Wiley & Sons.

Williams, C. (1992). The glass escalator: Hidden advantages for men in the "female" professions. *Social problems*, 253-267.

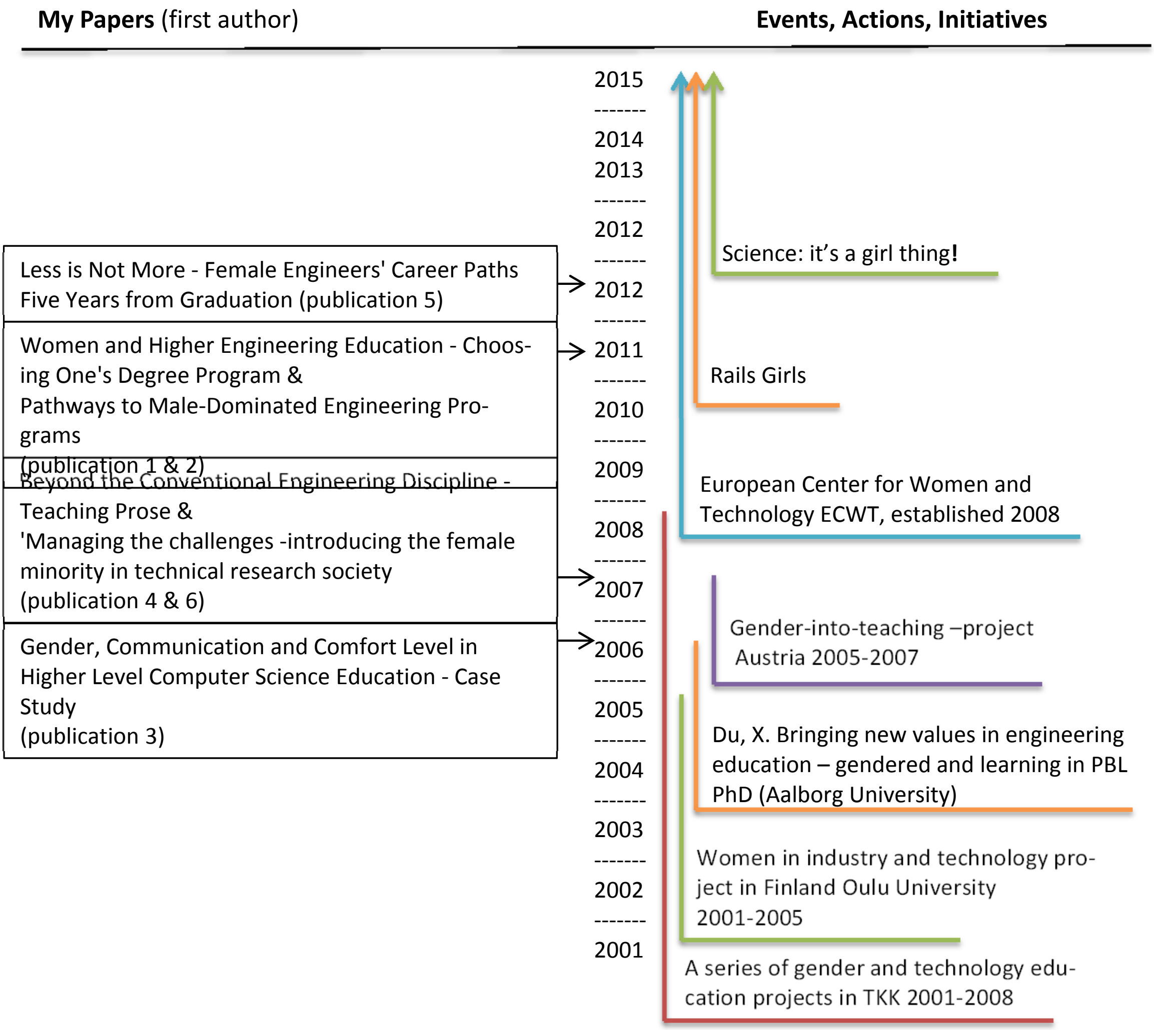
Wolfe, J.;& Powell, E. (2009). Biases in interpersonal communication: How engineering students perceive gender typical speech acts in teamwork. *Journal of Engineering Education, 98(1)*, 5-16.

Yurtseven, H. (2002). How does the image of engineering affect student recruitment and retention? A perspective from the USA. *Global Journal of Engineering Education, 6(1)*, 17-23.

APPENDIX A

Timeline: My Research vs. Other Projects

Timeline:
My Research vs. Other Projects



APPENDIX B

Course Feedback Form (translated from Finnish)

TKK / Department of Electrical and Communications Engineering

COURSE FEEDBACK FORM

Dear student! By means of this questionnaire we aim to develop courses. You feedback matters.
Course code and name _____________________________________Date_________
Study program____________Participation in course (0-100%): lectures_____exercises

Course evaluation (circle the best alternative)

1. Did the workload match the study credits?
   too much work (1) (2) (3) (4) (5) too little work

2. Evaluate course material

text book	poor (1) (2) (3) (4) (5) very good
lecture slides	poor (1) (2) (3) (4) (5) very good
other material	poor (1) (2) (3) (4) (5) very good

3. . Your overall assessment of the course poor (1) (2) (3) (4) (5) very good

Course personnel evaluation (This part of questionnaire is used as basis for teacher's salary bonus.)

		not applicable
Lecturer		
____	poor (1) (2) (3) (4) (5) very good	(E)
Assistant		
____	poor (1) (2) (3) (4) (5) very good	(E)
____	poor (1) (2) (3) (4) (5) very good	(E)
____	poor (1) (2) (3) (4) (5) very good	(E)
____	poor (1) (2) (3) (4) (5) very good	(E)

Course development
Did you learn in this course? Was there something that discouraged your learning process? Were you active on the course? What would you like to change in this course? How would you like to further develop the course?

You can return this form either in the examination or to student counselling mail box.
Thank you for your answers!

APPENDIX C

Student Survey (translated from Finnish)

Student Survey: Computer as a Tool -course

Exercise group:
No. of exercise:

Please circle the most appropriate alternative:

1 female
2 male

Evaluate the level of difficulty of the assingments in this exercise:

1 far too easy
2 pretty easy
3 appropriate level
4 pretty dificult
5 far to difficult

Did you ask assistant for help:

1 no, because a I did not need assistance.
b The assistant was too busy.
c I did not dare or have the nerve to ask.
d Something else, please specify.

2 yes What did you ask?

Did you ask other students for help?

1 no
2 yes What did you ask??

How many exercises did you accomplish? (number of last accomplished exercise)

If this exercise was not the first exercise, evaluate:
Was this exercise
better
worse
similar
than the earlier exercises.

Other additional feedback:

APPENDIX D

A Questionnaire of Literature Course (translated from Finnish)

A questionnaire of literature course – We hope to see your answer soon

Hi.

You have participated in our literature course. I hope you can quickly answer a few questions concerning the course. I research the long long-term significance of the course in TKK's course palette. The number of students in this course is small, so each answer counts. (You can also answer only part of the questions.)

1. Elaborate on your reasons for participating in this course. In case you participated more than once, what were the grounds for the re-run?
2. In a longer temporal perspective, what were the best features on the course? (Ideas, thoughts, high spirits, literacy awareness, motivation toward studies, joy of life, etc.).
3. Do you consider it likely that you will contact other students from the course later on? In what kind of situations? (For example, work or leisure-related common interests?)
4. Have you contacted the other students from the course? For what reason?
5. Draw freely from your stream-of-consciousness as to how your life has been after the course. How do you consider yourself as a person and a student? What are your plans for the future?

Our course of literature is uncharacteristic compared to other teachings in TKK. I aim to find out how the course participants have experienced the course and what they consider to be the course's benefits to them afterwards. I am also interested in what kind of students the course best serves.

The answers are studied confidentially. The respondent's personal data will not be used, and one will not be able to conclude a person's answers from the research results.

If this questionnaire begs any questions, I will be happy to answer. If you want to share other thoughts of this course or any other business, do not hesitate to write in a stream-of-consciousness manner.

Best regards,

Aura Paloheimo

Aura.paloheimo@tkk.fi

09-451 4850 / 040-079 4311

APPENDIX E

Career and Employment Survey for Graduates of 2005
Helsinki University of Technology

Career and employment survey
for Graduates of 2005
Helsinki University of Technology

Answer the questions by circling/marking with a cross the most accurate alternative or write your answer in the space provided.

You can also answer the Online survey at www.aarresaari.net/uraseuranta/english.htm **by using the identification number marked in the upper right corner of this form.**

EDUCATION AND WORK HISTORY

1. Municipality of residence before university studies:

____

2. Have you participated in any education after you completed your degree in 2005?

Please choose the appropriate alternatives.

1 I have participated in education organised or paid by my employer.
2 I have participated in labour market training.
3 I have participated in / completed professional specialisation studies, upgrading of qualifications, etc., please specify:____
____

4 I have completed studies and aim at completing another academic degree, please specify the field of study and the estimated year of graduation:________________________
____

5 I have completed scientific/artistic postgraduate studies, please specify the field of study and the year of graduation, if applicable:_______________________________________
____
____

6 I have completed other education or degree, please specify:____
____
____

7 I have not participated in education.

3. If you chose the alternatives 4 or 5 in the previous question, please state the most important reason for completing another academic or postgraduate degree?

____
____

4. How long have you been employed after your graduation?

____ years _____ months,
of which ___ years ____ months in an employment that corresponds to the level of my education.

5. How many employers have you had after your graduation (the present employer included)**?** _____ employers

6. How many employment / public service employment relationships have you had after your graduation (consider each fixed-term employment as a separate employment relationship)**?**
_____ employment / public service employment relationships

7. After your graduation, have you

a) performed as an independent entrepreneur / self-employed person / freelancer?

1 No 2 Yes, ____ years ___ months

b) been absent from working life due to family leaves?

1 No 2 Yes, ____ years ___ months

8. Have you been unemployed after your graduation?

1 I have not been unemployed.
2 Yes, ___ times, in total ___ years ___ months.

9. If you have had difficulties to find employment after your graduation, please assess how much the following factors have contributed to your situation:

Please circle the most appropriate alternative:

1 = not at all, 2 = only a little, 3 = somewhat,
4 = rather much, 5 = much, 6 = very much

1 Lack of work experience	1	2	3	4	5	6
2 Inadequate job-hunting skills	1	2	3	4	5	6
3 Lack of contact networks	1	2	3	4	5	6
4 My degree and its subject combination	1	2	3	4	5	6

5 My degree is not well-known	1	2	3	4	5	6
6 Poor situation in the labour market in the field of my studies	1	2	3	4	5	6
7 Regional labour market situation	1	2	3	4	5	6
8 Periods of unemployment between fixed-term employment relationships	1	2	3	4	5	6
9 Inadequate knowledge of working life	1	2	3	4	5	6
10 Unawareness of personal goals	1	2	3	4	5	6
11 Uncertainty of personal skills	1	2	3	4	5	6
12 I have not found a job that would interest me	1	2	3	4	5	6
13 Gender	1	2	3	4	5	6
14 A reason relating to the family or personal situation	1	2	3	4	5	6
15 Time of my graduation	1	2	3	4	5	6
16 Inadequate skills in Finnish	1	2	3	4	5	6
17 Something else, please specify:	1	2	3	4	5	6

SITUATION AT THE TIME OF GRADUATION

10. Which of the following definitions describes your situation most accurately at the time of graduation?

1 Employed
2 Unemployed
3 Full-time studies (a study block or studies leading to a degree)
4 Family leave (maternity / paternity / parental / child care leave)
5 Working with a grant
6 Something else, please specify:

____

11. If you were not employed at the time of your graduation, how long did it take before you started in your first job after graduating?

I started my first job ___ years ___ months after I graduated.

FIRST JOB AFTER GRADUATION

The following questions (12-20) concern your first job after you completed your degree in 2005. You may have started in the job before you graduated.

12. Of what type was the employment relationship in your first job?

1 Permanent full-time job
2 Temporary full-time job
3 Part-time job, ___ hours / week
4 Independent entrepreneur / self-employed person / freelancer
5 Employment by subsidies / training

13. Who was your first principal employer?

1 Private enterprise or a government-owned corporation (e.g. Itella Corporation, Yle), at least 250 employees.
2 Private enterprise or a government-owned corporation, 50-249 employees.
3 Private enterprise or a government-owned corporation, less than 50 employees.
4 Municipality, federation of municipalities, municipal enterprise (e.g. Hospital District)
5 Polytechnic
6 Government, unincorporated government enterprise
7 University
8 Association, congregation, foundation, or the like; institution or community governed by public law (e.g. Finnish Centre for Pensions, Finnish Institute of Occupational Health, Social Insurance Institution of Finland, or Bank of Finland)
9 Personal enterprise, practice, or business name etc.
10 Something else, please specify:

____

14. Which city or town was your first job located in?

____

15. Which of the following describes best the nature of your work in your first principal job?
You may choose more than one alternative.

1 Research
2 Education or teaching
3 Leadership or managerial duties
4 Consulting or training
5 Customer service / patient work
6 Marketing and sales
7 Planning, development, or administrative tasks
8 Communications and media

9 Office and staff tasks
10 Artistic work
11 Legal work
12 Religious work
13 Financing and economic management
14 Something else, please specify:

____

16. Which of the alternatives in question 15 describes your main duties/tasks most accurately?
Please choose only one alternative _______

17. What was your occupational title or job title in your first job?

____

18. Was the higher academic degree you completed 2005 a requirement for your first job?

1 No 2 Yes 3 I don't know

19. How well were you able to make use of the skills you learned during your university studies in your first job?

1 I wasn't able to make use of them almost at all.
2 I made use of them to some degree / partially.
3 I made use of them constantly.

20. How well did your first job correspond to the level of your education?

1 My job was clearly not as demanding as my level of education would have provided.
2 My job was partially less demanding than my level of education would have provided.
3 My job corresponded well to the level of my education.
4 My job was more demanding than my education would have provided.

YOUR SITUATION AT THE MOMENT

21. Which of the following definitions describes your situation most accurately at the moment?

1 Permanent full-time job
2 Temporary full-time job
3 Part-time job, ___ hours / week
4 Independent entrepreneur / self-employed person / freelancer
5 Employment by subsidies / training
6 Unemployed, my last employment ended (month/year) ___/___
7 Labour market training or the like
8 Full-time studies (a study block or studies leading to a degree)
9 Family leave (maternity / paternity / parental / child care leave)
10 Working with a grant
11 Something else, please specify:

____

Please answer the following questions based on your ***CURRENT PRINCIPAL EMPLOYMENT****.* ***If you are on family or study leave,*** *please answer on the basis of the job you are on leave from.* ***If you are an independent entrepreneur, a self-employed person, or a freelancer,*** *please answer to the applicable questions.* ***If you are not employed at the moment, or when for example your family leave began,*** *please move on to question 37.*

22. Who is your principal employer?

1 Private enterprise or a government-owned corporation (e.g. Itella Corporation, Yle), at least 250 employees.
2 Private enterprise or a government-owned corporation, 50-249 employees.
3 Private enterprise or a government-owned corporation, less than 50 employees.
(More alternatives on the next page)

4 Municipality, federation of municipalities, municipal enterprise (e.g. Hospital District)
5 Polytechnic
6 Government, unincorporated government enterprise
7 University
8 Association, congregation, foundation, or the like; institution or community governed by public law (e.g. Finnish Centre for Pensions, Finnish Institute of Occupational Health, Social Insurance Institution of Finland, or Bank of Finland)
9 Personal enterprise, reception, or business name etc.
10 Something else, please specify:

____

23. Name of employer *(optional information)*
The name of the employer can be used in career guidance as a concrete example of employers in a certain field.

____

24. Which city or town is your job located in?

____

25. Which of the following definitions best describes your principal employment at the moment?
You may choose more than one alternative.

1 Research
2 Education or teaching
3 Leadership or managerial duties
4 Consulting or training

5 Customer service / patient work
6 Marketing and sales
7 Planning, development, or administrative tasks
8 Communications and media
9 Office and staff tasks
10 Artistic work
11 Legal work
12 Religious work
13 Financing and economic management
14 Something else, please specify:

____

26. Which of the alternatives in question 25 describes best your main duties/tasks most accurately?

Please choose only one alternative _______

27. What is your occupational title or job title?

____

28. Is the higher academic degree you completed 2005 a requirement for your current job?

1 No 2 Yes 3 I don't know

29. How well are you able to make use of the skills you learned during your university studies in your current job?

1 I'm not able to make use of them almost at all.
2 I make use of them to some degree / partially.
3 I make use of them constantly.

30. How well does your current job correspond to the level of your education?

1 My job is clearly not as demanding as my level of education would provide.
2 My job is partially less demanding than my level of education would provide.
3 My job corresponds to the level of my education well.
4 My job is more demanding than my education would provide.

31. If your current job does not correspond to the level of your education, what was the most important reason for accepting the job? *Please choose one alternative.*

1 I'm continuing in a job I had before I graduated.
2 I haven't been able to find a job that would correspond to the level of my education.
3 My current job is more interesting than a job that would correspond to the level of my education.
4 The wages and/or terms of employment are better in my current job than in a job that would correspond to the level of my education.
5 Education I have acquired elsewhere has led me to my current job.
6 I have chosen not to get a job that would correspond to my education.
7 Some other reason, please specify:

____

32. How much is or was your gross salary in September 2010, regular allowances, tax value of benefits in kind, and overtime pays included? *If you are an independent entrepreneur, a self-employed person, or a freelancer, please report your average monthly income.*

___________ euros / month

33. Assess the job satisfaction in your current job based on the following statements: *Please circle the most appropriate alternative:*

1 = I completely disagree, 2 = I disagree, 3 = I somewhat disagree, 4 = I somewhat agree, 5 = I agree, 6 = I completely agree

1 My job is interesting.	1	2	3	4	5	6
2 My job enables me to advance in my career.	1	2	3	4	5	6
3 My job makes it possible to develop my skills.	1	2	3	4	5	6
4 My tasks are versatile.	1	2	3	4	5	6
5 My work is independent and I have responsibilities.	1	2	3	4	5	6
6 My job provides me with sufficient challenges.	1	2	3	4	5	6
7 My job is mentally too demanding.	1	2	3	4	5	6
8 I have too much work to do.	1	2	3	4	5	6
9 The continuity of my employment relationship is uncertain.	1	2	3	4	5	6
10 I'm able to balance between my job and other areas of life.	1	2	3	4	5	6
11 I have the career I planned for.	1	2	3	4	5	6

If you have a fixed-term employment or public service employment relationship at the moment, please answer the questions 34-36. If not, please move on to question 37.

34. What is the primary reason for your employment relationship or public service employment relationship being for a fixed-term? *Please choose one alternative.*

1 The nature of the work (e.g. project or seasonal work).
2 Temporary post.
3 Management of an open post / position.
4 Employer has not wanted to make the job permanent.
5 The post is for a fixed-term on my initiative.
6 I don't know the reason for my post being for a fixed-term.
7 Something else, please specify:

____

35. For which period of time is your current fixed-term employment relationship or public service employment relationship made?

For ____ years ___ months

36. Have you had several fixed-term employments or public service employment relationships with the same employer after your graduation?

1 No
2 Yes, the number of employment relationships: ________

SIGNIFICANCE OF UNIVERSITY EDUCATION

37. How satisfied are you with the degree you completed in 2005 in relation to your career?
Please circle the most appropriate alternative:

1 = extremely dissatisfied
2 = dissatisfied
3 = somewhat dissatisfied
4 = somewhat satisfied
5 = satisfied
6 = extremely satisfied

Please explain why:

____
____
____
____
____

38. How important are the following skills and know-how in your current job? How well did university studies develop the working life skills in question? *If you are not employed at the moment, please assess on the basis of your last employment. Please circle the most appropriate alternative.*

		How important are these skills and know-how in your current job? 1= not important at all, 2= only slightly important, 3 = somewhat important, 4 = rather important, 5 = important, 6 = extremely important	***How well did university studies develop these working life skills?*** 1 = extremely inadequately, 2 = inadequately, 3 = somewhat inadequately, 4 = rather well, 5 = well, 6 = very well
1	Theoretical skills from the field of study	1 2 3 4 5 6	1 2 3 4 5 6
2	Analytical, systematic thinking skills	1 2 3 4 5 6	1 2 3 4 5 6
3	Information acquisition skills	1 2 3 4 5 6	1 2 3 4 5 6
4	Problem solving skills	1 2 3 4 5 6	1 2 3 4 5 6
5	Team work skills and social skills	1 2 3 4 5 6	1 2 3 4 5 6
6	Negotiation skills	1 2 3 4 5 6	1 2 3 4 5 6
7	Organisation and coordinating skills	1 2 3 4 5 6	1 2 3 4 5 6
8	Managerial skills	1 2 3 4 5 6	1 2 3 4 5 6
9	Project management skills	1 2 3 4 5 6	1 2 3 4 5 6
10	Knowledge of legislation	1 2 3 4 5 6	1 2 3 4 5 6
11	Finance planning and budgeting	1 2 3 4 5 6	1 2 3 4 5 6
12	Knowledge of basics of business operations	1 2 3 4 5 6	1 2 3 4 5 6
13	IT and communication technology skills	1 2 3 4 5 6	1 2 3 4 5 6
14	Communication skills in Finnish	1 2 3 4 5 6	1 2 3 4 5 6
15	Communication skills in Swedish	1 2 3 4 5 6	1 2 3 4 5 6
16	Communication skills in English	1 2 3 4 5 6	1 2 3 4 5 6
17	Communication skills in other languages, please specify:________________________	1 2 3 4 5 6	1 2 3 4 5 6
18	Ability as a public performer	1 2 3 4 5 6	1 2 3 4 5 6
19	Teaching, educating and guidance skills	1 2 3 4 5 6	1 2 3 4 5 6

Thank you for your answers! Here you can give additional information. You may also comment on the questionnaire.

____

APPENDIX F

A User Survey for Web-Community for Women: Theme Interview

A User Survey for Web-Community for Women: Theme Interview

Working life

1. Tell about your duties at work. What is your job description?
2. What are the best parts of your job? What are the nasties?
3. What are you work responsibilities?
4. What kind of skills your job requires? (For example interaction skills, research skills, leading skills, teaching?)
5. What tools (programs, equipment) you use? How do you communicate with others?
6. Describe your work community (superior, colleagues, team members)
7. Is your work community male dominated? If it is, tell how it feels to work with your male colleagues.
8. Who do you work with (alone, in a team)? Are your close co-workers men or women?
9. Support: do you get support for your work? From whom you get support for your work? What kind of support (concrete, spiritual?) Would you need more support? From whom? What kinds of support do you long for more?
10. What is your work network? For example in what kind of societies/web societies you belong to?
11. What kind of problems/conflicts you face in your work? How you solve them?
12. Do you want to add something concerning your job?

Family and leisure

1. Tell about your current situation in life (spouse, children).
2. Everyday routines (hobbies, who picks up the children, household work, etc.) Problems?
3. How well you manage to balance work and family? Problems?
4. What kind of support you would like to your everyday routines? (For example child bringing, childcare).
5. Where do you get support for everyday routines? What kind of support?
6. How does the fluency of everyday routines affect your work success?
7. Are you a member of community/web community in your spare time? What kind?
8. Do you have time for yourself? What do you do in your spare time (alone, with family/friends)?
9. What do you wish for your future (work/family)?
10. Do you find yourself in the right professional field?

Aalto-DD 180/2015

ISBN 978-952-60-6503-8 (printed)
ISBN 978-952-60-6504-5 (pdf)
ISSN-L 1799-4934
ISSN 1799-4934 (printed)
ISSN 1799-4942 (pdf)

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