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# Women in technology-oriented fields

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## Abstract

*This study focuses on investigating the main elements that have an effect on women's decisions to enter a career in technology-oriented fields, and more specifically, to discover whether studying crafts, especially technical work, during basic education affects their decisions in this context. The study was carried out using a semi-structured questionnaire, and the data consist of the responses from 12 female technology education teachers and 12 female engineering students. A qualitative theory oriented content analysis was carried out through identifying, coding, analysing and reporting the patterns within the data.*

*The findings revealed that the most influential career anchor identified by all these women was a technical or functional competence. Secondly, their familiarity with the field was a relatively important element. These findings suggest some positive perspectives on women's interests in technology-oriented career paths, and indicating that supportive interventions can be implemented.*

**Key words:** *women; engineering; technology; career orientation*

## Introduction

Internationally, technology-oriented fields still seem to be a rather male-dominated area, and the reluctance of women to enter occupations in the natural sciences or technology has already been established in previous studies (Sander, 2012; Klapwijk & Rommes, 2009; Mammes, 2004). Based on EU statistics (She Figures, 2012), gender differences stand out in the field of science and engineering in most EU countries. It seems that because of the efforts that have been made, some of the gaps have been slowly shrinking over the recent years and women have been catching up with men in total employment and in some precise areas. Based on the She Figures (2012, p. 19) statistics, the share of women among highly educated people as professionals or technicians is 53 percent, the proportion drops to 32 percent among women employed as scientists and engineers, a narrower category of employment. This exemplifies the problem of gender segregation.

The role of Science, Technology, Engineering and Mathematics (STEM) education is fundamental to a successful industrial base, but also the skills, knowledge and understanding of the subjects involved to STEM are vital for young people in an increasingly science- and technology-driven society (Banks & Barlex, 2014). In Finland, there is still no special subject called technology education or STEM education. Technology education is, and continues to be, decentralised, and it is taught through various subjects (Autio, Hietanoro, & Ruismäki, 2011; Finnish National Core Curriculum for Basic Education, 2014). As early as 1866, Uno Cygnaeus, the founder of Finnish general education, considered technological content an important aspect of craft education, but technology, as a concept, was introduced (but not defined) for the first time in the Finnish Framework Curriculum for Comprehensive Schools in 1985 in the crafts subject (technical work and textile work) (Rasinen, Ikonen, & Rissanen, 2011). The latest National Core Curriculum for Basic Education (NCCBE, 2004) introduced seven cross-curricular themes for Finnish education, one of them being 'Human beings and technology'.

This has been important to technology education, as this cross-curricular theme argues the need for technology education in the Finnish curriculum (Järvinen & Rasinen, 2015, p. 4). Cross-curricular themes should be integrated into different subjects, and much of the technological content of the Human beings and technology theme is studied in the subject of crafts, in particular, technical work lessons (Rasinen, Virtanen, Endepohls-Ulpe, Ikonen, Ebach, & Stahl-von Zabern, 2009). Therefore, technology education at the primary level (grades 1–6) is often implemented during technical work but also in other lessons, depending on teachers' educational background and schools' organisational aspects.

Gender equality and non-discrimination have been a central focus of Finnish education (Committee on Alleviation of Segregation, 2010). However, it has been claimed that schools of basic education are still providing a very traditional image of gender roles for the pupils (Kokko, 2008). In spite of 30 years of curriculum work for gender equality, craft education is still very gender-divided. Girls are mainly studying textile work with female teachers, and boys study technical work with a male teacher (Guttorm, 2014; Virtanen, Räikkönen & Ikonen, 2015). This division has been seen as a natural choice, requiring no justification (Kokko, 2007). The significance of a deeply gendered craft education undeniably affects technology education by giving it a 'masculine' and 'exclusively male' label (Järvinen & Rasinen, 2012; Murphy, 2006; Shivy & Sullivan, 2005). It would seem that such a marked gender difference must have an effect on girls if they are planning their future career in a technology-oriented field.

In order to introduce more gender balance equality on the labour market, attention should be given to the entire set of factors affecting career choices. This is a question of unused potential. This study seeks to determine what are the main factors that have an effect on women's decisions to study and enter a career in technology-oriented fields and, more specifically, to investigate whether studying craft, and especially technical work, during basic education affects their decisions in this context.

## Career orientation in technology-oriented fields

Stereotypically, technology-oriented fields are insufficiently associated with values such as creativity, service, autonomy and entrepreneurship (Klapwijk & Rommes, 2009, p. 403). This is quite paradoxical, as engineering is often defined as the creative application of scientific principles to problem solving (Dandy & Warner, 2000). Contemporary practical engineering work in many domains actually revolves around creative problem solving skills supported by a fundamental understanding of the scientific principles and practical tools related to the domain. Moreover, interpersonal and emotional skills are a critical component of the creative problem solving skill set in today's working environments. In real life people in technology-oriented fields, work at the nexus of science, engineering and the humanities.

Dakers, Dow and McNamee (2009, p. 382) argue that technology, as a concept, in its modern sense, derives from the Indo-European root *tek* which means "to fit together the woodwork of a woven house" and this derivation has translated over time into the Greek term *techne,* which, "came to refer to the knowledge or skill of the *tekton,* one who produces something from wood" (Porkorny, 1967 cited in Roochnik, 1996, p. 19). The term *techne* is typically translated as 'art', 'craft', 'skill', 'expertise', 'technical knowledge' and even 'science' (Roochnik, 1996). In the nineteenth century, technology was situated in the realms of engineering, and these concepts still seem to share aspects that relate to human action: ethics, sustainability, criticality and design (Dakers et al., 2009, p. 384). Technology in the broadest sense means "human activity that transforms the natural environment to make it fit better with human needs, thereby using various kinds of information and knowledge, various kinds of natural (materials, energy) and cultural resources (money, social relationships, etc.)" (de Vries, 2005, p. 11). Engineers are the professionals who are carrying out the human activities described above.

An effective approach for achieving a higher number of women in technical careers has not yet materialized in EU countries, because the percentage of female students has remained more or less stable at approximately 10 percent (Klapwijk & Rommes, 2009, p. 404). Girls are, on average, more successful at school since they tend to achieve higher grades than boys, but they less frequently engage in the science, engineering and technology paths (She Figures, 2012). It has been shown that students will opt for technology if they have come into contact with technology in a positive way, are confident in being good at technical things, have certain skills and experience in the area, and when a technical profession matches their self-image (see Eccles, 1987). However, somehow, women fall behind with respect to these factors, as girls tend to come into contact with technology less often, thereby acquiring fewer skills and less knowledge about technology (Klapwijk & Rommes, 2009, p. 405). In a study of women in science, technology, engineering and mathematics professions, a striking result was that not one of 15 women said that their interest in science or technology was in any way evoked in kindergarten or at primary school (Sander, 2012).

It is obvious that during basic education, all pupils should be provided with equal opportunities to acquire the knowledge and skills required in society and working life. In crafts, this means that pupils should have equal opportunities to study technical and textile work, including having the same number of periods during comprehensive school (Committee on Alleviation of Segregation, 2010). Lindfors (2015) argues that gender-based tradition is the most serious barrier to equal technology education in Finland and that it will take time to dismantle. However, the new National Curriculum for Basic Education 2016 (NCCBE, 2014) will guide education towards multi-material, equal craft education, and thereby the gender-based tradition can be finally eliminated (Lindfors, 2015, p. 254).

*Career anchors*

Schein (1996) has constructed career anchors that describe individuals' 'internal career', a subjective sense of where an individual is heading in their career. An individual's career anchor can be described as their self-concept, incorporating perceived career-related abilities and talents, values, and motivations and needs (Schein). The following anchor categories (a modified version of Schein; Klapwijk & Rommes, 2009) present a person's orientation in their internal career (see Table 1).

Table 1 Career anchors

| Category | Description |
|---|---|
| *Security/ Stability* | Presents a person's orientation to finding a good employer and a job that guarantees a permanent job for a longer period of time. Nowadays, this anchor should be extended to include the general employability in a field; that is, how many different career paths are available. |
| *Autonomy/ Independence* | Presents a person's orientation to seek a job where she or he can work independently and autonomously |
| *Life style* | Presents a person's orientation to integrate maybe more than one career and personal family concerns into a coherent overall pattern. |
| *Technical/ Functional competence* | Presents a person's awareness of the importance of knowledge and skills in the field. These people know that they are very talented in something and are also highly interested in pursuing their skills and learning more. |
| *General managerial competence* | Presents a person's preference to work as a high-level general manager. |

| | |
|---|---|
| *Entrepreneurial creativity* | Presents a person's orientation towards becoming an entrepreneur or developing more of an autonomous career him- or herself. |
| *Service/ Dedication to a cause* | Presents a person's ambition to choose a profession in order to achieve certain ideals such as serving humanity or improving the environment. |
| *Pure challenge* | People who define their careers in terms of overcoming impossible odds and do not concentrate on a single functional skill but rather constantly seek variation and new challenges. |

Schein initially developed the career anchors to describe individuals' inner career orientation, but we argue that, especially nowadays, outer factors are also needed to describe peoples' orientation to decide what they want to do in their life. It is also important to note that most applicants to engineering universities in Finland are recent high school graduates who may not have any knowledge of the work of an engineer. Looking at the educational system in Finland, students are quite ill-prepared from a maturational perspective to make a choice in engineering studies because of barely any direct studies in school that would lead to that profession. Also, it is argued that traditional career theories have largely been premised on male experiences, values and goals (Mavin, 2001). Therefore, in addition to Schein's anchors, three extra categories—*Familiarity*, *Encouragement and Limited options,* were derived to broadly describe females' choices in their career paths.

The first category of 'familiarity' describes a person's ambition or orientation to follow an example of family members. A study of engineering and technology students' perceptions indicates that parents are a very frequent source of information about furthering education and career goals (Mativo, Womble, & Jones, 2013, p. 113). It is evident that individuals are susceptible to influence from their families with regard to occupational choices (Beauregard, 2007). Familiarity also describes a person's orientation to enter a field because of a history of doing something related to the area at home: for example, if there has been some kind of craftsman culture at home. The second category of 'encouragement' represents someone else's (teachers, friends) imparted understanding that has influenced a woman's decision-making by encouraging or supporting her in choosing something. The third category of 'limited options' describes a woman's decision to choose something because there were not many options at the university to choose between.

## Research questions and methods

The aim of this study was to examine women in technology-oriented fields. We wanted to identify those elements that have an effect on women's decisions when choosing careers. The main research questions were:

1. What are the main elements that have an effect on women's decisions to study and enter a career in technology-oriented fields?

2. More specifically, does studying craft, and especially technical work, during basic education affect their decisions in this context?

*Participants and procedure*

The study was carried out using a semi-structured questionnaire, and the data were collected from November 2014 to February 2015. Potential participants were asked whether they wanted to participate in the study, and the questionnaires were sent by email to those who volunteered. The study group consisted of 12, female, technology education teachers graduated from various locations in Finland and 12 female engineering students from Tampere University of Technology and Aalto University (Technology and Engineering). The rationale for choosing participants from these different areas of technology was the desire to investigate whether these women shared similar reasons for entering a career in technology-oriented fields.

The teachers worked in schools of basic education and taught technology education for pupils at grades 3–9 (ages 9–15). Six of the teachers had studied to become primary school teachers (grades 1–6, ages 7–12) in their university education, and had studied 25 or 60 ECTS of technology education and technical work. The remaining six teachers had studied to become secondary school teachers (grades 7–9, ages 13–15) and in their university education they had also studied 60–240 ECTS of technology education and technical work. The teachers were 26–54 years old and had been working as a technology education teachers from 1 to 29 years. It should be noted that figures from 2010–2014 show that in Finland, only about 12 female teachers who qualified to teach technical work at grades 7–9 graduated each year. Those teachers graduated from Department of Teacher Education in Rauma, Department of Teacher Education in Helsinki and School of Applied Educational Science and Teacher Education in Savonlinna, University of Eastern Finland. The primary school teachers in this study had graduated from the Department of Teacher Education in Jyväskylä and School of Education in Tampere University. We chose to investigate teachers who had already graduated and who were actually teaching technical work and technology education, because there are many options in work-life, and after graduation not all will choose to be a teacher.

The engineering students were 20–29 years old and had been studying for 2–6 years. The students were chosen from two of the main Universities of Technology in Finland that provide education in an engineering field. The students were from a range of degree programmes: Mechanical Engineering, Civil Engineering, Information Technology, Signal Processing and Communications, Materials Engineering, Environmental and Energy Technology, Electrical Engineering, Biotechnology and Science and Engineering.

The semi-structured questionnaire consisted of questions concerning background information (e.g., age and studies in general), whether participants had studied technical work, textile work or both in school at grades 4–9, if so, how much. Then participants were asked about their basic educational studies, how they felt about technology education during their basic education and how much they studied so-called STEM subjects. Then, participants were asked about their hobbies and the work of the family members. In addition, participants were asked to reflect freely on the following themes Why did you decide to study what you are studying now/ have studied?, What do you think affects a woman's interest in studying technology? and If you could change or add something to basic education, what would that be?

A qualitative theory-oriented content analysis was carried out through identifying, and coding, analysing and reporting the patterns within the data. This is characterised as a method for examining material with descriptive content, especially if the phenomenon is relatively unknown (Schreier, 2012). The analysis used Schein’s (1996) theory of career anchors to provide clearer and more concise guidelines around the analysis (see Vaismoradi, Turunen, & Bondas, 2013). When using qualitative content analysis, the primary aim is to investigate and discover themes based on the frequency of their occurrence. This logical inference allows the discovery of something new. Meaningful sentences or themes and manifest content were chosen as the analysis units. After coding, the analysis units were grouped and categorised based on the higher order heading of the theory of career anchors (Schein, 1996; Klapwijk & Rommes, 2009). In addition, three additional categories were derived from the data: *familiarity*, *encouragement and limited options*. In the abstraction phase, general descriptions of ‘a female engineer profile’ and ‘a female technical education teacher profile’ were formulated.

## Results

All the participants (n=24) had studied technology in the form of technical work to some extent during their basic education at grades 3–9, but only four of these women had chosen or had access to technical work at grades 5–7. Two of those continued to study technical work at grades 7–9 when it is an elective subject. This number shows the reality of the still-existing division between technical and textile work. The division creates a situation whereby girls who study textile work at grades 5–7 are left out of the technology-related activities that are part and parcel of technical work. Rarely do they choose to or *can* study it, either, at grades 7–9. The women's reflection about their decision in choosing textile craft instead of technical craft for grades 5–7 revealed that there were many external factors that had an effect on their decision-making. More than half (55%, 11/20) of the women in this study who had chosen textile work reflected that they would have chosen technical work but that there were some 'obstacles' that affected their decision (see Table 2).

Table 2 Women's reflections on their decision in choosing textile craft instead of technical craft (T=Teacher, E=Engineer)

| | |
|---|---|
| T2: | The atmosphere then was that technical work was for the boys and something else was for the girls. |
| T3: | I would have needed some encouragement or a friend with me to choose technical work. |
| T6: | I wanted to choose technical work, but I was told at home to choose textile work. |
| T8: | Group pressure affected the decision surely; in crafts we were divided based on our gender, and I didn't even think about choosing differently. |
| T9: | I chose textile work because it was more familiar to me, and I thought that I should know more about technical work to choose it. |
| T10: | I chose textiles, because I felt that girls would automatically choose textile work, and boys study technical work. |
| T12: | In primary school, I didn't even dare to think of choosing differently. |
| E1: | I was in textile work, where all the other girls were, but actually I would have rather studied technical work. |
| E2: | I would have chosen to study technical work, but my mother forced me to choose textile work. |
| E6: | I thought that technical work would have been more interesting and important, but I felt that I didn't have enough experience in it to choose it. |
| E11: | I chose textile work because all the girls chose it. |

All the engineering students (100%, 12/12) as well as 58 percent (7/12) of the teachers studied so-called honours mathematics (10–15 courses) in upper secondary school. The same pattern seems to continue in the extent to which participants studied physics, chemistry and biology in upper secondary school. Many (71%) of the engineering students, but only 29 percent of the teachers, studied honours physics and chemistry.

### *Female career anchors*

After categorising the data, two career orientation profiles were formulated. These profiles state the main elements, or anchors, that had an effect on the women's decisions to study and enter a career in technology-oriented fields based on the participants responses to the questionnaires.

*Female engineer profile*

The most influential career anchor identified by these women was 'technical or functional competence'. Many (10/12) of the respondents noted that they had a high level of competence and interests in mathematics, physics, chemistry or biology. Because of these talents and strong motivation to pursue these skills in studies and work life, they decided to become an engineer, and therefore technical university was a natural choice for them. 'Familiarity' was also a relatively meaningful factor in their career orientation. Half of the respondents (6/12) commented that one of their parents, a sibling or a husband has studied to be, and is working as, an engineer or in a field related to engineering. Because of the example of the family, it was easier for them to enter engineering. Also, a reason for becoming an engineer was to choose something completely opposite from what their mother is doing in a soft field as an artist or in health care. In addition, a relatively important factor for nearly half (5/12) of the women was the 'security/stability' of the field. Their reason for entering to study in a technological field was being well employed and to finding a good employer. They expected to find work easier than in other fields and that technological fields are not so economically insecure, or rather the salary is better. 'Encouragement' was only somewhat important for some (3/12) of the respondents. These said that they had received support and encouragement from the family to enter a technical field or in general, and had been encouraged to get a higher education degree.

*Female technology education teacher profile*

One of the most influential career anchor identified by these women was 'technical or functional competence'. While many (9/12) of the respondents had studied honours mathematics and/or physics at school, almost all (11/12) have high-level competence in crafts, enjoy crafts and creating things with their hands. They have always liked making and building different things as a child, and were good in crafts at school. 'Familiarity' was also a meaningful factor in their career orientation (11/12). One of the parents or many members of their family are also teachers and/or working in a field related to crafts or engineering. In their family, they had always made things by their own hands, and had many skilful people who are very interested of crafts. Also a relatively important factor for these respondents was 'encouragement' (5/12), because one of the reasons for choosing to study technology education and technical craft was the encouragement from the teachers during technology education and technical craft studies at university. 'Security/stability' was only somewhat important for them (3/12). The reason for studying to become a technology education teacher was a better likelihood of finding a job, because in general the field offers good employment options even in smaller municipalities. Also, because of the new national curriculum 2016, a broad understanding and qualification in crafts will enhance working options when looking for a job. In addition, a somewhat important factor was 'limited options' of choosing a minor subject in their studies. Some (3/12) of them chose technology education and technical work because it was the only good choice as a minor subject.

*How to encourage girls to enter technology-oriented fields*

It was evident that high levels of competency and information received from their families were important factors for these women in entering the technology-oriented fields in higher education. Many suggested that school counselling and guidance should be improved in providing pupils with information about the study options and job possibilities of technology-oriented and engineering fields. There was a need to show girls that even though the engineering and technology fields, particularly mechanical and electrical engineering, still have a label of being masculine, not all fields are like that. Girls should be encouraged and provided with information and possibilities to consider the various options available in the technical fields. The participants stated strongly that good female role-model examples should be provided as encouragement for girls. The masculine world might also be a positively affecting element for some girls. Reasons like 'as a woman in a technology-oriented field, one might find work easier' and that 'the field is economically more secure and the salary is generally better than in female-dominated fields', seemed to have an effect on some females' career decisions.

Many of the participants also suggested that teachers in natural science and engineering-related subjects (mathematics, physics, chemistry and technical work) at grades 7–9 should focus more on showing the technology related skills and knowledge that are needed later in working life These subjects should enhance gender-sensitive education and create learning experiences that recognise girls' and boys' different interests. In addition, there should be more concrete working and practical studies available in science education labs. Some kinds of studies in repairing and fixing, where students concretely solve problems and fix things themselves, would teach them important skills related to technology.

## Discussion

This article presents some suggestions in relation to the striking under-representation of women in the fields of science and engineering. Firstly, it offers an overview of the elements that have an effect on women's decision to study and enter a career in technology-oriented fields. Secondly, it specifically investigates whether studying craft, and especially technical work, during basic education affects their decisions in this context.

When dealing with the theme of women in technology-oriented fields, it became evident that women have a high level of competence related to the field they chose to study and/or are working in. With technology education teachers, strong self-confidence in crafts was addressed in this context, and with engineering students, particularly skills in mathematics, but also physics and chemistry, were highly important elements. Engineering students stated their awareness of how good skills in mathematics are a tool for a wide range of pathways in higher technical education. A study of technical university students who chose an engineering education found that they seemed to be aware that their aptitudes, especially in mathematics but also in natural sciences, will bring them success (Engström, 2015, p. 124).

A theoretical understanding of mathematics and physics is needed in the technological field; but additionally, skills such as technological problem-solving, design and creativity are relevant in the engineering field. This leads to the question of potential in technology education. Technology education and technical work are relevant to the degree that they have the potential to develop students' skills in many ways by raising their awareness of the various dimensions of technology and also enhancing the creativity and innovativeness of young people. Therefore, one way to encourage girls in technology-oriented fields would be to give girls and boys equal opportunities to study technology; that is, to end the practice of asking pupils to choose between textile and technical work. Through equal craft education, girls would also have the possibility to discover technological topics and gain self-esteem in the field. However, it seems that the gender neutral curriculum changes to a gendered curriculum when it meets the reality in schools and many girls are left out of technology-related activities, as were the women in this study (Virtanen, 2012; Virtanen et al., 2015). Obviously, women in technology-oriented fields feel that their own competences are a meaningful anchor in their career. Providing girls with equal possibilities to experience technological issues is only a start. In addition to that, and in the spirit of the new forthcoming Finnish National Core Curriculum for Basic Education 2014 (NCCBE, 2014) that addresses multi-disciplinarity and integration, technical craft should be broadened towards STEM: Science, Technology, Engineering and Mathematics.

A highly influential factor for these women in choosing their career seemed to be familiarity with the field or the examples of, and encouragement from, their families. The women in this study had received plenty of information about technology-oriented fields, which was influential in their occupational choices. Five (42%) of the teachers had relatives who are, or were, teachers. On the other hand, almost all of them had relatives who did crafts as a hobby or were skilled in doing things with their own hands and, for example, had a wood/metal work shop at home. The same result of the parents' influence in this question is evidenced in other studies which state that those women who see the profession of scientist or engineer as a possible and desirable career seem to have science and/or engineering-related qualifications, knowledge, interest and contacts in their family (Engström, 2015; Sander, 2012). These women have already received a high capital of engineering, technology or crafts in their childhood, and it seems to be that their interest in technology is often strongly initiated by their father (Sander, 2012; Luomalahti, 2004).

Previous studies have shown that interest and self-efficacy with respect to technology arise early in childhood (Turja, Endepohs-Ulpe, & Chatoney, 2009; Endepohls-Ulpe, Ebach, Seiter, & Kaul, 2012). As not all parents are interested in crafts and technology, or work in a technology-oriented field, we suggest that in order to raise the interest of those girls who will have no example from their family, it is important that schools take more responsibility for providing information and role models for these possible study and career options. It is necessary to improve school counselling and guidance in providing pupils with information about their study options and job possibilities in the technology-oriented and engineering fields. In addition, teachers in the natural sciences and engineering-related subjects should focus more intensively on showing the technology related skills and knowledge that are needed later in work life, especially for girls. It seems that girls often tend to be less confident in their own technical abilities, and therefore it is important that they would receive support and encouragement from their teachers (Virtanen et al., 2015; Endepohls-Ulpe et al., 2012).

Although this research presents the results of women's career anchors in technology-oriented fields, we should not consider women as a uniform category. The technology-oriented field is a very broad concept and there were differences among the women in engineering and the technology education teachers. Moreover, the empirical study was limited to a rather privileged group of women at masters' degree level. Hence, their career concerns and aspirations might be quite different from women with less education. Even thinking of having a career depends on an individual's educational, occupational and family background. Regarding this question, there was already a difference between the women in engineering and education.

Women's presence in technological fields is essential, because diversity fosters excellence in research and innovation. As the Finnish Minister of Education, Krista Kiuru, said on 15 October 2013 in her opening speech at the first Women in Tech seminar, "We cannot afford to waste any talents. We need all the best people working together, whether women or men" (Kiuru, 2013). Could we increase girls' interest in technology education and ultimately technology-related careers by providing girls with more possibilities to come into contact with technology and acquire skills and experiences in the area? Finally, we hope that this study provides some positive perspectives on women's interests in technology-oriented career paths and that thereby supportive interventions can be implemented.

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