UNDERREPRESENTATION OF WOMEN IN HIGHER TECHNOLOGY EDUCATION

Lappeenranta–Lahti University of Technology LUT

Master's Degree Programme in Software Product Management and Business

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ABSTRACT

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Underrepresentation of Women in higher Technology education

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Keywords: Gender equality, Women in Tech, WITECH, SLR

Women are underrepresented in technological field in higher education, even though generally more women than men are entering higher education in Finland. This study tries to find the factors which have influenced women to enter technological field studies in higher education. First a systematic literature review is done to find out what has been studied already about gender equality in technological field studies and what needs to be studied more. Missing points which have been found through the literature review are studied more through a survey. Survey is targeted to men and women who have been studying or are currently studying in technological field in higher education.

Systematic literature review revealed that there are several factors which have an impact on women to enter technological field studies. Survey results confirmed that women had more doubts than men in their capability in technology related studies in secondary education, but majority of respondents (both men and women) had experienced support when having these doubts from their parents, family or teachers. In several articles from systematic literature review teachers and schools support and encouragement were seen as an important tool to improve women's self-confidence in technology but survey revealed that women entered technological field studies in higher education were lacking the experience of teachers or schools support in technology related studies. Survey results revealed also that compared to women men had more often background from vocational school.

TIIVISTELMÄ

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Naiset vähemmistössä tekniikan alan korkeakouluopinnoissa

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Avainsanat: Tasa-arvo, Tekniikan naiset, WITECH, Kirjallisuuskatsaus

Naiset ovat aliedustettuina tekniikan alan korkeakoulu opinnoissa, vaikka naisia on yleisesti enemmän korkeakouluopiskelijoina. Tässä tutkimuksessa pyritään löytämään tekijöitä, jotka ovat vaikuttaneet naisten hakeutumiseen tekniikan alaan korkeakouluopintoihin. Ensin tehdään systemaattinen kirjallisuuskatsaus, jossa selvitetään, mitä sukupuolten tasa-arvosta on jo tutkittu tekniikan alan tutkimuksissa ja mitä pitää vielä tutkia. Kirjallisuuskatsauksen kautta löydettyjä puuttuvia kohtia tutkitaan enemmän kyselyn avulla. Kysely on suunnattu miehille ja naisille, jotka ovat opiskelleet tai opiskelevat parhaillaan tekniikan alalla korkeakouluissa.

Systemaattinen kirjallisuuskatsaus paljasti, että on olemassa useita tekijöitä, jotka vaikuttavat siihen, että naiset ovat päätyneet tekniikan alan opiskeluihin. Tutkimustulokset vahvistivat, että naiset epäilivät miehiä enemmän kykyjään tekniikan alan opinnoissa toisen asteen koulutuksessa, mutta suurin osa vastaajista (sekä miehissä että naisissa) olivat kokeneet tukea vanhemmiltaan, perheeltään tai opettajiltaan. Useissa systemaattisen kirjallisuuskatsauksen artikkeleissa opettajien ja koulujen tuki ja rohkaisu nähtiin tärkeänä työkaluna parantaa naisten itseluottamusta tekniikan alalla, mutta kysely osoitti, että korkeakouluissa tekniikan alan opintoja suorittavilta naisilta puuttui kokemusta opettajien tai koulujen teknologian tuesta. Tutkimustulokset paljastivat myös, että naisiin verrattuna miehillä oli useammin ammattikoulutausta.

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SYMBOLS AND ABBREVIATIONS

Abbreviations

SLR	Systematic Literature Review
STEM	Science Technology Engineering Mathematics
ICT	Information and Communication Technology
OECD	Organisation for Economic Co-operation and Development
AI	Artificial Intelligence

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1 Introduction

Within the next 10 years 130 000 new experts are needed in technology industry in Finland, from which 60 percentage is expected to have a higher degree in technology. Need for the workforce is created through growth in the sector and retiring of experts. (Technology Industries Finland 2021) Additionally to the lack of workforce, technology industry is suffering from gender inequality - only fifth of technology industries workers in Finland are women (Hautala 2020). Benefits of narrowing the gender gap in technology industry are enrichment of the industry through diversity in labour and narrowing the salary gap between women and men when more women would enter better paid careers (Rämö 2021). By introducing more women to the technology field, it would be possible to answer to the need of new workforce and promote gender equality in the industry.

Underrepresentation of women in technology field in Finland is visible already in higher education where majority are men, even though there are more women generally in higher education (Keski-Petäjä and Witting 2018). Engineering and Information and Communication Technology (ICT) studies in higher education are dominated by men in Organisation for Economic Co-operation and Development (OECD) countries and the gap between men and women entering higher education in engineering or ICT has been stable from year 2013 to 2019 (OECD 2021 188). In lower education percentage of girls having their strength in technology supporting subjects e.g. science or mathematics is higher than the percentage of women graduating from Science, Technology, Engineering or Mathematics (STEM) in higher education (Stoet and Geary 2018 10). How could this leak of potential future STEM experts be stopped or at least reduced?

In this study the aim is to find the factors which have influenced the interest of women to study in the field of Technology in higher education and how those factors are different to men. Research questions to be answered are:

RQ1: What factors have influenced women to study in the field of Technology in higher education?

RQ1.1: How are factors which have influenced women different to factors which have influenced men to study in the field of Technology in higher education?

First a Systematic Literature Review (SLR) is done to find out what kind of research has been already done and what kind of literature exists around the topic. SLR results are analysed and, based on what kind of viewpoints are missing a survey is created to answer the research questions.

2 Related studies

As told in the introduction Technology Industries Finland has pointed in their study that there is a need for workforce in technology industry now and in the future (Technology Industries Finland 2021). The Finnish ministry of economic affairs and employment confirms this shortage in labour in the software industry (Ek 2020, 24-25). One reason for the future need of workforce in the software industry is presented by the Finnish Software and E-business Association with their study which revealed that 85 % of software companies in Finland were looking up for economic growth in the future, study was done in year 2021 (Roiha 2021). Even though it is verified by several organisations that there is a need for more workforce to software industry in Finland there hasn't been done much research about how to get more experts into the software industry. What can be found, published after 2018, are research about what prevents Finnish women to enter software engineering roles (Wolff, Knutas and Savolainen 2020, 1) and research about how to attract more women to the sofware industry (Hyrynsalmi, S. M., Hyrynsalmi, S. 2019a, 1) or what motivates them to make a career change in adult age to software engineering industry (Hyrynsalmi, S. M., Hyrynsalmi, S. 2019b, 1). Globally there has been done several research about how Artificial Intelligence (AI) developed mainly by men is adding discrimination to the society and how gender diversity teams are improving software development. In this chapter we will go shortly through those studies and their key findings.

2.1 Women and software engineering careers

Wolff, Knutas and Savolainen (2020) studied Finnish women who were interested to enter software engineering roles and what prevented them to do so. Research found out that even Finland is one of the most gender equal countries, gender stereotyping is still very high. Children are raised with the ideology that they can select freely their career but when growing up and choosing a career in a field not typical to their gender they will experience negative impacts of stereotyping. By breaking these stereotypes through media, software industry would be able to attract more women into the field. (Wolff et al. 2020, 8)

Hyrynsalmi S. M. and Hyrynsalmi, S. (2019a, 1) studied Finnish women who had made or were about to make a career change to software industry. Women experienced software industry as attractive but it seemed that there was overabundance in study offerings and the level of study offerings were very basic, more advanced training was missing. Advanced level training was found to be provided by universities, but these trainings required full time commitment which is difficult to arrange for people already in working life. To introduce more people into the software industry there is a need for flexible advanced training related to software engineering for those who have already a degree or who have previous work experience. (Hyrynsalmi et al. 2019a, 2)

What motivates women to make a career change into software industry according to Hyrynsalmi et al. (2019b) were equal salary, flexibility and meaningfulness of the work climate, career opportunities and how they benefit from having already some work experience. Additionally, the need for new workers and new positions created into the software industry had a positive impact in software industry's attractiveness. (Hyrynsalmi et al. 2019b, 7)

There has been already lot of work done to get more women into software industry, but women are still doubting to change into male-dominant field. Each woman entering the software industry can be seen as a role model, which are needed to change the industry to more attractive to women. (Hyrynsalmi 2019, 4)

2.2 Impact of gender equality in software engineering

Previous studies show that working towards a more gender equal world is not the only motivation to get more women to the field of software engineering. There were two main reasons why to improve gender equality in software industry which were pointed out in previous studies. First reason is that AI developed mainly by men can be discriminative (Zuiderveen Borgesius 2018, 5) and secondly as software development is teamwork it would

benefit from more diversity development teams (Ortu, Destefanis, Counsell, Swift, Tonelli and Marchesi 2017, 1).

AI is undoing decade of work done to improve gender equality. Machine learning applications are mainly developed by men and if the data provided to AI is stereotypical, the decisions made by AI will be stereotypical as well. (Leavy 2018, 14)

Zuiderveen Borgesius (2018, 10-14) introduces in his study following ways of how AI can be discriminative:

- Data used in AI is labelled by humans and these labels can lead to discrimination. As an example, Zuiderveen Borgesius wrote about AI for sorting employees based on label "rarely being late often". This example was setting employees in an unequal situation because those employees who have a longer distance to work are more likely to be late and that employees with immigrant background might live wider away from the office. (Zuiderveen Borgesius 2018, 11-12)
- Training data for AI might be biased for two reasons: training data is historical data, which can be biased or data collecting procedure is biased causing biased data for AI. AI reflects and reproduces discriminate decisions if the data provided to it is biased. (Zuiderveen Borgesius 2018, 11-12)
- Organisations need to decide what kind of attributes they are looking for in the AI systems, which might lead to discrimination if attributes selected lead to preferring some specific group e.g., humans based on gender or ethnical background. (Zuiderveen Borgesius 2018, 12)
- Data provided to AI might also include protected characteristics, characteristics which cannot be seen when decisions are made by e.g., human gender or ethnical background of people living in a certain neighbourhood. (Zuiderveen Borgesius 2018, 13)

- Discrimination with AI can be also intentional by using protected characteristics which are well known for decision making in AI, well known by the organisation developing its AI system. It is harder to detect organisations discrimination if it is done with AI than if organisation openly discriminates. (Zuiderveen Borgesius 2018, 13-14)

And how does AI discrimination relate to getting more women into software industry? According to Leavy (2018, 14) women are more likely to recognize gender discrimination done by AI, which is one more reason why more women are needed in software development.

Another reason why to introduce more women into software industry is the nature of software development. Software development is mainly teamwork and more gender diversity software developing teams are more productive (Ortu et al. 2017, 15). The same conclusion is made by Russo and Stol (2022, 830) who studied the personality traits of women and men and how they differ. According to Russo and Stol (2022, 830) personality traits which affect the way of working, work performance and teamworking of women and men software engineers differ from each other. Software development teams' performance is better if it includes both genders as both men and women have negative and positive personality traits related to teamwork. (Russo and Stol 2022, 830) Women engineers honesty-humidity trait score was higher than the score of men. Honesty-humidity trait is related to higher work performance as an individual and as a team member. Additionally, emotionality trait score of women was higher than the score of men, which can be seen as a negative personality trait as it is decreasing teams' viability. Psychopathy trait is compensating negative and positive personality traits between men and women as men engineers are scoring higher in this trait. Members with high scores in psychopathy are decreasing team's innovativeness, creativity and commitment. (Russo and Stol 2022, 829-830)

In a summary software industry in Finland is facing shortage in labour and getting more women to the industry might be one solution or at least a relief for this problem. There are

women who are interested in entering software industry and work needs to be done get more of those women into software engineering careers. Additionally to the shortage in labour in software industry, reasons for introducing more women into the industry are that software developed by mainly men can be discriminative and productivity of software development could be raised by more gender equal development teams.

3 Research process

Research is done in two phases. In the first phase what kind of literature exists already about gender equality in technology education is researched with SLR. SLR results will be analysed to find missing viewpoints about the topic. In the second phase a survey is created, questions of the survey are done based on SLR analysis.

3.1 Systematic literature review

SLR is done according to Kitchenhams guide to conduct systematic literature review in software engineering. SLR is done to find out what needs to be further investigated about a certain theme by searching systematically through available literature. Systematic means that the review process is conducted and documented so that it is repeatable. (Kitchenham and Charters 2007, 13) In the following search strategy, exclusion criteria, data extraction forms and analysis as review protocol steps are introduced and explained.

Search strategy needs to be determined and followed. Strategy includes information where literature is searched and with which criteria. (Kitchenham et al. 2007, 14-16) In this SLR literature is searched from Google Scholar starting from year 2012. Literature is searched based on the title. Title should contain words technology, education and at least one of the following words: women, gender, equality or gap. Following search string is used: “allintitle: technology education women OR gender OR equality OR gap”.

3.1.1 Study selection criteria

Study selection criteria which include including and excluding criteria is meant to be used for identifying only those studies which provide direct information about the research question. (Kitchenham et al. 2007, 18-19) In this SLR five reasons to exclude literature from the review were used:

- Literature written in other language than English.
- Literature is not available for free.
- Literature is not peer-reviewed.
- Research in the literature has been conducted outside of Europe.
- Literature is not related to gender equality in technology education.

3.1.2 Data extraction forms and analysis

Data extraction forms are used for collecting all necessary information of founded literature to answer the research question (Kitchenham et al. 2007, 29). In this research data is extracted from the literature in two phases. In the first phase general information of each article is collected. General information is used for finding out what kind of research has been already done around the research theme, in which countries, when, with which topics and from which target groups. Following general information from each article will be collected:

- Publishing year
- Country
- Article topic
- Research question
- Target group of the research

In the second phase of data extraction similarities and discrepancy between articles key findings or conclusion are detected. List of key themes is created and from those a table is created which contains information about how many articles support each of them. Themes are analysed by going through what kind of findings are given from different articles.

Through the analysis missing viewpoints are explored and those are documented so that they can be answered through the survey.

3.1.3 Deviation

After conducting the search protocol and having less than 10 articles it was decided that also references from the literature selected to the review are reviewed. From references literatures are selected which are mentioned in more than one reviewed literature and which fill the same inclusion and exclusion criteria as for the articles selected from the search results.

3.2 Survey

Through SLR is found out what is already known and what kind of gaps there are about certain topic, which can then be used as the objective in a survey (Fink 2003, 11). In this research the survey will be a self-administered questionnaire which can be answered by respondents themselves online (Fink 2003, 22).

Survey is created on Webropol platform. Questions are created so that the survey is easy to fill minimizing the risk that respondent won't interrupt answering. Things which might cause interrupting are that survey is too time consuming or questions need too much effort to answer.

Survey is shared through universities connections to organizations who are working on getting more women into technology industry in Finland and through researcher's connections through LinkedIn.

3.2.1 Target group

Target group of the survey are women and men who have experience in higher education in engineering, technology or science. With experience is meant that respondents should have been studying or currently studying in some of those fields in university or in university of applied sciences.

3.2.2 Questions

Questions will primarily be closed questions were respondent needs to select from predefined answers correct ones (Fink 2003, 18). When creating closed questions, it is important to find all possible options what to answer e.g., when asking about respondents' gender there will be three options: female, male or other so that even those can answer who don't identify themselves as female or male. Open questions were respondents use their own words to answer are not forbidden but because they are more difficult to compare and interpret their amount will be limited (Fink 2003, 17). Survey questions are limited to max twenty questions from which majority are closed multiple choice questions and one to five open questions.

Questions are created based on SLR results. Through SLR results main themes are analysed and searched if there are viewpoints which are missing or if there are connections between themes which need to be studied.

4 Research results

In this chapter research results are discovered and discussed. Chapter will first go through SLR results and after that through survey results.

4.1 SLR results

There were 262 search results from Google Scholar from which 30 were related to technology education and gender equality. From these 30 articles nine articles were done in Europe. Table 1 contains reference list about selected nine articles and identifier for each article, which will be used when article is referenced in further text.

Table 1 Reference list of SLR results

ID	**Article**
S1	Niiranen S., Räikkönen E., Ikonen P. 2014. Increasing Girls' Interest in Technology Education as a Way to Advance Women in Technology / Gender-based motivational differences in technology education
S2	Stoet, G., Geary, D. 2018. The gender equality paradox in STEM education
S3	Niiranen S., Räikkönen E. and Ikonen P. 2014. Women in technology – oriented fields/ Gender-based motivational differences in technology education
S4	Hallström J., Elvstrand H., Hellberg K. 2015. Gender and technology in free play in Swedish early childhood education
S5	Pérez-Sabatera C., Pérez-Sabater M. 2013. Breaking gender stereotypes in technology education: Developing strategies in the English classroom
S6	Reis A., Patrocínio C., Lourtie P. 2012. Gender issues in attracting students to science, technology and engineering higher education
S7	Sander E., Endepohls-Ulpe M., Quaiser-Pohl C. 2016. ADULT EDUCATION IN SCIENCE TECHNOLOGY ENGINEERING AND MATHEMATICS UNDER THE GENDER ASPECT A Critical Overview of Programs and Strategies in Germany
S8	Kelemen-Erdos A., Szekeres V 2018. Women Motivations Applying for Science, Technology, Engineering and Mathematics Education and Workplaces in Hungary
S9	Endepohls-Ulpe M., Ebach J., Seiter J., Kaul N. 2012. Barriers and motivational factors for taking up a career in a technological field in Germany and Austria

Table 2 lists nine selected articles and following information: publishing year, publishing country, article topic and theme and target group of articles research. 5/9 of articles did use in their research as target group secondary school pupils. 2 articles did use primary school pupils as their research target group and one article did use even preschool children in their research. Students in higher education was used as target group only in 2 articles and in both researches the target group was only women with or in higher education in technology or engineering field. These findings support the idea to do the survey for graduated or studying people in higher education in technology or engineering. By using men and women as target group gender differences could be pointed out.

Table 2 SLR general information

ID	Publishing year	Country	Topic	Research question	Target group
S1	2014	Finland	Gender-based motivational differences in technology education	What raises girls' interest in technology education?	Primary school pupils in the fifth and sixth grade.
S2	2018	United Kingdom	The gender equality paradox in STEM education	What are the reasons behind women's gender equality paradox in STEM education?	Secondary and tertiary school pupils.
S3	2014	Finland	Women in technology - oriented fields	What has led women to study and work in technology-oriented field?	Women who had studied engineering and craft teachers.
S4	2014	Sweden	Gender and technology in free play in Swedish early childhood education	How boys and girls explore and learn technology and how they differ?	Preschool pupils.
S5	2013	Spain	Breaking gender stereotypes in technology education: Developing strategies in the English classroom	How gender imbalance is present in written text and discussion in the	Secondary school pupils and university students.

				field of technology in English classes?	
S6	2012	Portugal	Attracting students to science, technology and engineering higher Education	How to attract students to science, technology or engineering studies in higher education?	Secondary school pupils and first year engineering students.
S7	2016	Germany	Adult education in science technology engineering and mathematics under the gender aspect A Critical Overview of Programs and Strategies in Germany	How to support and motivate women to enter STEM related careers?	Secondary school pupils.
S8	2018	Hungary	Women Motivations Applying for Science, Technology, Engineering and Mathematics Education and Workplaces in Hungary	What are the motivations behind women's study and career decisions and how STEM career has been chosen?	Women with higher education in the field of STEM.
S9	2012	Germany, Austria	Barriers and motivational factors for taking up a career in a technological field in Germany and Austria.	What are women's barriers and motivations to enter career in technological field?	Primary and secondary school pupils.

In most articles the reason for conducting research related to gender equality in technology education was that women are underrepresented in technology studies and/or careers. Additionally, to lack of women in technological field, reason to conduct research was the lack of workers in technological field in the future. With SLR main themes of literatures research conclusions were listed.

Table 3 contains main themes and number of how many articles referenced the theme. Tables 4 to 6 include the information articles did give for each theme. The most common theme which did arise in the literature was women's self confidence in technology. Women's or girls' self-confidence was pointed out in several research which were made in different levels of schools (from preschool to higher education). Mainly women's self-confidence in

technology was mentioned lower as men's self-confidence and S1 pointed out that it could be and should be strengthened through teachers' support. S7 suggested courses and training to deepen the knowledge of technology to improve women's self-confidence in technology. The conclusion in S9 article that women who are studying in technical field are more self-confident about their technical skills than women studying other subjects, confirms the idea that through raising women's self-confidence in technology in lower education could lead to more women choosing higher studies in the technology field.

Table 3 SLR Main Themes

Theme	**Number of references**
Women's self confidence in technology	5 (S1, S3, S4, S7, S9)
Parents or family's effect on study/career decision	4 (S3, S6, S8, S9)
Attractiveness of technology studies or career	4 (S3, S5, S6, S9)
Differences between male and female	3 (S2, S4, S9)
Teachers or schools' effect on study/career decision	3 (S1, S4, S9)
Additional training, courses etc. for women about technological studies and careers	3 (S3, S7, S9)
Usage of role models	2 (S3, S5)

Parents or family's effect on study/career decision, differences in studying or using technology between male and female and attractiveness of technology studies or career were themes which were all referenced in 4 articles. Parental effect in selecting technology studies meant in S6 that those women whose parent or both parents have an education in technology field are more likely to choose to study in the same field as well. In article S3 was found also an opposite effect were mothers' career in a soft skill field e.g., healthcare was supporting woman to select the opposite and lead women to study in technological field. S3 pointed also that only 3 of 12 female engineering students answered that their family had supported or encouraged them to select technology related studies, which could mean that parents or family's education background has a bigger effect to women selecting technology studies than family's support or encouragement.

Attractiveness of technology studies or career were pointed out in the literature through what kind of image students have from future career in technological field and what kind of image is created through tv series from people studying or working in the technological field. In S3 was found out that career in technological field was seen more secure and well employed, which were the reasons to enter technological studies. S5 pointed out that generally engineers are shown as geeks or nerds in tv series, which can affect negatively to students' interest in studying in technological field – especially in computer science. Related to fields' attractiveness S6 pointed out that only 30% of secondary students thought that engineering is important for their country's development. Any literature did not mention the effect of image creation of higher education schools themselves e.g., how technology studies are promoted to secondary school students, if they are targeting all genders or if they are targeting more men than women, consciously or unconsciously.

Table 4 Themes and their content 1

Id	**Women's self confidence in technology**	**Parents or family's effect on study/career decision**	**Attractiveness of technology studies or career**
S1	Girls had more often fear of doing wrong.		
S3	Majority of the respondents were aware of their high-level skills in mathematics, physics, chemistry or biology.	Half of respondents said that they had in their family a member who had studied or was working in the field of engineering.	Career in technological field was seen more secure and well employed, which were the reasons to enter technological studies.
S4	Girls are less confident in their technical abilities.		
S5			Generally, engineers are shown as geeks or nerds in tv series, which can affect negatively to students' interest in studying in technological field.
S6		Women whose parent or both parents have an education in technology field are more	Only 30% of secondary students thought that engineering is

		likely to choose to study in the same field as well.	important for their country's development.
S7	Courses and training to deepen the knowledge of technology would improve women's self-confidence in technology.		
S8		Positive childhood experiences in technical activities can lead to positive attitudes towards technical careers in adulthood.	
S9	Women who are studying in technical field are more self-confident about their technical skills than women studying other subjects.	Male and female engineering students got more support in technical activities and interests from their fathers in their childhood.	

There were three differences in studying or using technology between male and female which were pointed out in the literature. In S2 boys' and girls' performance in generic science literature tests were compared and discovered that girls perform similar or even better than boys in generic science literature. Boys' personal academical strengths were in science and mathematics while girls' strengths were in reading comprehension, which can explain that more boys choose technology related education than girls, if educational decisions are done based on academical strengths. S9 studied differences between engineering and non-engineering students and male and female engineering students. In S9 studies was found out that female engineering students feel less capable in their studies than male engineering students, which could be related to women's' lower self-confidence in technology. Other difference pointed out in the literature were usage of technology in play. Technology in play was presented in S4 where it was found out that preschool girls use technology to build something which is needed in the play while for boys using technology is a play itself.

Teachers' effect on student's study/career decisions and effect of additional training, courses etc. for women about technological studies were referenced both in three articles. Teacher's effect was already mentioned in the self-confidence theme were S1 pointed out that girls

were hoping for more support and encouragement from teachers than boys and that girls need more encouragement and appreciation from teachers of their technical skills than boys. S4 pointed out that those female students who are not interested in technology won't have any touchpoint to it if they are not supported to use technology. By raising female students' knowledge about technology, the interest in technology could be raised. The same conclusion was made in S3 article, which pointed out that schools should provide information and role models of technology-oriented studies and careers for girls, especially for those whose parents or families don't have any experience or interest in technological field.

Table 5 Themes and their content 2

Id	**Differences between male and female**	**Teachers or schools' effect on study/career decision**
S1		Girls hoped for more support and encouragement from teachers.
S2	Girls performed equally good or better than boys in science literacy tests.	
S3		Schools should provide information and role models of technology-oriented studies and careers for girls.
S4	Preschool girls use technology to build something which is needed in the play while for boys using technology is a play itself.	Those female students who are not interested in technology won't have any touchpoint to it if they are not supported to use technology.
S9	Female engineering students feel less capable in their studies than male engineering students.	

Additional technology related training, courses and workshops were raising women's self-confidence in technological field according to S7 and S9. S3 suggested that school counselling and guidance about technology and engineering field studies and careers should be improved to show women that in those fields there are options which are not as masculine as assumed. S3 pointed also out that women would need more information about what skills and knowledge are needed in technological career.

Usage of role models to motivate women to choose studies in technological field were referenced in two articles. Half of S3 respondents told that at least one of their parents or siblings or spouse was or were studying or working in engineering field or engineering related field. S5 pointed out that even it is a small action to increase students' awareness of gender stereotypes or about available role models in technological field, every single action should be used to increase women's representation in technological field.

Table 6 Themes and their content 3

Id	Additional training, courses etc. for women about technological studies and careers	Usage of role models
S3	School counselling and guidance about technology and engineering field studies and careers should be improved to show women that in those fields there are options which are not as masculine as assumed.	Half of respondents told that at least one of their parents or siblings or spouse was or were studying or working in engineering field or engineering related field.
S5		All actions to increase students' awareness of gender stereotypes or about available role models in technological field should be used to increase women's representation in technological field.
S7	Additional technology related training, courses and workshops were raising women's self-confidence in technological field.	
S9	Intervention programs in technical courses to understand students' abilities in technical field is an essential tool to support female students in their future careers.	

Secondary schools' pupils were in many research the target group but none of them did compare pupils from different kind of secondary educations. Those research where target group were students in higher education or people working in the engineering, technology or science field didn't analyse what was respondents secondary education except for their success in mathematics, physics or other "technology career supporting" subjects.

4.2 Survey results

After conducting SLR following four questions did arise:

1. Teachers support on those students who don't have role types in their family or friends. Would those students need more support than those with role types in their family or friends?

2. Which is more significant factor in selecting technology field studies, parents' background in technology or parents support and encouragement to study in the field of technology?

3. What about schools' image and the information given from studies, is there need for improving degree descriptions or changing image of technology field studies?

4. What is the effect of secondary education, especially success and studies in technology supporting subjects and what is the percentage of students having other than high school background?

These questions were used when creating the survey questions which can be found from Appendix 1. Survey was answered by 60 persons from which 41 were women and 19 men. Except for one female respondent all respondents did have background in engineering, science or technology-related studies in higher education. In further analysis of the survey only answers from those who have background in engineering, science or technology-related studies in higher education are used.

4.2.1 Teacher's support

Compared to men women would have needed more or they didn't get support but would have wanted support from teachers in technology related subjects in secondary studies (men 37% and women 54%). 31% of women felt that they got enough support from teachers while the percentage of men was 47% (Figure 1). The same conclusion that women need and would like to have more support in technology related subjects because of their lower self-confidence in technology was found in several articles through SLR.

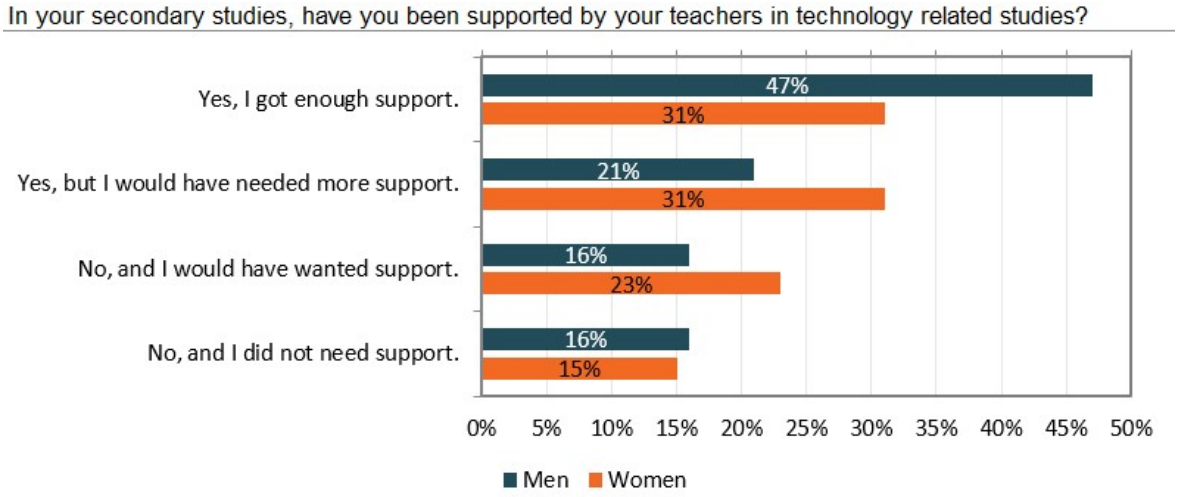

Figure 1 Teacher's support

In women 22% had experienced encouragement from secondary teachers or school to enter technology related studies in higher education, which is 10% less than the same percentage in men. Still majority of both genders (men 68% and women 78%) lacked this experience.

When asked about capability doubts in technology related studies in secondary education 32% of men felt that they haven't experienced any doubts in their capability while in women the percentage was 18%. Majority of women (82%) had experienced capability doubts in technology studies, but majority had also experienced support from family, teachers or others when having doubts in their capability. Only 10% of women weren't supported by anyone when having capability doubts in technology related studies in secondary education while the percentage of men lacking support was 21%. For both genders majority of support was from family or others and minority (men 11% and women 18%) had experienced support from teachers when having capability doubts. (Figure 2)

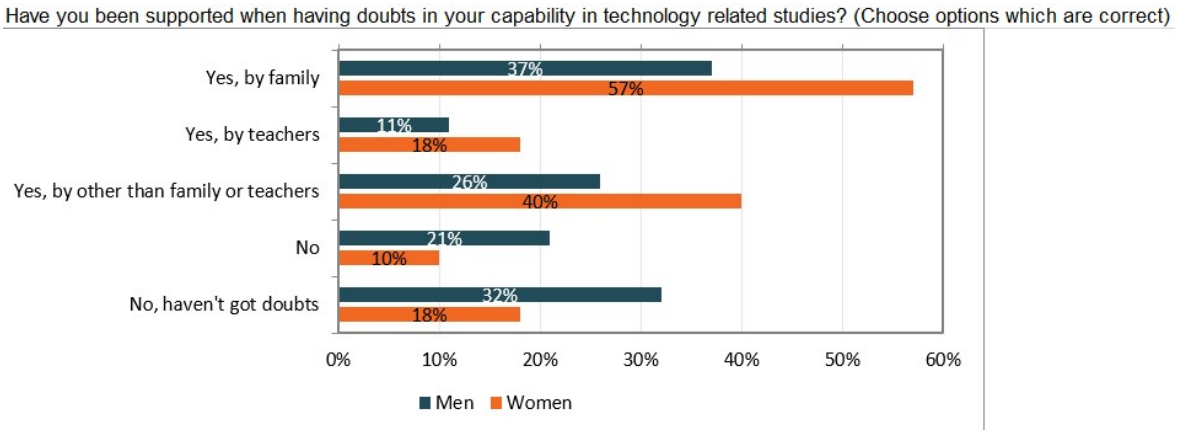

Figure 2 Capability doubts

When comparing women with a family member with a degree in engineering or technology and women without this kind of role type in their family, those with the role type in their family had experienced more support from their family (80%) as those without a role type in the family (44%) when having capability doubts in technology related studies (Figure 3). Over 50% of those women with role type in their family (60%) and those without a role type (50%) felt that they would have needed more support or that they did not get support and would wanted support from their teachers in technology related studies in their secondary education.

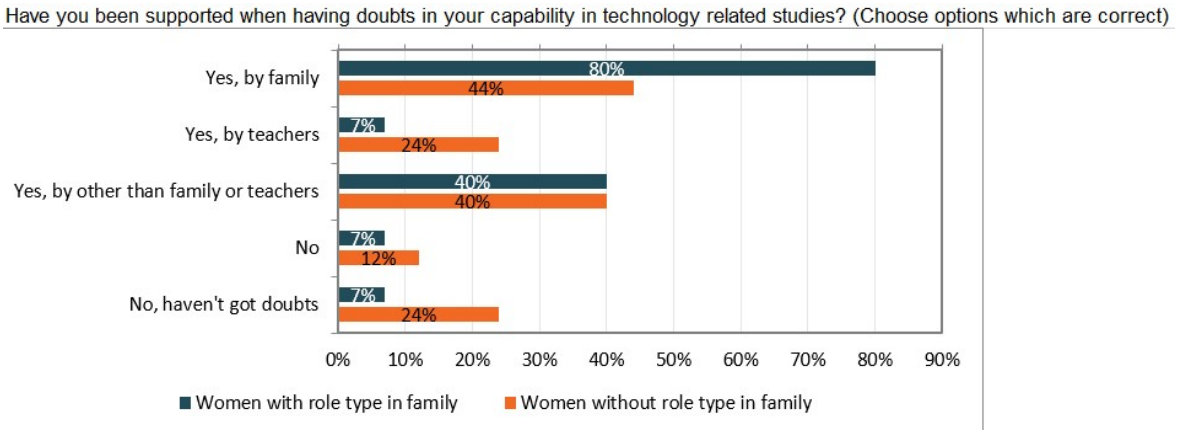

Figure 3 Capability doubts comparison role type available or not

With these results there is a lack of support in technology related studies in support and encouragement to enter engineering or technology studies in higher education from secondary teachers or schools to students', men or women, with family background in engineering or not. Majority of men and women did still get support when having doubts in their capability in technology related subjects in secondary education even though the support wasn't from teachers or school. Majority were supported or encouraged by their family to enter engineering or technology related studies in higher education.

4.2.2 Parents and family's effect

From all respondents 38% did have a family member with a degree in engineering or technology. In men the percentage was a bit higher than the percentage of women (men 42%, women 37%). 8% of all respondents' mothers had a degree or were currently working in engineering or technology field. In women 22% had their mother working in medical or healthcare field while in men the same percentage was lower with 16%. This difference could support the finding in SLR that women having their mother working in a soft skill area would choose the opposite of their mother's career and enter technological field. In both genders over 50% of respondent were supported or encouraged by their parents to enter engineering or technology related studies (men 63%, women 50%) (Figure 4).

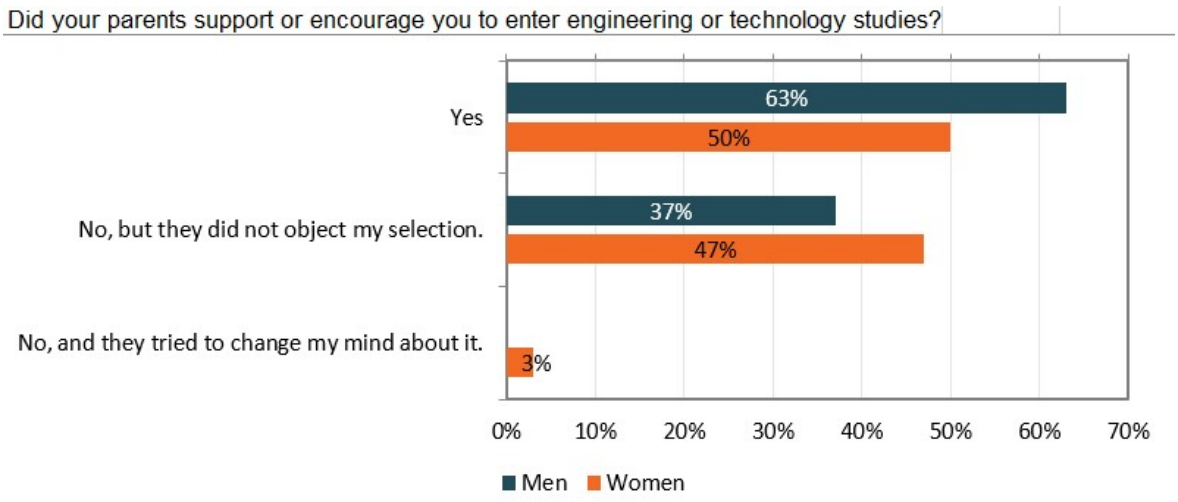

Figure 4 Parents support and encouragement

Those women with a role type with engineering or technology degree in their family experienced more support or encouragement from their family to enter engineering or technology related studies in higher education (60%) compared to those women without a role type in their family (44%). 27% of those women having a role type in their family the role type or one of them was their mother (Figure 5).

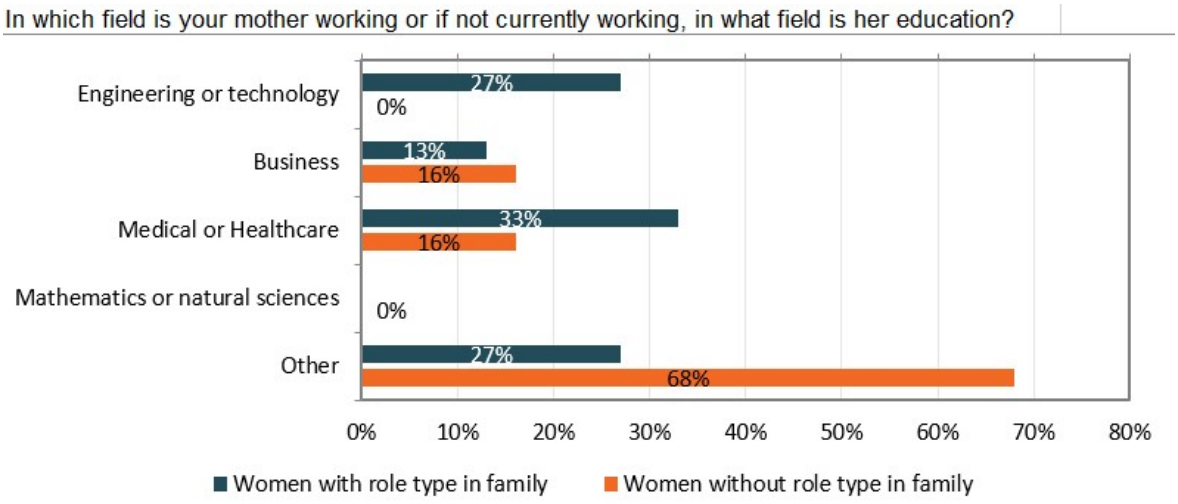

Figure 5 Mothers career

According to survey results, women having a family member with engineering or technology related degree and parents support or encouragement to enter engineering or technology related studies in higher education have an equal impact in women to select engineering, technology or science related studies compared to SLR results where it seemed that parents background would have a bigger impact than the support or encouragement of parents.

4.2.3 School image

Majority of men (79%) felt that they belong to the target group of their higher education degrees while in women the percentage was less than half (45%). For men the only reasons why not belonging to the target group was respondents age or other reasons both with 11%.

In women the biggest reason why not belonging to the target group was gender (35%) followed by their previous studies (15%), age (15%) and other reasons (13%) (Figure 6). Even though living in one of the most gender equal countries engineering and technology field studies are seemed masculine to women according to the survey results. In the SLR results S3 article pointed out that schools should improve counselling and guidance about technology and engineering field studies to change the masculine image of those fields.

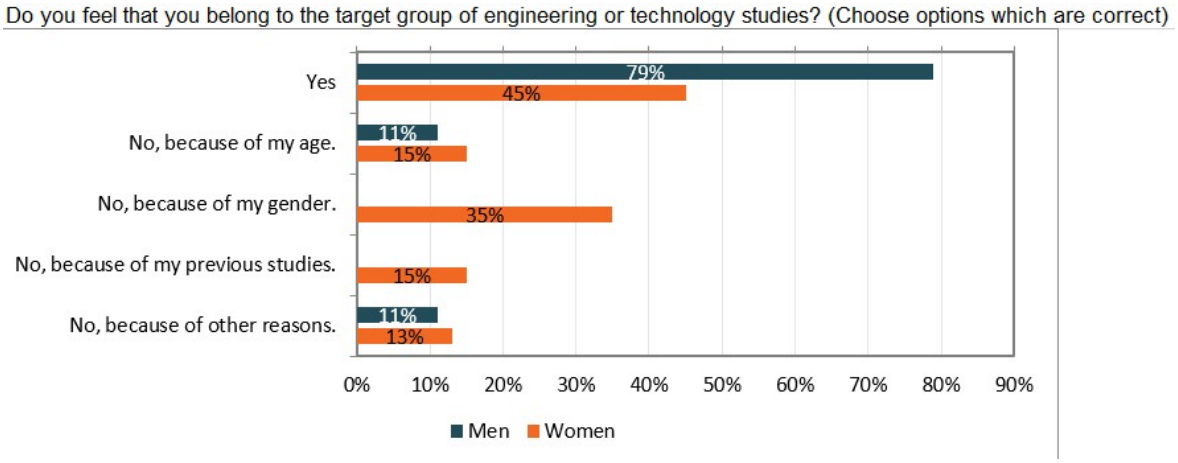

Figure 6 Belonging to the target group

Engineering or technology studies were seemed from both genders equally attractive compared to other fields studies (men 79%, women 80%). 16% of men and 15% of women felt that engineering or technology studies weren't as attractive as other ones because of stereotypes created by tv-series, movies, or social media. 5% of both genders thought that engineering or technology studies attractiveness compared to other studies did suffer because of the image created by schools.

Majority of respondent (71%) did agree that the degree descriptions of their higher education were clear, and they had understood what they are going to study and what kind of qualities are needed. 19% had a neutral opinion about the degree descriptions and only 10% did disagree (Figure 7). 69% of respondent did agree that they did get enough information about engineering and technology related studies when selectin higher education. 18% felt neutral about information given and 13% felt that they would have needed more information about

those studies. If the picture of engineering and technology being masculine is left out, schools have mainly succeeded in giving enough information about their studies content and the general image of engineering or technology studies is positive. Improvement is still needed to change the masculine image of engineering and technology studies.

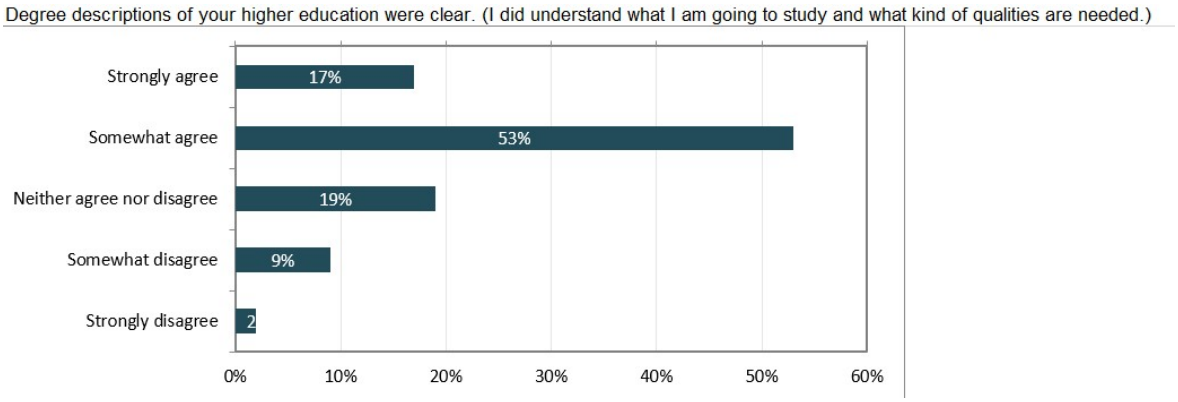

Figure 7 Degree descriptions

4.2.4 Secondary education

Majority of men and women had completed their secondary education in high school (men 63% and women 70%). 37% of men had completed vocational school or double or triple degree (combination of high school and vocational school) while the percentage of women was lower with 25%. Vocational background had 21% of men but in women the percentage was half of it with only 10%. (Figure 8)

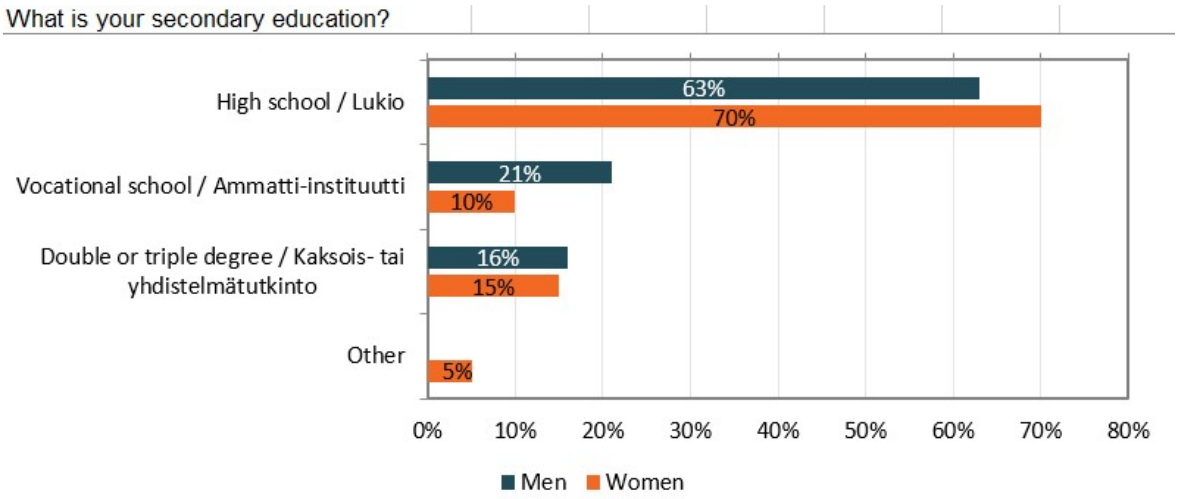

Figure 8 Secondary background

Near half of respondent of men and women had taken optional courses in mathematic or physics or other “technology career supporting” subjects (men 58% and women 42%). 8% of women answered that other optional courses prevented them to select those subjects while in men the percentage was 0%. In men there were more respondent who answered that their school did not provide optional courses with 5% of respondent while in women the percentage was 3%. When comparing respondent with high school background and vocational school background, in both groups about 50% (50% with vocational and 47% with high school background) of respondents had taken optional courses in mathematics, physics or other "technology career supporting" subjects in their secondary education. Other 50% of respondents with vocational background answered that they did not take those courses even their school provide them, and they had the possibility to select those courses. 6% with high school background answered that their other optional courses made it impossible to select those “technology career supporting” once and 4% answered that their school did not provide these kinds of courses.

52% of women felt that their success in mathematics, physics or in other “technology career supporting” subjects in secondary education had an impact in their further study selection. In men the same percentage was higher with 58%. Majority of respondents with vocational school background (80%) answered that their success in those “technology career supporting” subjects didn’t impact their further study selection.

Related to the teachers support, the percentage of respondents with vocational background who would have needed more, or they did not get support and would have wanted support from their teachers was bigger than the percentage of those respondents with high school background (67% with vocational background and 45% with high school background) (Figure 9).

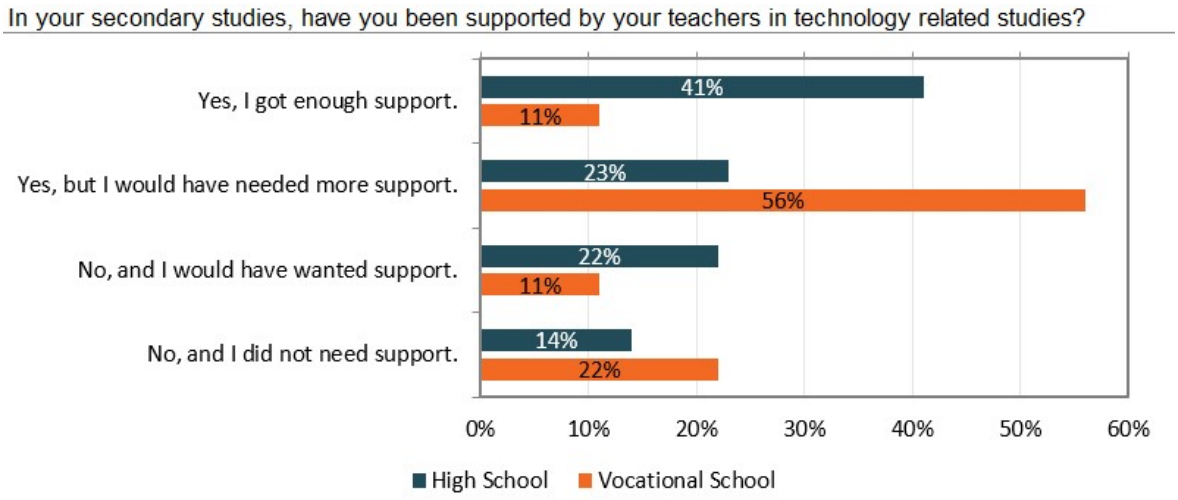

Figure 9 Teacher's support, high school background vs vocational school background

5 Discussion and implications

For a reminder the main research question was: What factors have influenced women to study in the field of Technology in higher education? Through the SLR teachers and schools support for women in secondary and lower education in mathematics, physics and other "technology career supporting" subjects were seen as an important tool to improve women's self-confidence in technology and through that encourage them to select technology related studies in higher education. Still through the survey results teachers or schools support was lacking for women who had selected technology field studies in their higher education. Based on the survey results more impact in respondents study selection had the support they got from their family when having doubts in their capability in technology related subjects and their families support and encouragement to enter technology or engineering studies in higher education. The SLR results also pointed out the importance of parents and family's role in women's higher education selections, but parents' educational background was seen as having more impact in women's study selection than their support or encouragement to enter technology or engineering studies. Through the survey parents educational background and their support and encouragement to enter technology or engineering studies was seen as equally effective.

In the SLR there were not so many studies found which would have been studying the impact of secondary education selections to students' higher education selections. In the survey questions about respondents' secondary education was asked, majority had background from high school in both genders but when looking at those with vocational school background men had more often background from there. This could be explained by the gender gap already visible in vocational school. In those with vocational background their success in typical "technology career supporting" subjects had minor impact in their study selection, which might be related to the hands-on experience they have already collected during the secondary education. About half of respondent had selected optional courses in mathematics, physics or other "technology career supporting" subjects, which could be compared to general information about what courses are selected from optional courses in secondary education, to see if the percentage in the survey is bigger than generally.

SLR was conducted only by researcher, which means that as literature selected was selected based on qualitative criteria, when SLR would be conducted by some other person selected literature might differ from literature selected to this research. As well SLR analysis was done only by researcher and those results might differ too if analysis would be done by some other person. Bias which might occur in survey results is generated by those respondents who did not answer even though they would belong to the target group. These non-respondents might have some common character or characters which affects their will to participate in the survey, causing bias in the survey results. The name of the survey was "Women in Tech Survey", which might led to less men to answer as they might have felt that this survey is not about them, even though their answers played a big role when comparing differences between genders. Overall number of survey respondents was good with 60 answers but the number of men who answered was 19, which makes the answers of men less reliable as the answers of women. Survey did not ask about respondents' age which might cause that secondary or higher education has been changed since some respondents have been conducting their studies.

Future research could be a research with comparison group of women without a higher education in the field of engineering or technology, or about the need of soft skills in technological field to encourage women to the field through showing what kind of "feminine" skills are needed.

6 Conclusions

This research studied available literature about women's underrepresentation in technological field and through the survey factors which have impacted women and men to study in technological field in higher education. Through SLR results can be confirmed that women's motivation to enter technological field studies is built through several different factors. Teachers, schools, parents and families support and encouragement, women's success in technology related subjects, role types and study selection in lower education are all factors which have an impact in their higher education selection.

Even though majority of both men and women had experienced doubts in their capability in technology related subjects in their secondary education they both got supported mainly by their family. As discovered in SLR results the survey results confirmed that women experience more doubts in their capability related to technological field studies. But in women majority, especially those with a role type in their family got supported when having doubts in their capability and encouraged by their family, to enter engineering or technology field studies. Minority of those having doubts in their capability had experienced support from their teachers and schools. When kept in mind that the respondents had selected engineering, technology, or science field studies in higher education despite of the lack of support from teachers or school and despite of the doubts they had experienced in their secondary education – would there be more women in those fields when more effort would put into secondary teachers and schools support in technology related studies and in their support and encouragement for female students to enter engineering, technology, or science related studies in higher education?

Almost third of women's mother had a degree or were working in engineering or technology field, which is more than the presentation of women generally in those fields. If having mother working in technological field is supporting women to enter this field than with each mother or women going to be mother who enters technological field might encourage their daughters to follow their steps.

In SLR results there was no research found which would have analysed the secondary school background other than through the success students had in technology supporting subjects. Survey did ask about respondents' secondary education and about one third from men and women had other than plain high school background. Men had more often background in vocational school, which could be explained that already in vocational school there is a gender gap in technological fields (Tanhua 2018). In future studies could be analysed what could be done to encourage more students with vocational school background to enter higher education in technological field.

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Appendix 1: Survey question

1. Agreement to participate *

*This question is mandatory for your consent to collect data.

- I am over 18 and want to participate to this survey voluntarily.

2. What is your gender?

- Female

- Male

- Other

- Don't want to answer

3. Please select the option that describes your current situation most accurately:

- I am currently studying towards my first Bachelor's or Master's degree, with a major in engineering, science or technology.

- I am currently studying towards my first Bachelor's or Master's degree in other field, and I have a minor in engineering, science or technology.

- I am currently studying towards my first Bachelor's or Master's degree in other field.

- I am currently doing my second, or adult education degree (muuntokoulutus) with a major in engineering, science or technology.

- I am a graduate from engineering, science or technology-related university-level degree program (any degree, Bachelor or advanced).

- I am a graduate from other degree program (any degree, Bachelor or advanced), and I had a minor in engineering, science or technology.

- Other

4. What is your secondary education?

- High school / Lukio

- Vocational school / Ammatti-instituutti

- Double or triple degree / Kaksois- tai yhdistelmätutkinto

- Other

5. In your secondary studies, have you been supported by your teachers in technology related studies?

- Yes, I got enough support.

- Yes, but I would have needed more support.

- No, and I would have wanted support.

- No, and I did not need support.

6. In your secondary education did you take optional courses in mathematics, physics or other "technology career supporting" subjects?

- Yes

- No

- My other optional courses made it impossible to take these subjects.

- School did not provide optional courses.

7. Did your secondary education results in mathematics, physics or in other "technology career supporting" subjects have an impact on your selection for the later educational choices?

- Yes, it enabled me to select the educational path I was interested in.

- Yes, and it prevented me from selecting the educational path I was interested in.

- No

8. In your secondary studies did teachers or school encourage you to enter engineering or technology studies in higher education?

- Yes

- No

9. Have you been supported when having doubts in your capability in technology related studies? (Choose options which are correct)

- Yes, by family

- Yes, by teachers

- Yes, by other than family or teachers

- No

- No, haven't got doubts

10. Has someone in your family a degree in engineering or technology?

- Yes

- No

11. In which field is your mother working or if not currently working, in what field is her education?

- Engineering or technology

- Business

- Medical or Healthcare

- Mathematics or natural sciences

- Other

12. Did your parents support or encourage you to enter engineering or technology studies?

- Yes

- No, but they did not object my selection.

- No, and they tried to change my mind about it.

13. Do you feel that engineering or technology studies are less attractive than other ones?

- Yes, through the image schools have created.

- Yes, through the stereotypes created by tv-series, movies or social media.

- No

14. Do you feel that you belong to the target group of engineering or technology studies? (Choose options which are correct)

- Yes

- No, because of my age.

- No, because of my gender.

- No, because of my previous studies.

- No, because of other reasons.

15. Degree descriptions of your higher education were clear. (I did understand what I am going to study and what kind of qualities are needed.)

- Strongly agree

- Somewhat agree

- Neither agree nor disagree

- Somewhat disagree

- Strongly disagree

16. I did get enough information about engineering or technology studies when selecting higher education.

- Strongly agree

- Somewhat agree

- Neither agree nor disagree

- Somewhat disagree

- Strongly disagree

17. If you wish to emphasize some aspect from this survey, leave us some feedback, or mention something related that was not asked by us, you can write your comments on the space below