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Sonja Niiranen

Increasing Girls' Interest in Technology Education as a Way to Advance Women in Technology

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Editors
Timo Saloviita
Department of Teacher Education, University of Jyväskylä
Pekka Olsbo, Ville Korkiakangas
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ABSTRACT

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Technology-oriented fields are still largely male-dominated, and an effective approach for increasing the number of women in natural science and technology careers has not yet been achieved in EU countries. A related concern, particularly in Finland, is that even though gender equality and non-discrimination have long been critical concerns in education to date there has been very little of research in Finland about girls' motivations towards technical craft or technology education, nor about their relation to women's career aspirations in technology-oriented fields. The present study is my contribution to the concern of getting more women into technology by investigating how to increase girls' access to and interest in technology education in basic education, and to add to our understanding of what affects women's interests in entering technology-related careers in Finland. This dissertation is compiled from four sub-studies: a document analysis (Study 1), two questionnaire studies (Studies 2 and 3) and an interview study (Study 4). In total, the empirical data comprises of the answers of 281 pupils to a questionnaire, the answers of 24 women to a questionnaire and 7 interviews. The data analysis methods varied in each of the sub-studies by use of mixed methods, or a multi-methodological approach.

First, the findings suggest that in order to promote girls in technology education, it would be important that they would have equal possibilities to discover technological topics and gain self-esteem in the field already in primary school. Based on the findings, it is also clear that there are differences in girls' and boys' motivations concerning the contents of technology education. Thus, curriculum writers and teachers should pay more attention to girls in order to enable them to see that technology is relevant for them. Concerning women in technology-oriented fields, it is evident that the most influential career anchors were their high-level of competence and familiarity of the field. Also, based on the findings it is evident that there have been, and still might be, gender related issues in technology education and in working life. To conclude, technical craft and technology education should be developed with an eye towards gender-sensitive learning experiences and pupils should be offered the support and encouragement needed to experience new learning habits. Technology education has the potential to foster pupils' technological literacy in ways that respond equitably to human needs now and into the future.

Keywords: technical craft; technology education; curriculum; girls; women; motivation; career orientation; gendered processes; equality

Author's address Sonja Niiranen
Faculty of Education
Department of Teacher Education
P.O. Box 35
FI-40014 University of Jyväskylä, Finland
sonja.k.niiranen@jyu.fi

Supervisors Professor Mirja Tarnanen
Department of Teacher Education
University of Jyväskylä

Professor (emeritus) Pentti Moilanen
Department of Teacher Education
University of Jyväskylä

University lecturer (emeritus) Aki Rasinen
Department of Teacher Education
University of Jyväskylä

Reviewers Professor Marc de Vries
Delft University of Technology

Esa-Matti Järvinen
Adjunct professor of technology education
University of Eastern Finland, University of Helsinki

Opponent Professor Marc de Vries
Delft University of Technology

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Jyväskylä 1.8.2016
Sonja Niiranen

LIST OF ORIGINAL ARTICLES

This dissertation is based on following publications, which are referred in the text by Roman numerals I-IV:

Article I Rasinen, A., Virtanen, S., Endepohls-Ulpe, M., Ikonen, P., Ebach, J. & Stahl von Zabern, J. 2009. Technology education for children in primary schools in Finland and Germany: different school systems, similar problems and how to overcome them. International Journal of Technology and Design Education 19(4), 367–379. doi:10.1007/s10798-009-9097-5

In this article, the analysis of technology education in the five EU-countries was mainly performed by the first author. The role of the second author was on the analysis of technology education in Finland.

Article II Virtanen, S., Räikkönen, E., & Ikonen, P. 2015. Gender-based motivational differences in technology education. International Journal of Technology and Design Education, 25(2), 197–211. doi:10.1007/s10798-014-9278-8

Article III Niiranen (née Virtanen), S. & Niiranen, S. 2015. Women in technology-oriented fields. Australasian Journal of Technology Education 2. doi: http://dx.doi.org/10.15663/ajte.v2i1.29

Article IV Niiranen, (née Virtanen), S. & Hilmola, A. 2016. Female technology education teachers' experiences of Finnish craft education. Technology and Design Education: An International Journal, 21(2).

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1 INTRODUCTION

Concern has been expressed for many years due to the situation that there are relatively few women who have entered occupations in the natural sciences, engineering or technology (e.g. Klapwijk & Rommes 2009; Mammes 2004; Sander 2012; She Figures 2012, Women in STEM 2011). EU statistics (She Figures 2012) show that in recent years, because of efforts that have been made to address this problem, some of the gender gaps have been slowly shrinking and women have been catching up with men in overall employment terms and in specific fields. Even though gender equality and non-discrimination have long been critical concerns in education, there has been very little research in Finland to date about girls' motivations towards technical craft or technology education, nor about their relation to women's career aspirations in technology-oriented fields.

In terms of the ability to acquire understanding of and knowledge about technology, today's society places high demands on individuals as technologies that mediate our lives are very complex (Elvstrand, Hellberg & Hallström 2012, 163; Dakers 2011). Technology education contributes to this in different ways by providing people with required skills and technological literacy, which they need to understand and utilize to become empowered citizens of tomorrow (Compton 2011). Thus it can be construed that in order to introduce a more equitable gender balance in technology related topics in education and consequently in the labour market, attention should be focused on offering girls more opportunities to become familiar with technology and gain skills and experience in this area. This is important, especially in Finland, due to the fact of a gendered history of craft and technology education. Therefore, it is highly relevant to continue to expand our knowledge of technology education and to give attention to gender differences already in primary education.

There may be many possible factors contributing to the question of what are the main challenges in advancing women in technology-oriented fields. However, I think it is important to investigate what role technology education might have in this setting. This study is my contribution to this discourse, both within Finland and internationally. Hopefully, these findings enrich understanding of what could be done in order to increase girls' access to and interest in technology education as a way to advance women in technology-related careers in Finland.

1.1 Premises of the study

In today's society, technology is playing an increasingly important role in most people's lives and therefore knowledge and abilities learned through the science, technology and engineering lessons become vital for all citizens (Ardies 2015; Banks & Barlex 2014; Ritz & Fan 2015). Whenever and wherever each of us was born and spent our early years, we have been profoundly influenced by the technologies we have encountered (Keirl 2011, 237). Thus, engagement with technology is an unavoidably central component of people's lives, and the experiences with technology have an impact on personal interests, career aspirations and social role patterns related to technology (Volk 2007; Williams 2009). But what is technology? According to Dakers, Dow and McNamee (2009, 382) in its modern sense, technology as a concept 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, 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, Dow & McNamee 2009, 384). Technology in the broadest sense, also used with this meaning in this dissertation, 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, 11).

Technology education has been developed to help people with technology. It has a role in shaping future debates and discourses by developing technological literacy by encouraging critical thinking and by raising awareness of various dimensions of technology (Elshof 2005; Compton 2011). The community of technology education clearly has the potential to foster designerly thinking and technological literacy in ways that respond equitably to human needs now and into the future, and to work towards sustaining the ecological resources and environments upon which such developments depend (Rockstroh 2013). Technology education can provide active engagement and participation, meaningful experiences and concrete representations of activity. It has been suggested that problem-based activities can assist people to become critically literate to address issues through active engagement in both: tool-related hands-on and discursive practices of technology (Wilkinson & Bencze 2011). Technology education would be relevant to the degree that it inspires the creativity of young people to invent what amounts to a 'new', more sustainable world (Elshof 2011; Pavlova 2009). As de Vries, says, 'Design is not just a matter of choosing between alternatives. It can also be the creation of new alternatives' (de Vries 2005, 97.) Also, the more recent recognition that there is a variety of cognitive skills which can be developed and nurtured through application to a practical context provided the basis for the promotion of the notion that this constitutes a unique type of literacy—technological literacy (Williams 2009, 248).

Even though some countries have national standards for technological literacy and for technology education at all educational levels, its subject status varies and there is no common framework for teaching about technology around the world (Cross 2011; de Vries 2005). In fact, the precise identity or definition of technology education is still unclear, and there are many varying orientations towards teaching it in primary and secondary schools worldwide (de Vries 2005; Williams 2009). Also, technology education professionals and research in the field are confronted with an uncertain future by being somewhat isolated and not having a solid baseline of research (Martin 2011). Some countries, such as Finland, do not have technology education as a subject in the school curriculum. On the other hand, for example in Germany, Australia, United Kingdom and the Netherlands the role of technology education is seen as a vital component of education also in general secondary and high school level, as schools provide optional courses for all of their students (Mativo, Womble & Jones 2013). In many countries, technology education has evolved from craft education, and with curriculum changes and subject inclusions, subjects dealing with resistant materials (wood and metal), textiles and food technology have been brought together (Alamäki 1999; Cross 2011).

Another concept related to technology education is the term STEM (Science, Technology, Engineering and Mathematics), which has become established in the field of education, and technology is one of the subject areas included under the STEM umbrella. All over the world knowledge and understanding of the subjects involved in STEM are considered vital for young people in an increasingly science- and technology-driven society, and STEM education is seen as a new 'arms race' that governments are prepared to invest heavily in (Banks & Barlex 2014). The call for improved STEM education continues under the auspices of strengthening the flow of qualified people into the STEM workforce and enhancing STEM literacy for the general population (Ritz & Fan 2015).

In order to understand technology education in Finnish basic education, it is necessary to consider it within the subject of craft, especially technical craft. In Finland, there is no independent subject called technology education or STEM education in basic education; rather, the education on these topics is currently decentralised and taught through various subjects (Autio, Hietanoro & Ruismäki 2011; NCCBE 2004; NCCBE 2014). However, craft education, especially technical craft, can be seen as supporting technology education due to the fact that as early as 1866, Uno Cygnaeus described 'technological' content as an important aspect of craft education (Rasinen, Ikonen & Rissanen 2006, 449).

Equivalent school subjects with similar objectives can be found for instance in ’Design and Technology’ (UK), ’Slöyd’ (Sweden) and ’Design, wood, metalwork, and home economics’ (Denmark) (Lepistö & Lindfors 2015). Since those times, boys have traditionally studied technical craft while girls have studied textile craft. Craft education is a practical subject with hands-on activities, and pupils actively practise experimentation, investigation, invention, problem solving and designing skills. In craft education workshops (technical and textile), pupils are working with different materials and techniques when working with their projects.

When considering the relation of technology education and the craft subject, technology as a concept was only introduced—but not defined—for the first time in the Finnish Framework Curriculum for Comprehensive Schools in 1985 as a component of the craft subject, ‘technical work and textile work’ (Rasinen, Ikonen & Rissanen 2011, 99). In the next Framework Curriculum for Comprehensive Schools in 1994, technology was more clearly mentioned in the general objectives of the curriculum, however, the document did not give operational instructions on how to study technology (Rasinen et al. 2006). Finland’s National Core Curriculum for Basic Education 2004 (hereinafter NCCBE 2004), which is still in effect, introduced seven cross-curricular themes in Finnish education, one of which is ‘Human beings and technology’, that self-evidently addresses technology education. The objectives of this theme dictate that basic education has to offer pupils fundamental knowledge of technology, its development and impacts; it also has to guide pupils towards sensible choices and lead them to consider the ethical, moral and equality issues associated with technology (NCCBE 2004). These themes should have the central emphasis in educational and teaching work and they should be included in studies of various subjects. Even though technology education remains undefined in any depth, it appears that much of the technological content of the ‘Human beings and technology’ theme is studied during technical craft lessons and they share same specific aims (Järvinen & Rasinen 2015). Also, pupils seem to think there is a connection between manual skills and technology due to the fact that 90 % of the pupils regarded them as interrelated (Järvinen & Rasinen 2015).

Despite of the guidelines of NCCBE 2004, most schools in Finland have still guided pupils to choose between technical and textile craft after grade four and teaching and learning of craft has been based on traditional gender segregation (Lepistö & Lindfors 2015; Wakamoto 2012). Based on a performed re-analysis of the assessment data of Finnish National Board of Education 2010 by Hilmola (2015), many schools in Finland still guide pupils to choose between technical and textile craft after grade four (see also NCCBE 2004). The data of 4,792 pupils revealed that even though the gendered division between technical and textile craft still exists, more girls are choosing technical craft than before, although boys are not choosing textile craft (Hilmola 2015). According to those data, 52.4% (1,275) of the girls studied only textile craft and 59.4% (1,444) of the boys studied technical craft. A total of 9.1% (221) of the girls but only 0.7% (18) of the boys chose opposite to the prevailing trend for their gender, with the girls opting for technical craft and the boys opting for textile craft. Depending on the school's policies, some pupils did not choose between the crafts but studied both equally. In the data of 4,792 pupils, 37.6% (915) of the girls and 38.7% (940) of the boys studied both technical and textile craft. (Hilmola 2015.)

The guideline in Finland's new National Core Curriculum for Basic Education 2014 (hereinafter NCCBE 2014) is that craft should be an integrated subject for girls and boys during compulsory lessons in grades one to seven. Then, craft should include instruction in both technical craft and textile craft for all pupils at the basic education level. The objectives of the above guideline dictate that it will not be possible to teach crafts based only on the contents of either technical craft or textile craft; rather, the contents of both crafts will be needed when the NCCBE 2014 is implemented. There is also a distinct argument that in the teaching of crafts, methods relating to both technical craft and textile craft are used. The main change from the NCCBE 2004 is the fact that the core contents of technical craft and textile craft will no longer be taught or referred to separately. Pupils' own interests in implementing craft education will be emphasised in the future, but the interpretation of this in practice remains to be seen when the new curriculum comes into effect in August 2016.

In terms of discipline, this dissertation is situated in education and more specifically in the field of technology education. The four sub-studies included in this dissertation continue the tradition of technology educational research that originated at the department of teacher education in the University of Jyväskylä where lecturers Matti Parikka and Aki Rasinen conducted the first technology education experiment beginning in 1991. During this experiment three doctoral dissertations related to technology education were finalised in Jyväskylä (Kantola 1997; Parikka 1998, Rasinen 2000). During the years 2007–2009 I took part in the European Union funded project called Understanding and Providing Developmental Approach to Technology Education (UPDATE) project, which is where I found the inspiration for this research. The technology education team in the department of teacher education, referred to as the 'E-team', has focused on research that relates to developing technology education curriculum as well as pedagogical and gender aspects in technology education. This dissertation is also related to research in psychology and sociology on the issues of motivation, career aspirations and equality.

1.2 Aim and structure of the dissertation

In embarking on this research, my purpose was to gain a deeper understanding of what could and should be done in order to increase girls' access to and interest in technology education in basic education and ultimately women's interests towards technology-related careers in Finland. In order to investigate those issues, I have compiled four sub-studies, introduced briefly in this dissertation. The original articles on each of the sub-studies are given as appendices at the end of the dissertation. All these four studies, with their own specific aims and research questions, investigate issues related to technology education and gender in basic educational schools in Finland and women in technology-oriented fields.

Study 1 (Article I) aims to define technology education, with a special focus on describing Finnish technology education in detail based on Finland's current NCCBE 2004. Then, in order to produce broad knowledge on primary school aged pupils' motivations and interests in technology education, Study 2 (Article II), an empirical study, aims to clarify pupils' motivation towards technology education and technical craft in primary school. In Study 3 (Article III), also an empirical study, the research focus was broadened to include adults, women, who have actually entered a career in a technology-oriented field. The aim of the study was to explore what are the main factors that have an effect on women's decisions to study and enter a career in technology-oriented field and, specifically, to investigate whether studying craft, and especially technical craft, during basic education affects their decisions. Study 4 (Article IV) also focuses on women in a technology-oriented field. The aim of the study was to explore inequality that women may experience when studying and working in technical craft and technology education. Specifically, this study focuses on investigating the gendered processes that might exist in the area of craft education, especially in relation to technical craft in Finland. A semantic overview of these sub-studies and their relation to the general aim of this dissertation is given in Figure 1.

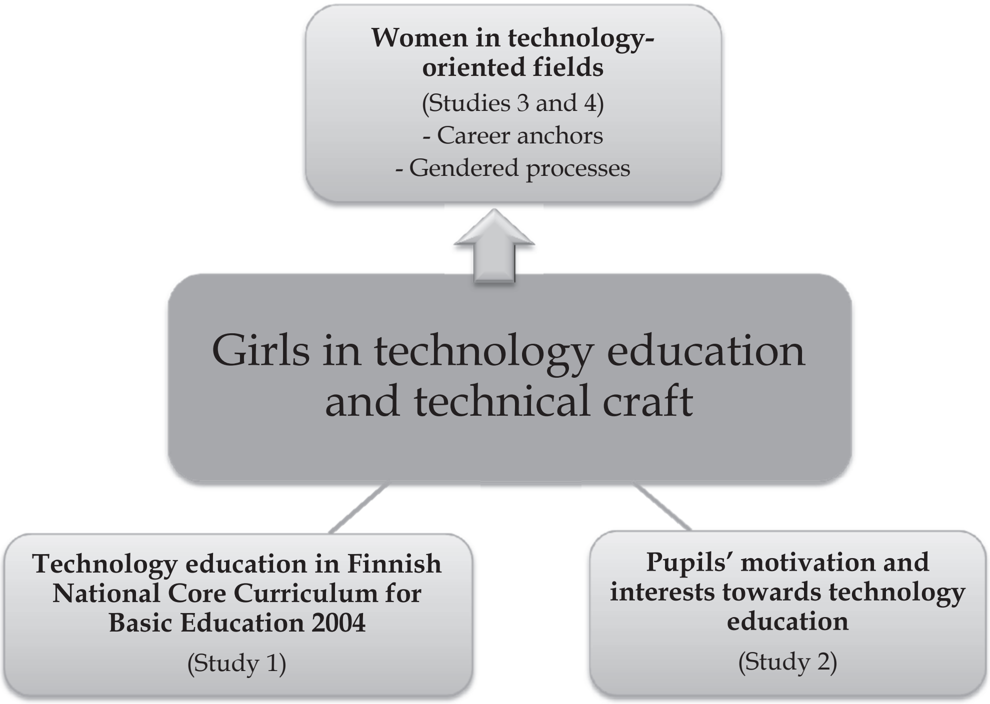

FIGURE 1 A semantic overview of the four sub-studies included in this dissertation

The structure of the dissertation is as follows. In Chapter 2, I introduce the background and the contexts related to the four sub-studies. This chapter is divided into four parts that reflect topics related to girls and women in technology: 2.1) women in STEM fields, including a discussion about the problematic situation of technology as a male-dominated area; 2.2) motivational differences between girls and boys in technology education; 2.3) women in technology-oriented fields; and 2.4) gender equality and inequality regimes women may experience when studying and working in today's technology-oriented fields. The third chapter describes the methodologies of the sub-studies, i.e. research questions and how data were collected and analysed. In Chapter 4, I summarise the main findings of each of the sub-studies. In Chapter 5, first I discuss the findings of the four sub-studies as pieces of an integrated solution by highlighting some practical suggestions for developing technology education in the future. After the discussion, I reflect on the research process and address the ethical considerations included throughout each study. Finally, I offer some viewpoints for future research.

2 THEORETICAL BACKGROUND OF THE STUDY

In the following section, I discuss the theoretical starting points and main concepts used in this dissertation. My intention is to position the study within the field of educational and technology educational research. Thus, I will first begin with outlining the central premises of the current situation concerning women and technology (2.1). Next, I will review in detail the concepts of motivation (2.2), career anchors (2.3) and gendered processes (2.4) that are related to the four sub-studies I have carried out. Within this framework I aim to introduce perspectives connected to girls' in technology education and women in technology.

2.1 Women in technology

Technology has a deeply gendered history, and the discourses relating to gender and technological activity reflect this fact by labelling it 'masculine' and 'not a place for a woman' (Layton 1993, 35 in Murphy 2006). When defining gender, I see it as it has been presented in Gendered Innovations (2013, 9) as a 'socio-cultural process that refers to cultural and social attitudes that together shape and sanction 'feminine' and 'masculine' behaviours, products, technologies, environments, and knowledge'.

In general, Western masculinity is associated with independence, self-reliance, strength and leadership, and femininity with conformity, passivity, nurturing and concern for people (Riggs 1994). Even at a young age, children experience social processes that expose them to ideas of what it means to be a girl or a boy in their society, and they start to construct their identities through observation of others and participation in communities such as peer groups (Paechter 2007). Additionally, other people in their lives, such as parents and educators, also have an influence on reinforcing the development of early gender-typed attitudes and behaviours or punishing those that contradict gender norms (Turja, Endepohls-Ulpe & Chatoney 2009). Although there is a scarcity of technology education research concerning the early childhood years, it has been pointed out that one aspect of learning gendered behaviour patterns, identified in the early 1980s, is the impact of children's toys and play (Francis 2010; Elvstrand, Hellberg & Hallström 2012). Children are directed towards certain types of play, and provided with certain kinds of toys, which afford opportunities for girls to develop communication skills and emotional literacy, and for boys to develop technical knowledge and skills (Francis 2010). It has also been suggested that girls have difficulty in building a relationship with technology, which could serve to promote their interests in technological careers and activities, because they have less experience than boys in playing with technological toys (Mammes 2004). It appears that girls use technology in a different way compared to boys. When constructing something, girls often have a special purpose (an object for use) when building something they need in play; boys on the other hand more often see the process of construction itself as play, and the main purpose of the playing (Elvstrand et al. 2012).

Murphy (2007) indicates that if learning is thought as a process of creating meanings, among other things, then it can be understood as a relationship among people in an activity. In this process, gender is a significant influencing element embedded in our thinking and routines (Murphy 2007, 239). She also adds that often when attempting to represent masculinity and femininity, they are placed in opposition; in other words, what one is, the other is not (Murphy 2007, 240). Blaine (2007) argues that even if categories help us to economise our cognitive resources and develop stereotypes, we simultaneously risk discarding a great deal of individual information. Also, these group-based beliefs do not provide very accurate information about the individuals who belong to the group (Blaine 2007). Madureira (2012) clarifies that the concept of gender is always viewed in a socio-cultural context. From that perspective, embedded beliefs, values, stereotypes, prejudices and practices mark what is socially expected from men and women (Madureira 2012). However, as Goffman (1979) claims, there is no static gender identity, only a learned capacity to absorb and provide depictions of masculinity and femininity (McDermott 1996, citing Goffman in Murphy 2007, 240).

Even though technology is somewhat neglected in early childhood education curricula in EU countries, boys are able to maintain their interest in technological topics and activities while girls tend to turn away from technology at an early age (Turja et al. 2009, 362). However, 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 feel that a technical profession matches their self-image (see Eccles 1987). Regardless, 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, 405). They also tend to be less confident with their capacities and their attitudes towards natural sciences were less positive compared to boys (de Weerd & Rommes 2012).

Based on various studies, it is evident that an increase in the number of women in technical careers has not yet been achieved in EU countries, and the reluctance of women to enter occupations in the natural sciences or technology is still a challenge that many educators confront all over the world (e.g. Klapwijk & Rommes 2009; Mammes 2004; Sander 2012; She Figures 2012). Girls are, on average, more successful at school, and tend to achieve higher grades than boys, but they less frequently enter science, engineering or technology paths of study (Endepohls-Ulpe 2012; She Figures 2012). There are, however, some differences between European countries in terms of women pursuing careers in science and technology—for example, the number of women in STEM fields in Eastern European countries (especially in Bulgaria and Romania) is notably higher than in other European countries (Quaiser-Pohl 2012). Quaiser-Pohl (2012, 54) reflects that the reasons for the differences between the different countries lie in various factors of their political and social structures, e.g. the educational system of a country and its economic situation, and in its public and private institutions.

2.2 Girls' motivation towards technology education

Technology has become ubiquitous in societies, and people constantly need to acquire various new technological skills and knowledge to manage daily tasks. Consequently, it is important that technology education incorporates all children in the provision of equal opportunities for technological literacy. Research measuring pupils' motivation and attitudes towards technology, as well as gender-related interests in technology, has been gaining momentum. In general, girls tend to have negative attitudes towards STEM, and they also appear to have lower self-efficacy as well as lower intellectual and practical interest in STEM-field subjects. (Ardies, De Maeyer & Gijbels 2013; de Vries 2005; Endepohls-Ulpe, Ebach, Seiter & Kaul 2012.) A striking result in a study of women in the science, technology, engineering and mathematics professions was that not one of the 15 women questioned said that their interest in science or technology was in any way evoked in kindergarten or at primary school (Sander 2012).

When considering girls' interest towards technology education and learning, motivation is in a central focus. Ryan and Deci (2000) argue that the concept of motivation reflects the natural propensity for human beings to learn and act, so that a person who feels inspired to act in a certain way and is energized or activated towards achieving a specific end is considered motivated. Motivation is a multifaceted, dynamic phenomenon; people not only have different amounts, but also different kinds of motivation (Ryan & Deci 2000). Motivation can be divided into two basic categories: intrinsic and extrinsic motivation. Intrinsic motivation refers to doing something because it is inherently interesting or enjoyable while extrinsic motivation refers to doing something because it leads to a distinct outcome or reward (Ryan & Deci 2000). It can be also argued that there is a third motivational construct, amotivation, which occurs when someone does not perceive contingencies between actions and outcome (Autio et al. 2011). A propensity for intrinsic motivational tendencies appears to be expressed under specific conditions that elicit, sustain and enhance this special type of motivation versus those that subdue or diminish it (Ryan & Deci 2000). The meanings derived from situations are linked to one's existing purposes, goals and intentions and can therefore be catalysed in various situations (Hill 2007; Ryan & Deci 2000). Also, depending on the era and educational culture, definitions of motivation emphasize either intrinsic or extrinsic factors as its main driving force.

Kosonen (1996) states that a person is always in a state of motivation that is affected by her/his goals, motivational orientation or direction, earlier experiences, knowledge and skills, emotions, social interactions and attitudes. People's goals, as well as perceptions of their work in a particular learning task, play a significant role in determining their motivation as well as the strength of their individual motives (Kosonen 1996; 2010; Shachar & Fischer 2004). Kosonen (1996) adds that motivation can be divided into various kinds of motives, which function as a basis for conceptualising it. In her theory, the motivation categories are described as (1) motives based on emotional experiences, (2) motives based on accomplishment and achievement, (3) motives based on social interaction, (4) motives based on external incentives, (5) motives based on benefits and rewards and (6) motives based on reluctance (see Kosonen 1996). Johnson and Johnson (1985) have defined how the motivation to learn is generated through interpersonal processes that are also determined by the social interactions among learners and/or teachers within the learning situation. These interactions create different motivation systems, which in turn affect learners' achievement levels and expectations differently (Johnson & Johnson 1985). Therefore, motivation is always defined by the values of an individual student, and intrinsic and extrinsic factors contribute to their motivation (Hytti, Stenholm, Heinonen & Seikkula-Leino 2010).

One complementary approach to define motivation is to focus on learners' interests. Interest in this context refers to choosing something among alternatives or favouring something over its alternatives (Rust 1977). Hidi and Harackiewicz (2000) distinguish between individual and situational interest. According to them individual interest is seen as a relatively stable motivational orientation towards some particular topic, while situational interest refers to a short-lived, situation-specific interest (Hidi & Harackiewicz 2000, 152). Differences in school subjects and contents therefore have an effect on learning, depending on how important they are felt to be. Interestingly some studies show that activity-oriented subjects (music, craft and technology, art education) are the most popular and most motivating subjects for pupils in basic education (Hilmola 2011; Juntunen 2011; Laitinen 2011; Seiter 2009).

When looking for possible differences between girls' and boys' ambitions and motivations it is evident that there are some significant variations regarding attitudes towards technology. In general boys find technology less boring than girls, and this interest becomes even greater with age, resulting in boys becoming much more interested in technology (Ardies, De Maeyer, Gijbels & van Keulen 2015). Behavioural and personality differences between girls and boys can be seen already at a young age when children play. Girls play in smaller groups and are more tolerant with rules, and for them the game itself is less important than the relationships between the participants (Riggs 1994). It has been shown that girls state a preference for working together, and social interaction between the pupils in a classroom is evidently important for girls (Murphy 2007). However, in classroom work pupils appreciate having responsibility and autonomy for their own learning, and this is an essential aspect of technology education pedagogy. A study of autonomy-supportive teachers highlighted that those teachers who supported students' autonomy and initiative created more intrinsic motivation in their students (Reeve, Bolt & Cai 1999). Evidently teachers play an important role as socializers by influencing students' motivation and attitudes towards technology.

Studies have revealed that interest and self-efficacy with respect to technology arise early in childhood (Endepohls-Ulpe et al. 2012). Parents, especially when they have a profession related to technology and children's technological toys at home, have a positive influence on their children's attitudes when they are young (Ardies et al. 2015). It has been shown that several activities and themes in early childhood education could be included to promote technology education by sparking children's interests towards it and initiating discussions about it (Turja et al. 2009). Studies have also indicated that already at the primary school level, boys are more self-confident than girls in learning technical skills, and despite an equal or nearly equal achievement between girls and boys in mathematics, it is noted that in science and technology education girls need to receive more encouragement and appreciation for their competence from their teachers (de Weerd & Rommes 2012; Endepohls-Ulpe 2012; Jakku-Sihvonen 2013; Murphy 2007). Although female students may be equally or even better qualified than their male fellow students, they often decide in favour of typically female professions thereby giving away the chance to shape technology according to their own interests (Sander 2012).

It is critical for teachers and educators to be interested in understanding what motivates students to learn. By engaging them with meaningful activities and by supporting them in their studies students can be helped to see technology as a field of relevance for their everyday activities and their future careers.

2.3 Women in technology-oriented fields

The opportunities women have to shape their own lives have dramatically increased in the past few decades (Quaiser-Pohl & Endepohls-Ulpe 2012). Technology-oriented fields, however, are still a rather male-dominated area, nor has an effective approach for achieving a higher number of women in natural science and technology careers yet materialised in EU countries. The reluctance of women to enter occupations in the natural sciences or technology has already been established in number of previous studies (e.g. Klapwijk & Rommes 2009; Mammes 2004; Sander 2012). Based on the statistics of She Figures (2012, 18) the share of women among highly educated people working as professionals or technicians is 53%, but the proportion drops to 32% among women employed specifically as scientists and engineers, a narrower category of employment. The preliminary results of She Figures (2015) indicate that despite positive signs, large differences remain when it comes to the subjects that women and men study in higher education. For example, women's representation in engineering, manufacturing and construction studies remains low (She Figures 2015). This exemplifies the problem of gender segregation.

In relation to the recruitment for technical professions, women are often treated as a homogeneous group (Klapwijk & Rommes 2009). However, factors influencing career development are broad and are often distinguished as being intrapersonal and contextual (van Tuijl & van der Molen 2015). The choices that men and women make are influenced by the particular options that are available to them, by each person's basic goals, motivation and self-definition, as well as by the balance between the attainment value and the perceived costs of various options (Endepohls-Ulpe et al. 2012). The low interest of women in STEM fields is a complex problem and requires more research to explain the variety of factors contributing to this lack of interest. While students' individual hierarchical patterns of occupational values, such as their interests, enjoyment, perceived competence or self-efficacy are influential to their career aspirations, 'subjective task values' (STV)—the perceived values of various subjects or activities—also play a key role in the choices individuals make regarding their further education and occupation (Chow, Eccles & Salmelo-Aro 2012; van Tuijl & van der Molen 2015).

Schein (1996) has conceived the concept of career anchors that describes an individual's 'internal career', which he defines as 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, motivations and needs (Schein 1996). The following anchor categories (a modified version of Schein 1996; Klapwijk & Rommes 2009) present a person's orientation toward their 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 permanent employment for a longer period of time. Nowadays, this anchor should be extended to include 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 the possibility of integrating more than one career and personal family concerns into a coherent overall pattern.
Technical/ Functional competence	Presents a person's orientation to an 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 orientation to a 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 for him- or herself.
Service/ Dedication to a cause	Presents a person's orientation to the ambition to choose a profession in order to achieve certain ideals such as serving humanity or improving the environment.
Pure challenge	Presents a person's orientation to defining his or her career in terms of overcoming all odds, and a preference for constantly seeking variation and new challenges rather than concentrating on a single functional skill.

Schein initially developed the career anchors concept to describe individuals' inner career orientations, but especially nowadays, outer factors must also be taken into account to describe peoples' orientation to decide what they want to do in their lives. Also, it is argued that traditional career theories have largely been premised on male experiences, values and goals (Mavin 2001). With a masculine image of technology and technical sector professions, career anchors need to be revised in order to provide a wide range of information in relation to women's career aspirations.

It is evident that individuals are susceptible to influence from their families with regard to occupational choices, especially in relation to technical careers (Beauregard 2007; Sander 2012). Regarding parents' or families' influence on women's occupational choices, it has been stated that those children who have a father and/or mother with a technological profession have greater ambitions for pursuing a technological job themselves, and are more interested in and less anxious about technology (Ardies 2015). Studies also indicate that women who see the profession of scientist or engineer as a possible and desirable career have science and/or engineering-related qualifications, knowledge, interest and contacts in their family (Engström 2015; Sander 2012). Also, these women's interests in technology and science are often initiated by their father (Sander 2012; Luomalahti 2004).

When dealing with the theme of women in technology-oriented fields, studies indicate that women who choose to study and work in technology are confident in being good at technical things, and have acquired skills and experience in that area (Eccles 1987; Sander 2012). Those female technical university students who chose an engineering education were aware that their aptitudes, especially in mathematics but also in natural sciences, that would bring them success (Engström 2015). Another study of motivational factors for taking up a career in a technological field revealed that compared with their non-engineering peers, both male and female engineering students reported higher self-efficacy, and intellectually- and practically-based interests regarding technical themes (Endepohls-Ulpe et al. 2012). It appears that stereotypically technology-oriented fields are insufficiently associated with values such as creativity, service, autonomy and entrepreneurship (Klapwijk & Rommes 2009, 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 revolves around creative problem solving skills supported by a fundamental understanding of the scientific principles and practical tools related to the domain.

Peoples' attitudes develop slowly and over a long period of time, making it difficult to influence on them through learning activities that are not sustained (Volk 2007). In addition, studies indicate that a student's career aspirations are largely stable from the age of 14, but are not linear and can be influenced by education (Ardies et al. 2015). Therefore, schools and teachers in the natural-sciences- and technology-related subjects should focus more intensively on providing information about the broad range of vocations, activities and opportunities that STEM fields offer.

Women's presence in technological fields is desirable due to the fact that diversity fosters excellence in research and innovation (Gendered Innovations 2013). This leads to the question of what are the main challenges in advancing women in technological fields?

2.4 Gendered processes

As presented in Gendered Innovation (2013) gender is an important factor that influence to the ways we speak, our mannerisms, the things we use, and our behaviour, which all signal who we are and establish rules for interaction. Moreover, gender norms refer to attitudes about the behaviours, preferences, products, professions, and knowledge, which are appropriate for women and/or men. Gender norms draw upon and reinforce gender stereotypes, which are widely held, idealized beliefs about women and men, femininities and masculinities. These norms are produced through social institutions such as families, schools, workplaces, and universities and within wider cultural products such as textbooks, literature (e.g. fairy tales), films, and video games. (Gendered Innovation 2013.)

All organisations have inequality regimes, which can be defined as loosely interrelated practices, processes, actions and meanings that result in and maintain class, gender and race inequality (Acker 2006). Acker (1990) argues that an organisation or any other analytic unit, for example, a family, has gendered patterns based on distinctions between masculine and feminine or male and female. These patterns include advantages and disadvantages, exploitation and control, action and emotion, and meaning and identity (Acker 1990, 146). She also describes how these social processes are often complex and gendering occurs in various interacting processes that are parts of the same reality in practice, although analytically distinct (Acker 1990). According to her, the first set of processes is the construction of divisions of labour (Acker 1990, 146). These processes are allowed behaviours, allowed locations in physical space and allowed power, including institutionalised means of maintaining divisions in the structure of labour markets or in the family. The second set of processes is the construction of symbols and images (Acker 1990, 146) that explain, express or reinforce divisions between women and men, and take many forms for example in language, ideology, dress. The third set of processes, that produces gendered social structures involve interactions between women and men (Acker 1990, 146–147) including all of those patterns that result in the enactment of dominance and submission. These processes help to produce gendered components of individual identity, which may include awareness of other aspects of gender such as choice of appropriate work, language use or clothing, and presentation of self as a gendered member of an organization (Acker 1990, 145–147).

Gender equality and non-discrimination have long been of primary concern in Finnish education, and these factors are set to attain legislative status based on the renewed National Core Curriculum for Basic Education 2014 (Committee on Alleviation of Segregation 2010; Curriculum Reform in Finland 2016). It has been claimed that basic education still demonstrates a very traditional image of gender roles to their pupils (Berg, Guttorm, Kankkunen, Kokko, Kuoppamäki, Lepistö, Turkki, Väyrynen & Lehtonen 2011, 98; Kokko 2008). In spite of many years of curriculum work around gender equality, education in craft is still often gendered because girls mainly study textile craft with a female teacher, while boys study technical craft with a male teacher (Kokko & Dillon 2011). Is basing technology on domestic roles the way to express to girls what kind of technology they need (see Murphy, 2007)? Such a marked gender difference in school must have an effect on girls if they are planning a future career in a technology-oriented field. It has been shown, for example in the UK, that many professions still seem to remain gender-segregated, meaning that many jobs are either male or female-dominated and most children and young people continue to prefer gender-appropriate jobs dominated by their own sex (Miller & Hayward 2006).

If gender is viewed as a social construction that emerges as pupils commit to meanings and positions (e.g. gendered processes) while participating in activities in subject contents, then its influence on pupils can be changed (Murphy 2007). Technology education should focus on providing pupils gender-sensitive learning experiences that recognise both girls' and boys' different interests as individuals. To achieve this, attention should be paid to dismantling assumptions about what girls and boys can and want to do, and pupils should be offered the support needed to develop new learning habits (Murphy 2007). Furthermore, in order to help pupils to develop their attitudes towards technology and find their own position in relation to it, technology education should be expanded to include a broader view of technological practices, which embrace wider and more future-oriented conceptions of technological activity and careers (Murphy 2007, 250).

Education can be considered to have an important impact on preparing children and young adults to participate in the rapidly changing technologies of the future and to provide them with the abilities and knowledge necessary to perform a wide variety of jobs (van Tuijl & van der Molen 2015). Indeed, there is increasing evidence of the importance of career-related decisions made during the primary school years (Auger, Blackhurst & Wahl 2005). Teachers are playing a key role in dismantling gendered practices and renewing the image of technology education, because they are well placed to alter pupils' perceptions and indeed their whole identity (Murphy 2007).

3 RESEARCH METHODS

In this research, my general aim has been to provide information about two research questions: 1) How can girls' access to and motivations in technology education be increased in Finnish basic education? and 2) What affects women's interests in entering technology-related careers in Finland? What both of these perspectives have in common is whether increasing girls' access to and interest in technology education at the basic education level might ultimately increase the number of women who enter technology-oriented fields in Finland. To do so, I have implemented four separate sub-studies each dealing with different issues related to female pupils at schools and adult women employed or studying in technology-oriented fields.

3.1 Methodology of the four sub-studies

Each of these studies approaches the main research task from a different point of view, in order to gain a holistic picture of the research topic. In each study, different data and analysis methods were utilised, and were determined by depending on the aim and focus of the research. This way it was possible to include a variety of groups related to my research interests and to discover new valid elements related to the data. The methods are presented in more detail in the original studies (Articles I-IV), however in the following sections I provide a brief introduction that summarises these studies and their research questions, empirical data and analysis methods (see Table 2).

TABLE 2 Overview of the specific research questions, the data, and the analyses used in the sub-studies

Sub-study	**Title of original article**	**Research questions**	**Empirical data**	**Analysis method**
Article I (Study 1)	Technology education for children in primary schools in Finland and Germany: different school systems, similar problems and how to overcome them	What is technology education in Finland?	Finnish National Core Curriculum for Basic Education 2004	Theory-oriented qualitative content analysis
Article II (Study 2)	Gender-based motivational differences in technology education	What is the structure of pupils' motivation towards technology education in primary school grades five and six? What are the main differences between girls' and boys' motivations?	Questionnaire completed by pupils (n=281)	Explorative Factor Analysis (EFA), *t*- tests
Article III (Study 3)	Women in technology-oriented fields	What are the main elements that have an effect on women's decisions to study for and enter a career in technology-oriented fields? Specifically, does studying crafts, and especially technical craft, during basic education affect their decisions in this context?	Semi-structured questionnaire (n=24)	A qualitative theory-oriented content analysis

Article IV (Study 4)	Female technology education teachers' experiences of Finnish craft education	What are the inequality regimes women may experience when studying and working in today's technology-oriented world? Specifically, do gendered processes exist in to technical craft field?	Semi-structured theme interviews	A qualitative theory-oriented thematic analysis

3.2 Study 1

The aim of the first study was to define technology education with a special focus on describing Finnish technology education in detail. This study reported the results of the European project called UPDATE (Understanding and Providing a Developmental Approach to Technology Education) Workpackage 3 (WP3). The data for this study consisted of the pre-analyses of the curricula made in collaboration with WP3 project partners during 2007-2009 and of Finland's NCCBE 2004 document. The five EU countries included in the study were Austria, Estonia, France, Germany and Finland. The content analysis for the five EU curricula was created by assessing successive parts of the pre-analysed curriculum documents based on certain criteria or elements for coding. Aki Rasinen (the first author of Article I) was the principal investigator in this project and carried out a large part of this analysis.

My role was specifically to perform the detailed analysis of the Finnish NCCBE 2004. Therefore, in addition to the previous comparison, a concentrated theory-driven content analysis was carried out for the NCCBE 2004. When performing the analysis of NCCBE 2004, an integrated theoretical framework (see Article I) was created and utilized in the analysis. This framework was developed to provide more concise guidelines for the analysis by presenting more detailed contents and pedagogical aspects for technology education. The framework was an adaptation of two models: Parikka's (1998 see Appendix 1) model for defining the concept of technology and Parikka's and Rasinen's (1993 see Appendix 2) model of definition of technology education. In addition to these two models, concepts used in the framework were categorised, when creating the framework, into levels 1–3 to create a hierarchy for a multidimensional concept of technology and to describe the development of pupils' technological literacy step by step. Thus the levels described the mental processes of pupils' understanding and the level of technological competence.

Qualitative, theory-driven content analysis was determined to be the best method for describing the meanings of qualitative material in a systematic way due to the use of pre-determined analytical criteria, because as Schreier (2012) argued, if there are certain criteria or a theory for interpretation, meanings can be more standardised. The advantage of using theory driven (framework or criteria in this study) qualitative content analysis was that the procedure provided categories to centre the analysis. These aspects in a framework guided in interpretation and provided headings for textual descriptions. In the analysis, the detailed textual descriptions of the objectives and contents of each subject and cross-curricular theme in the NCCBE 2004 were categorised into the levels 1–3.

3.3 Study 2

The second study was driven by the need to examine what would raise girls' interest in technology education and encourage them to see technology as something relevant for them. In order to produce broad knowledge on primary school aged pupils' motivations and interests in technology education, it was relevant to expand the perspective to study pupils at school and to compare girls' and boys' motivations. To do so, a quantitative questionnaire study was conducted via a structured questionnaire for pupils in the fifth and sixth grade (n = 281, 144 girls and 137 boys). A questionnaire study allowed me to gather a quantitatively larger data set and therefore it was possible to gain representative knowledge on the phenomenon. Potential schools were asked whether they wanted to participate in the study, and once they agreed paper questionnaires were printed and sent to the schools in 2009. Seven schools took part in the study. The schools varied in their size and location, including bigger and smaller schools from both cities and rural areas in Finland, representing the overall situation in Finnish craft and technology education. In schools, classroom teachers asked pupils to fill in the questionnaire and then the teachers returned them to me.

The questionnaire consisted of questions concerning pupils' backgrounds (e.g., age and gender), whether pupils had studied technical craft, textile craft, neither or both in school, as well as a series of motive statements (1-32, see Article II). In this study, a motivation instrument from Kosonen (1996) was applied to investigate the structure of pupils' motivations. However, the questionnaire was modified in order to obtain information about essential aspects of technology education that was not described in Kosonen's instrument. In her study, she created motivation categories based on a factor analysis in order to study pupils' motivations in music. Craft and technology education is similar to music as instruction of both of these subjects provides pupils with tools and skills to develop their own identity and do practical things. The difference between the subjects is self-evidently in the contents and in the working processes. The motivation categories that were used in this study were (1) motives based on emotional experiences, (2) motives based on the contents of technology, (3) motives based on accomplishment and achievement, (4) motives based on social interaction, (5) motives based on reluctance and (6) motives based on the working process. The category 2 was modified in order to obtain information about the contents of technology education and the category 6 was replaced to investigate the aspect of working processes in technical craft and technology education.

An ordinal Likert scale measurement was created to measure the level of agreement of the participants. Pupils were asked to mark their degree of agreement or disagreement on, for each motive statement, on a Likert scale of 1=I fully agree to 4=I fully disagree. Likert scale is the most widely used scale in surveys and typically it is five-levelled. Designing a scale with balanced keying, an equal number of positive and negative statements can obviate the problem of acquiescence bias or tendency of participants to answer 'I don't know'. Especially with children the use four-level Likert scale is preferable (Metsämuuronen 2009).

In the analysis phase, a Principal Component Analysis (PCA) was performed first in order to obtain the information necessary for determining if the data may be used in subsequent analysis. The idea of using the PCA was to investigate redundancies by variable procedure. This method is used in a situation like this study where there are a number of variables and there is an assumption that they would inter-correlate under more general, underlying variables. O'Rourke and Hatcher (2013) explain that PCA is virtually identical to Exploratory Factor Analysis (EFA), but that there are significant conceptual differences between the two, and both methods can be used to identify groups of observed variables that tend to hang together empirically. Factor analysis is used when the researcher believes that one or more unobserved or latent factors exert directional influence on participants' responses to observed variables (O'Rourke & Hatcher 2013). These variables with high inter-correlations will measure one underlying variable, which is called a factor.

Factor analysis is mostly used for large data sets to create indices with variables that measure conceptually- similar things (Metsämuuronen 2009). It is a useful tool for investigating variable relations for complex concepts such as motivation. Therefore, in order to examine the structure of pupils' motivations towards technology education, an Explorative Factor Analysis (EFA) was performed on the motive statements. EFA is used when there is not a definite predefined idea or structure of the variables. EFA helps the researcher identify the number of such latent factors (O'Rourke & Hatcher 2013). Maximum Likelihood was used as the method of extraction while the rotation method utilised was Direct Oblimin (for more detail see the original Article II), which allows for the correlation of factors. After extracting the factors using reliability-measurement-counted EFA, mean scores and Cronbach's alphas, the reliability coefficients for the mean scores were computed using the obtained factor structure as a basis.

Then independent samples *t*-tests were used to examine gender-related differences in pupils' motives. Also, Cohen's *d* was used to indicate the magnitude of the difference between girls' and boys' means.

3.4 Study 3

In the third study, the research focus was broadened to include adults, women, who have actually entered a career in a technology-oriented field. The study sought to determine what are the main factors that affect women's decisions to study and enter technology-oriented fields and, specifically, to investigate whether studying crafts, and especially technical craft during basic education affects their decisions. This study was carried out using a semi-structured questionnaire, and the data were collected in 2014-2015. Potential participants were asked to participate in the study, and questionnaires were sent by email for those who agreed. The study group consisted of 12 female technical craft and technology education teachers who graduated from various universities in Finland and 12 female engineering students from the Tampere University of Technology and Aalto University's School of Engineering. The rationale behind choosing participants from these different areas of technology was a desire to investigate whether these women shared similar reasons for entering careers in technology-oriented fields.

The teachers worked in schools of basic education and taught technical craft and 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 European Credit Transfer and Accumulation System (ECTS) units of technical craft and technology education. 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 technical craft and technology education. The primary school teachers in this study had graduated from the Department of Teacher Education in Jyväskylä, University of Jyväskylä, the School of Applied Educational Science and Teacher Education in Savonlinna, University of Eastern Finland and School of Education in Tampere University, University of Tampere. The secondary school teachers were graduated from Department of Teacher Education in Rauma, University of Turku, Department of Teacher Education in Helsinki, University of Helsinki and School of Applied Educational Science and Teacher Education in Savonlinna, University of Eastern Finland. The teachers were 26–54 years old and had been working as a technical craft and technology education teachers from 1 to 29 years.

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 for this study consisted of questions concerning background information (e.g., age and studies in general), whether participants had studied either technical craft or textile craft or both in school in grades three to nine, and for how long. Then participants were asked about their basic educational studies, how they felt about craft and technology education during their basic education and how much they studied mathematics, physics, chemistry, biology and ICT, so called STEM subjects. Participants were also asked about their hobbies and the work of their 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?'

The data were analysed by using a qualitative theory-oriented content analysis. This type of analysis was chosen because it is a suitable method for examining material with descriptive content, especially if the phenomenon being studied is relatively unknown (Schreier 2012). For this analysis, Schein's (1996) theory of career anchors was used to provide guidelines for the analysis. When using qualitative content analysis, the primary aim was to investigate and discover themes based on the frequency of their occurrence. This logical inference allowed 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. 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 technology education teacher profile' were formulated.

3.5 Study 4

Finally, the fourth study aimed to identify inequality that women may experience when studying and working in today's technology-oriented field. Specifically, this study focused on investigating the gendered processes that might exist in the area of craft education, especially in relation to technical craft in Finland. As was stated in Chapter 2, technology has a deeply gendered history, and the discourses relating to gender and technological activity reflect this fact by labelling it 'masculine' and 'not a place for a woman' (Layton 1993, 35 in Murphy 2006). Therefore, I wanted to investigate if technology education in Finland has socio-cultural processes that refer to cultural and social attitudes that shape and sanction feminine and masculine behaviours, environments, and knowledge.

The study was carried out using semi-structured theme interviews and the data were collected at the end of 2014. Potential participants were asked whether they wanted to participate in the study, and interviews were carried out with those who volunteered. All candidates who were asked to participate in the study decided to do so. The data consisted of interviews with seven female technical craft and technology education teachers who have graduated from various universities in Finland. These teachers were working in schools for basic education teaching technical craft for pupils in grades three to nine. Three of the participants were primary school teachers and four of them worked in secondary-level schools. All of them had studied at least 25 (ECTS) of technical craft and technology education in university.

The semi-structured theme interview consisted of questions concerning background information (e.g., age and studies in general), whether participants had studied technical craft, textile craft or both in school from grades three to nine, and to what extent they had studied it. Then participants were asked to reflect on various themes concerning their basic educational studies, and their studies of technical craft and technology education at university. The themes of the questions were: 'How was it like to study technical craft at school and what was your attitude towards it?', 'Why did you want to become a technology education teacher?', 'How were your craft teachers and were they males or females?', 'Did you experience any gendered actions during your studies at school or at the university or later on as a technical craft teacher?'

In the analysis phase, a qualitative theory-oriented thematic analysis was carried out through identification, coding, analysis and reporting of patterns within the data (Braun & Clarke 2006). Qualitative research involves an interpretative approach of the world and it provides a possibility to acquire overall understanding of the phenomena under study. However, in order to achieve a better response to the theoretical assumptions, Acker's (1990) theory of gendered processes was used in the analysis. In the theory-oriented qualitative theme analysis, the first step was to formulate explicit definitions and coding rules for each category by determining which textual examples will be coded under which category. In the second step, the identified themes were listed based on the frequency of their occurrence, and grouped and categorised under headings of gendered processes theory (Acker 1990). In the abstraction phase, general descriptions of each category were created with original examples from the data.

4 SUMMARIES OF THE ORIGINAL SUB-STUDIES

In this chapter, an overview of the main findings is presented based on the original studies. The theoretical background, research questions and main findings of the studies are summarised in a Table 3.

TABLE 3 Summary of the main findings related to the research questions of the sub-studies

Sub-study	Title of original article	Research questions	Theoretical background	Findings
Article I	Technology education for children in primary schools in Finland and Germany: different school systems, similar problems and how to overcome them	What is technology education like in Finland?	Theoretical framework based on a model from Parikka and Rasinen 1993	In Finland, technology education reveals a gender related division. Technical craft is relevant to the degree that it has the potential to develop students' skills by enhancing the creativity and innovativeness.
Article II	Gender-based motivational differences in technology education	What is the structure of pupils' motivation towards technology education in primary school, grades five and six?	Motivation instrument for studying motivational aspects in arts subjects (Kosonen 1996)	There are some differences in girls' and boys' motivations concerning the contents of technology education.

		What are the main differences between girls' and boys' motivations?		The difference was significantly evident in six of the nine factors.
Article III	Women in technology-oriented fields	What are the main elements that have an effect on women's decisions to study for and enter a career in technology-oriented fields? Specifically, does studying crafts, and especially technical craft, during basic education affect their decisions in this context?	Theory of career anchors that describe individuals' internal career aspirations (Schein 1996)	The most influential anchors were a high level of competence related to the field and familiarity with the field. Relatively important anchors were security and stability of the field and encouragement from family or teachers.
Article IV	Female technology education teachers' experiences of Finnish craft education	What are the inequality regimes women may experience when studying and working in today's technology-oriented world? Specifically, do gendered processes exist in technical craft?	Theory of gendered processes (Acker 1990)	Women have experienced gendered patterns as divisions of labour, symbols and images, and interactions between women and men during their basic education, at university or in their work life.

4.1 Article I: An analysis of technology education

Rasinen, A., Virtanen, S., Endepohls-Ulpe, M., Ikonen, P., Ebach, J. & Stahl von Zabern, J. 2009. Technology education for children in primary schools in Finland and Germany: different school systems, similar problems and how to overcome them. International Journal of Technology and Design Education 19(4), 367–379.

The first study aimed to define and compare the technology education curricula of five EU countries (Austria, Estonia, France, Germany and Finland), with a special focus on describing Finnish technology education in more detail. These results are based on the work of European UPDATE project Workpackage 3 (WP3). The data consisted of the pre-analyses of curricula from Austria, Estonia, France and Germany and a detailed analysis of Finland's NCCBE 2004. In order to describe technology education at a more detailed level, a theoretical framework (see Article I) was created and used for providing more concise guidelines for the analysis. The analyses of the five EU countries' curricula concentrated on describing technology education for school children ages 6-12 (primary and junior secondary levels). The central aim was to discover the strengths and weaknesses of each country's curriculum and system for organising technology education. Another objective was to identify any gender-related reasons why girls drop out of technology education and lose interest in technological careers. The following five factors were taken into account in the analysis: 1) position and status of technology education in the curriculum, 2) aims of the technology education, 3) pedagogical means and methods for technology education, 4) the main themes and structure of the curriculum's content and 5) the characteristics of the teachers in charge of technology education.

Based on the comparison of the positions of technology education one could basically claim that technology education as a discrete subject at this level of education does not exist in any of these countries. In Austria pupils studied 'technical education', in Finland 'technical work' (as a domain of craft) and in Estonia 'craft and technology education' in basic education. In addition, in Finland a cross-curricular theme, namely 'Human beings and technology', relates to technology education. In France studies of technology can be described as somewhere between science and technique, 'applied science and applied technology'. In German primary schools (grades one to four) technological contents are studied during social studies 'sachkunde' and 'craft' lessons. One of the problems in technology education is the differentiation between a craft subject or courses on crafts (except in France). As a conclusion it could be stated that because technology education does not have a discrete status, it is studied mainly during craft and social studies lessons.

The aims of technology education are often general in nature or very substance-related, without clear operational instructions on how to implement them in practice. There are no standards or clear instructions on how to implement technology education, nor is there a distinct 'identity' for technology education in these five countries. Also the contents, especially in relation to crafts can be quite traditional and therefore do not educate children to meet the technology of today. Only Estonia has a teachers' handbook for all classes, and in Austria only one book for junior secondary schools is available. The national curricula or the guidelines for technology education are imprecise and ambiguous and this looseness appeared to be one reason for the huge gap between curriculum guidelines and actual teaching. This lack of specifics in curricula and guidelines therefore makes it difficult therefore for teachers with any or very little education in technology to teach contents with which they are not familiar, particularly if there is no easy access to resource materials.

The analysis of the pedagogical means and methods for technology education showed that there was more to be studied than mere contents. The emphasis in education should be on pedagogical approaches such as: observation; exploration; experimentation; discovery; analysis; problem solving; design; manufacture and innovation. A detailed analysis of one Finnish national curriculum, NCCBE 2004, revealed that pupils are encouraged only during technical craft lessons to learn important skills like innovativeness, inventiveness, creativity and problem solving in a technological context. Technical craft can be seen as supporting technology education by encouraging pupils in the creative use of various materials and techniques for different purposes. This could be combined with studying technological structures, concepts, systems, applications and attempts to find creative solutions to the problems they encounter.

Regarding the girls' reservation concerning technological topics, and taking into account the findings presented above, especially in Finland, some basic principles for instruction in technology education were suggested. First, when technology related aspects are often studied during technical craft lessons and if pupils are guided to choose between technical and textile craft after grade four, it can be construed that technology education reveals a gender-related division. This division means that those girls who study textile craft in these grades do not participate in technology-related activities that are part and parcel of technical craft studies. Secondly, based on the analysis of NCCBE 2004, technical craft is relevant to the degree that it has the potential to develop students' skills in many ways by enhancing the creativity and innovativeness of young people. The importance of these competences in the field of technology are relevant for several areas of life.

4.2 Article II: Gender-based motivational differences in technology education

Virtanen, S., Räikkönen, E., & Ikonen, P. 2015. Gender-based motivational differences in technology education. International Journal of Technology and Design Education, 25(2), 197–211.

The aim of the second study was to examine what would raise girls' interest in studying technology and encourages them to see technology as something relevant for them. To accomplish this aim, a questionnaire study was conducted for pupils in the fifth and sixth grade in primary school (n = 281, 144 girls and 137 boys). The questionnaire consisted of questions concerning pupils' background (e.g., age and gender), whether pupils had studied technical craft, textile craft, neither or both in school as well as a series of motive statements (1-32). For each motive statement, pupils were asked to mark their degree of agreement or disagreement on a Likert scale of 1-4 (1=I fully agree, 4=I fully disagree). In order to examine the structure of pupils' motivations towards technology education as consisting of various motives, an Explorative Factor Analysis (EFA) was performed on the motive statements. Then, independent samples *t* tests were used to examine gender differences in pupils' motives (see Article II).

In relation to the contents of technology, the study showed that girls were clearly more interested than boys in studying environment-related issues. Girls also enjoyed making useful and decorative artefacts for their homes slightly more than boys. In contrast, boys liked building electronic devices. One explanation for this result might be that electronic projects are done mainly during technical craft lessons, and 62 % of the girls included in this study studied only textile craft. Interestingly, boys and girls equally were happy about creating their own ideas and realising them. Also creating an attractive artefact was equally important to them. These findings indicate that pupils care about what kinds of artefacts or projects are made in craft lessons and therefore teachers should leave room for pupils' own designs.

The study also revealed that boys are more self-confident than girls in learning crafts skills. Boys were significantly more enthusiastic about craft lessons than girls, and boys felt that they could learn new things and that it was fun for them to learn how to use different tools. Boys felt a bit more excited than girls when doing crafts and strongly disagreed that it was boring. Moreover, it was evident that social interaction between the teacher and the pupils in class was an important factor for girls. Girls hoped to receive support and encouragement from their teachers and had minor fears of doing something wrong. They also needed to receive encouragement and appreciation for their technical competence, particularly from their teachers. These findings demonstrate the importance of introducing girls to technology education and taking extra effort in encouraging them in their studies.

A factor of the working process (group work and problem solving) indicated that in general, pupils enjoyed working in groups and had a preference for working with someone. However, compared to girls, boys were more eager to solve problems and test and try things. Having pupils working in groups may not automatically contribute to learning but it can reinforce pupils' motivation towards the task. Evidently pupils had a preference for group work and problem solving tasks.

As a conclusion, on the basis of these findings, it is clear that there are differences in girls' and boys' motivations concerning the contents of technology education and how important pupils perceive the subject to be. Curriculum writers and teachers should pay more attention to girls in order to enable them to see that technology is relevant for them. If the considerations and findings of this study are taken into account in curriculum planning and teaching, girls might see technology education as something valuable for them, thereby becoming and remaining motivated to study it.

4.3 Article III: Women in technology-oriented fields

Niiranen (née Virtanen), S. & Niiranen, S. 2015. Women in technology-oriented fields. Australasian Journal of Technology Education 2.

Whereas the first and second studies aimed to investigate technology education in curriculum level at schools, and also pupils' motivation towards it, the third study sought to determine what were the main factors that had an effect on women's decisions to study and enter a career in technology-oriented fields. Additionally, the specific focus was on finding out whether studying technical craft during basic education had affected women's decisions in their career aspirations. The study was carried out by use of a semi-structured questionnaire with 12 female technical craft and technology education teachers and 12 female engineering students. The data was analysed by using a qualitative theory-oriented content analysis. 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.

TABLE 4 Female career anchors

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 technical craft and 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 craft 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 technical craft and technology education was the encouragement from the teachers during technical craft studies at university. 'Security/stability' was only somewhat important for them (3/12). The reason for studying to become a technical craft 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 craft education 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 technical craft and technology education because it was the only good choice as a minor subject.

Based on these findings, it is evident that the most influential career anchors for these women were their high-level of competence and familiarity of the field. Therefore, in order to advance women in technology, it would be important that girls would have the possibility to discover technological topics and gain self-esteem in the field already in primary school. Also, as not all parents are interested in crafts and technology, or work in a technology-oriented field, and 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. Therefore, it would be necessary to improve school counselling and guidance in providing pupils with information about their study options and job possibilities in technology-oriented and engineering fields. In addition, teachers in the natural sciences and technology-related subjects should focus more intensively on showing the technology related skills and knowledge that are needed later in working life, especially for girls.

4.4 Article IV: Female technology education teachers' experiences of Finnish craft education

Niiranen, (née Virtanen), S. & Hilmola, A. (2016). Female technology education teachers' experiences of Finnish craft education. Technology and Design Education: An International Journal, 21(2).

The fourth and last study focused on to identify the inequality that women may experience, when studying and working in a technology-oriented field. Specifically, the study focuses on investigating the gendered processes that exist in the area of craft, especially in relation to technical craft, as being a representative part of technology education in basic education. The study was carried out using a semi-structured theme interviews and the data consisted of the interviews of seven female technical craft and technology education teachers. The participants were asked to reflect on various themes concerning their basic educational studies of technical craft and technology education, their technology-related studies at university and about the craft education at the schools in which they were working. The data were analysed by the use of a qualitative theory-oriented thematic analysis and the discovered themes were listed and then grouped and categorised under headings of gendered processes theory (Acker 1990).

The study showed that almost all of these women had experienced gendered patterns as divisions of labour (Acker 1990, 146) at school, when choosing which craft (textile or technical) to study or some of them did not even to have any opportunity for that decision. At that time, and even today many schools in Finland guide pupils to choose between technical and textile craft after grade four (Hilmola 2015). While all of these women had studied textile craft in grades five to seven, many of their statements of choosing revealed aspects of allowed behaviours or institutionalised means of maintaining the division in craft. Their reflections were: T1: 'I chose textile craft because I felt that it was the way it should be done; however, I also liked textiles a lot', T2: 'The atmosphere then was that technical craft 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 craft', T4: 'Girls and boys were separate, girls in textile and boys in technical craft', T5: 'I did not get much help or encouragement from the technical craft teacher, so I chose textile craft because it was easier for me', T6: 'I wanted to choose technical craft, but I was told at home to choose textile craft' and T7: 'At that time, there was not any decision making about this question'. It can be seen that many of these women chose textile craft instead of technical craft in primary school due to a tacit assumption that girls should automatically choose textile craft or based on other reasons such as parents' encouragement or peers' decisions or group pressure.

The gendered processes, construction of symbols and images (Acker 1990, 146), takes many forms that express and reinforce the division between women and men. Six of the participants remembered having only male technical craft teachers during their basic education (grades one to nine). This result revealed that the image of technology as a masculine domain has been striking, but in addition, how working was pedagogically organised and what pupils did during lessons had an effect on girls' perceptions. Some of the participants also remembered that the products they were guided towards during technical craft lessons were gendered for female pupils, for example, a doll's bed, and that almost all the products were pre-designed by a teacher (male) and therefore they were perceived to have a male perspective for using them. Some of the women remembered gendered appearing actions by their teachers, such as never receiving help at all from the teacher during the lesson or the teacher's unwillingness to help them solve problems or show them how to do something. One of the participants reported that it was only the teacher who could use the machines, while they as pupils (girls only) used hand tools.

The third set of processes, interactions between women and men (Acker 1990, 146–147), appeared to be most evident in terms of the women's own schooling, but also later in their studies at university and while working as technical craft teachers. All seven participants had experienced gendered patterns involving the enactment of dominance, submission, questioning or wondering from male teachers, colleagues, technical support staff at school or boys at school. This set of processes were further divided into three sub-categories: 1) Belittling and questioning: that describes a situation where a person speaks to another in a way that patronises or belittles the other person on the basis of gender by using questions such as the following: 'Oh my, do you really know how to do this?', 'Do you actually know what this is?', 'Well that should be done this way, you know' or 'Well you don't need it anyway, so I don't have to show you that'. 2) A request to prove skills: that describes a scenario where a woman is asked to prove her skills, for example, 'If you can't prove that you are adequately skilled and really able to do this…' or a scenario where someone is looking for specific qualifications but gets 'angry' because a person is qualified but is a woman. In this context, however, some of the participants experienced women being used as a good example of a technology teacher on the basis of their superior skills. 3) Denial: that describes the behaviour of a person who will not cooperate at all or will not accept a woman as a colleague without receiving an extra compensation.

In terms of gendered components of individual identity (Acker 1990, 147), six of the participants presented the aspects or assumptions of a woman's technical craft identity as a member of that group. The most evident assumption was related to the expectation of having excellent technical skills. As one participant said 'I did not believe that my own skills were good enough to study it' and another one expected that 'all boys must be so dexterous and good in that'. One participant stated that 'there might have been rarely one girl, in technical craft, who was also very skilled'. One participant saw this in a way that 'as I have been a skilled girl who can do all these things, it was not a problem for me to be a girl in technical craft'. Also, possessing traits of masculinity such as being relaxed and not taking things too seriously was mentioned in one participants' response as she expressed that 'I am, myself, quite relaxed and do not stress easily and I also do not want to be with people who take things too seriously. I felt that male students are not like that and knew that many of them were going to study technical craft, so I thought that studying with them would be nice'. Also, one participant said 'often female students were working with a male student in order to get some kind of help and support, but I did not have one to work with. – I wanted to show that I can do it alone and manage without male help'.

To conclude, if technical craft and technology education in Finland is seen as an important subject in providing young people opportunities to work in a practical way, accessing the domain of technological knowledge and working technologically, girls should be provided with equal opportunities to experience these issues. Also, based on the findings of this study, it is evident that there have been, and still might be, gender related issues in technology education and in working life. These actions and processes must have an effect on girls when they are planning their futures. Should girls be encouraged not discouraged towards technology?

5 CONCLUDING DISCUSSION — SEARCHING FOR WAYS TO ENCOURAGE GIRLS IN TECHNOLOGY EDUCATION

Based on various studies, it is evident that an increase in the number of women in technical careers has not yet been achieved in EU countries, and the reluctance of women to enter occupations in the natural sciences or technology is still a challenge that many educators confront all over the world (Klapwijk & Rommes 2009; Mammes 2004; Sander 2012; She Figures 2012). Even though girls seem to be, on average, more successful at school, they less frequently pursue science, engineering or technology paths, and certain disciplines remain overwhelmingly male (Endepohls-Ulpe 2012; She Figures 2012). Studies have also shown that interest and self-efficacy with respect to technology arise early in childhood and it is therefore important for technology education to step up and spark children's interests towards it (Endepohls-Ulpe et al. 2012; Turja et al. 2009). In the present study my aim was to contribute to efforts to get more women to study technology and pursue technological careers by investigating on how to increase girls' access to and interest in technology education at the basic education level and finding out what affects women's interests in entering technology-related careers in Finland. In this chapter, I shall discuss and sum up the challenges in developing technology education on the basis of my empirical findings.

5.1 Girls in technical craft and technology education

The first two studies were conducted in an attempt to define and examine technology education in Finland based on current NCCBE 2004 and to explore pupils' motivation towards technical craft and technology education. The general aim behind those studies was to investigate how girls' access to and interest in technology education could be increased. As described in the previous chapters and in Study 1 an internationally shared concern related to technology education is that it has a discrete status in only a few countries' curricula. Aspects of technology are studied; however, these activities often occur during craft or social studies lessons. In Finland, crafts, especially technical craft, can be seen as supporting technology education. In addition to craft studies there is the 'Human beings and technology' cross-curricular theme that self-evidently addresses technology education. The cross-curricular themes are implemented in a way that teaching is integrated with different subjects, and the 'Human beings and technology' theme shares much of its technological content with the objectives of technical craft. When dealing with the issue of girls in technology education in Finland the situation becomes even more complicated. The NCCBE 2004 states that craft instruction should encompass core technical and textile content in grades one to seven. In addition, pupils may be given the chance, in their craft studies, to emphasize either technical or textile craft according to their interests and inclinations. Despite the guidelines of the NCCBE 2004, many schools in Finland still guide pupils to choose between technical and textile craft after grade four and exclude the other craft from their studies (Hilmola 2015; Wakamoto 2012). This depends on the school's policies; however, crafts, and therefore also technology education in Finland reveals a strong gender-related division. The division of crafts in grades five and six creates a situation whereby girls who study textile craft in these grades do not participate in technology-related activities that are part and parcel of technical craft studies. In fact, girls in grades seven to nine rarely choose to study technical craft, or even have the option to choose it. One might ask whether girls need encouragement to opt for a wider range of technical subjects, rather than those defined by the role of a traditional homemaker. This marked gender difference in crafts must have an effect on girls when they are planning their future careers.

A deeply gendered history in craft studies and the discourses relating to gender in technological activity have labelled technology as a masculine and male-dominated arena. The situation will change in August 2016 when Finland's new NCCBE 2014 will come into effect. According to the Finnish National Board of Education, the need for a renewed core curriculum stemmed from the major changes society has undergone since the beginning of the 21st century (Curriculum Reform in Finland 2016). The guideline in the new NCCBE 2014 is that crafts should be an integrated subject for girls and boys during compulsory lessons in grades one to seven and it should include both technical craft and textile craft for all pupils. The objectives of the above guideline dictate that it will not be possible to teach crafts based only on the contents of either technical craft or textile craft; rather, the contents of both types of craft lessons will be needed when the NCCBE 2014 is implemented. There is also a distinct argument that in the teaching of crafts, methods relating to both technical craft and textile craft are used. The main change from the previous NCCBE 2004 is the fact that the core contents of technical craft and textile craft will no longer be taught or referred to separately. The NCCBE 2014 dictates that pupils' own interests related to craft should be emphasised in the future, but the interpretation of this in practice remains to be seen when the new curriculum comes into effect in August 2016. This change is compatible with current views of gender equality meaning that people can develop their abilities and make choices without gender related restrictions (Jakku-Sihvonen 2013).

Today's society places high demands on individuals in terms of the ability to acquire understanding of and knowledge about technology (Elvstrand et al. 2012, 163). Technical craft and technology education is relevant to the degree that it has the potential to develop students' skills in many ways by raising their awareness of the various dimensions of technology, including technological literacy, and also enhancing the creativity and innovativeness of young people. Technology education is also important in providing young people opportunities to work in a practical way, accessing the domain of technological knowledge and working technologically both individually and alone (Järvinen & Rasinen 2015; Martin 2012). Thus, the development of crafts into an integrated subject for both girls and boys can be seen as a positive change when thinking about girls' possibilities to study technology. However, in the new NCCBE 2014 curriculum, there is a concern for technology education in relation to how technological issues will be studied in the future during other subjects' lessons than crafts. Even though the new curriculum emphasises that pupils are to be provided with the knowledge, skills and competencies needed in society and their working lives in the future, technology as a cross-curricular theme, or now overarching theme, does not actually exist anymore as such. One challenge that has already been stated in the previous international research is that if technology education does not have a discrete status and if the aims of it are very general in nature or, on the other hand, very substance-related, it is difficult for teachers to teach contents that they are not familiar with. Without the guidelines of a curriculum and clear operational instructions on how to implement that curriculum in practice, particularly if there is no easy access to resource materials, my fear is that technology education might not get its due time in the busy school environment. The importance of competencies in the field of technology for several areas of life—advancement in education included—should be emphasised but who will do that in the future?

On the basis of the findings of Study 2, it is clear that there are differences in girls' and boys' motivations towards technology education and how important pupils perceive the subject to be. Therefore, providing girls with equal possibilities to experience technological issues is only a start. In order to promote girls' interests and encourage them to study technology, new and improved practices also need to be created. The findings of this study showed that girls were clearly more interested than boys in studying environment-related issues. This finding is similar to the results found in international surveys about girls and females in STEM areas. For instance, the number of women in environmental and chemistry studies and professions in Finland and Germany is higher than in other areas of science, technology, engineering and mathematics (Pulkkinen 2013; Quaiser-Pohl 2012). Moreover, it was evident that social interaction between the teacher and the pupils in class was an important factor for girls. Girls clearly hoped to receive support and encouragement from their teachers and had minor fears of doing something wrong. They also needed to receive encouragement for and appreciation of their technical competence, particularly from their teachers. The same finding was evidenced in a study of teachers' influence on students' self-efficacy and attitudes towards exact science studies. The perceived attention from a teacher was more closely related to self-efficacy in girls than in boys (de Weerd & Rommes 2012). These findings demonstrate the importance of the way that technical activities are conducted in class and how much teachers can influence pupils' motivation. Activities should be planned and presented in such a way that all pupils would be interested in them and might see technology education as something valuable for them, thereby becoming motivated to study it. If girls do not receive adequate and encouraging instruction, they will definitely turn away from technological topics. In addition, it was evident, based on these findings, that teachers should make extra efforts to encourage girls in their studies in order to help them in male-dominated fields.

The new NCCBE 2014 outlines the change to integrate craft studies into a subject that includes both technical and textile crafts for all pupils in grades one to seven. It also addresses multi-disciplinarity and integration between the subjects and seven overarching themes. One of the highlights of Study 2 was the connection identified between girls' motivation in preserving nature and the environment and technology education. In addition, Study 3 revealed the need for teachers in the natural sciences and technology-related subjects to focus more intensively on showing the technology related skills and knowledge that are needed later in working life. Internationally, technology educators in various countries are integrating engineering concepts that can be used to increase students' understanding and principles for solving real technological, social and environmental problems (Ritz & Fan 2015). Therefore, also in Finland one way to develop technology education, technical craft, would be to broaden it towards, so called STEM fields. However, in Finland, there is not STEM education as such in basic education; rather, the education on these topics is currently decentralised and taught through various subjects (NCCBE 2004; NCCBE 2014). The concept of STEM education covers a broad range of subjects, contents and practices, and these differences have resulted in varied interpretations of what STEM actually means (Ritz & Fan 2015). In Finland, this could mean that already project-based craft education would integrate and lean more strongly on using knowledge from science and mathematics in solving real-world technology and engineering problems. The hands-on nature of this subject helps students conceptualise scientific and technological knowledge and bring it into real world uses (see also Ritz & Fan 2015). This ideal also goes well with the spirit of the new NCCBE 2014 that encourages multi-disciplinarity and integration between the subjects and the overarching themes. This would also help in providing girls more experiences of technology-oriented and STEM fields.

5.2 Women in technology-oriented fields

Whereas previously discussed studies aimed to investigate technology education at the curriculum level and in schools, the last two studies aimed to investigate women in technology-oriented fields. In Study 3, I aimed to determine what were the main factors that had an effect on women's decisions to study and pursue a career in technology-oriented fields. Additionally, my specific focus was on finding out whether studying technical craft and technology education during basic education affects women's career aspirations.

First, looking at technology-oriented fields in society, they are rooted in mathematics and the natural sciences. A theoretical understanding of those areas is important in technological fields; skills such as technological problem solving, design and creativity are also relevant in practical engineering. Within the educational community, some countries have merged the content of natural sciences and technology education (e.g., France, Israel, the Netherlands), while others have experimented with the development of engineering programs for their schools or integrated engineering content into their technology education curricula (e.g., Canada, Sweden, United States) (Ritz & Fan 2015). Looking at this balance of theoretical knowledge and practical skills in higher technology-oriented education, MIT's (Massachusetts Institute of Technology, which is among the world's top universities in engineering) motto is 'Mens et Manus' which translates from the Latin to 'Mind and Hand' (see Figure 2). This motto reflects the educational ideals of above all, education for practical application. (MIT history, retrieved in 11.12.2015.) This ideal of mind and hand, theory and practice, in balance also links the academic engineering tradition to the tradition of technology education; designing and technological problem solving via hands-on doing often supported by knowledge from natural sciences and mathematics.

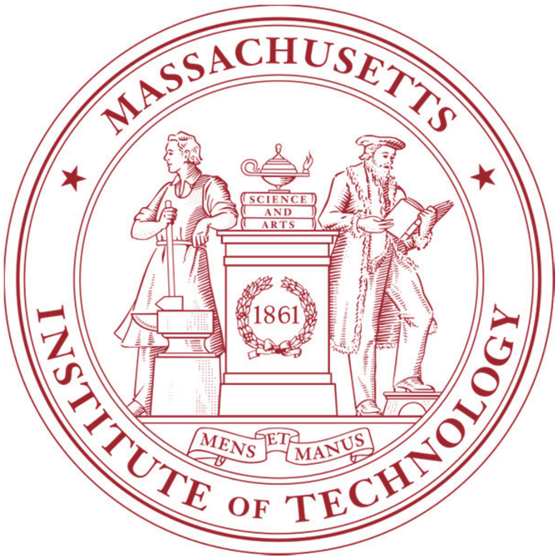

FIGURE 2 The MIT seal. 'Two sides of a complete engineer – the brawny hands-on guy and the elegant nerd' as stated on 'The MIT 150 exhibition nomination' web site (retrieved in 14.12.2015)

Continuing to the findings of Study 3 concerning female technical craft teachers and female engineering students, they showed that these women who were studying at the university level and later on working in technology-oriented fields did have a high level of competence related to the field they have chosen to study or work in. They had also had examples in, and encouragement from, their families about technological fields and therefore they have received significant intellectual capital regarding technology or engineering in their childhood, which was influential in their occupational choices. It has been stated that women's presence in technological fields is essential, because diversity fosters excellence in research and innovation (Gendered Innovations 2013). As the former 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). Therefore, to answer to this call and interest those girls who do not have first-hand examples of technological professionals in their families or do not see technology as a relevant topic for them in pursuing technology education and careers, it is highly important that schools take more responsibility for providing all pupils equal opportunities to get experience with and information about technology. Schools need to respond to the global economic challenges and enable pupils to see the full spectrum of possible study and career options in STEM fields.

Another dimension in thinking about women in technology-oriented fields and technical craft and technology education for girls is the realisation that innovation lies at the heart of the Europe 2020 Strategy for smart growth.

The Innovation Union flagship aims at making Europe a global leader in solving societal challenges (Gendered Innovations 2013). This leads to the question that, if innovation skills are something to be taught at schools, whose responsibility will it be to ensure this happens, and is implemented well? According to Study 1, in Finland, technology education is currently connected only in technical craft with the understanding of everyday technology and technological concepts, systems and applications. Also, based on the analysis of NCCBE 2004 pupils are encouraged to learn skills like innovativeness, creativity and problem solving in relation to technology mainly during technical craft lessons. Therefore, if pupils are guided to choose between technical and textile craft after grade four, this division means that those pupils, mainly girls, who study textile craft in these grades do not participate technology education that is implemented during technical craft lessons. There is no doubt that innovative skills are very important for the future lives of pupils and also the demands of working life are rapidly changing in this direction. I agree with Martin (2012), who claims that technology education can be a perfect vehicle to promote these skills as it is the only subject where pupils can see in three dimensions the results of their own technological decision-making. Thus it can be construed that if girls do not receive adequate and encouraging instruction, they might be discouraged from engaging with technological content.

The findings of Study 4, regarding the experiences of female technical craft teachers, showed that girls have been prepared to participate in future technologies by studying basically only textile craft. Since 1886 when Uno Cygnaeus introduced craft education into Finnish basic education, it has been more or less divided into technical and textile crafts. This image of technology as a masculine domain has been striking, due also to the fact that six of the seven participants remembered having only male technical craft teachers during their basic education. A study by Ikonen and Kukila (2015) of Finnish female technical craft teachers' experiences and perceptions of craft education revealed similar evidence; all 12 participants reported that they only had male technical and female textile craft teachers (Ikonen & Kukila, 2015).

The findings of Study 4 also revealed that all seven females have encountered gendered interactions such as belittling or questioning that also appeared later in these women's university studies, job application endeavours and careers as technical craft teachers. After 130 years, a major change will soon be implemented—the aforementioned integration of both technical and textile craft for all pupils in grades one to seven. It is clear that the women in this study struggled to establish a firm foothold in the technology-oriented field of their choosing; as one of them asked, 'Does it have to be such a rocky journey when one has a true will to be a female technical craft teacher?' Educators should take care of their students and understand that there are individual differences between needs, behaviours and attitudes of girls and boys, women and men. As Kirsti Lonka, a professor of Educational Psychology said on 7th October 2015 at the Women in Tech forum, 'Embrace the difference and diversity between men and women. There is talent in everyone, gender doesn't matter if you master the skills.' (Lonka 2015).

5.3 Methodological reflections and ethical considerations

In this dissertation I have utilised qualitative and quantitative methods in the four sub-studies in order to obtain a wide array of information relating to my research questions. In this section I shall explain and argue for my reasoning on the various data collections and methodological decisions, i.e. the quality and trustworthiness of the findings of the four separate studies I have carried out during the period 2009-2015. In the following section I will also address the ethical considerations included throughout each study. In all sub-studies, I have followed the generally accepted principles of academic scholarship such as honesty, meticulousness and openness throughout the research and analysis processes. I agree that the quality and trustworthiness of the findings rest on the coherence and cohesion of the overall research process and therefore I will make that process as open and visible as possible. Particularly in qualitative research, ethical considerations relate to transparency of the research processes due to the role of the researcher.

To begin with the main question, I will address the research topic of the dissertation. In 2009 when I started this project, I had already worked as a university teacher of technology education since 2005. From 2007 to 2009 I had also taken part in the Workpackage 3 work of the European UPDATE project, which was a great opportunity for me as a young teacher to learn about technology educational issues internationally. This project consortium had a unique developmental approach for technology education, by having a strong focus on early childhood and primary education. My interest in this research topic evolved from my work in this project and what I had experienced as a technology education teacher before that. Thus, in my first research plan my idea was to investigate technology education in basic education in Finland. It became clear over the course of the project, however, that I would specifically like to focus on the women who are actually studying or working in technology-oriented fields. My professional development as a teacher might also have affected this orientation, because in 2010-20I2 I worked part-time in developing entrepreneurship education in the department of teacher education. That experience increased my interest in career and working life options and naturally guided my research interests in the area of technology education to this direction too. To sum up, my main aim has stayed the same—to investigate girls in technology education and how to develop technology education in the future in order to increase girls' access to and interest in technology education in basic education. However, in my later studies (Studies 3 and 4) I wanted to expand my focus to study women who have actually entered technology-oriented fields in order to identify the elements that might have an effect on women's interests in technology-related careers in Finland.

In the year 2009, when I started to work on Study 1, I had been engaged with the topic already for some months while working on the UPDATE project. That year we had developed criteria for curriculum analysis for various countries in cooperation with other Workpackage 3 partners and also constructed pre-analyses of five national curricula (Finland, Estonia, Germany, France and Austria). Aki Rasinen was the primary investigator in this analysis and my role was to perform a detailed analysis of the Finnish NCCBE 2004. The data in this study, the NCCBE 2004, was easy to access because it is an official document of the Finnish National Board of Education. Before performing the analysis of the NCCBE 2004, I developed a theoretical framework (see Article I) guiding me in the process. The advantage of using this framework in a qualitative content analysis was that it provided categories and aspects for interpretation that follow the research questions. The framework was an adaptation of two models of technology education: Parikka's (1998) model for defining the concept of technology and Parikka's and Rasinen's (1993) definition of technology education. This study provided me the first opportunity to develop a new theoretical framework with a technology educational perspective. Underlying the idea of integrating two models into the one was a need to bring together the various contents and pedagogical aspects of technology education. Even though the framework provided me an accurate structure for analysing technology education and I received positive feedback for it from my international colleagues in an international conference, one critical comment was brought up. It concerned mapping the different contents of technology education and pedagogical ways. This question was related to the nature of knowledge and how to set it or measure it using levels (see Dakers et al. 2009). The problematic matter was how to set value laden issues (e.g. debating and critical thinking) and skills (e.g. innovativeness and problem solving) relating to technology education into a hierarchy. I decided not to differentiate them, but to categorise them under the highest level, namely 'understanding and reasoning'.

In Study 2, in order to expand the perspective and to study pupils at school and their interests and motivations towards technology education, I decided to conduct a quantitative questionnaire study for pupils in fifth and sixth grade in primary school. I chose to investigate pupils in these grades due to the fact that pupils will choose between technical and textile craft, depending on school's policies, mainly after the fourth grade, but craft is still a compulsory subject at school. In the following, I will describe in detail the processes related to transparency of constructing the instrument, data collection and input as well as performing the factor analysis with the reliability measures and the use of various statistical tests.

There are various instruments that have been created for measuring attitudes, PATT (Pupils' Attitudes Towards Technology) being one of the most developed in the field of technology. After familiarising myself with PATT instrument, I decided to utilise one that is not so general in nature. Osborne, Simon & Collins (2003) describe how attitudes towards something do not consist of a single unitary construct, but rather a large number of sub-constructs e.g. values, motivations, perceptions, anxiety, achievement or fears etc. Even though motivations and attitudes are closely related concepts, I thought that a more specific instrument, directed for investigating motivations, would be suitable for exploring technology education at school. Therefore, in this study, I decided to apply Kosonen's (1996) motivation instrument in order to investigate pupils' motivations. However, I modified the instrument in order to obtain information about essential aspects of technology education that were not described in Kosonen's instrument (see more in detail chapter 3.3).

Commonly, and also in the Kosonen's (1996) motivation instrument, motivation has been measured through the use of questionnaires that consist of Likert-scale items. In order to get representative data and to conduct a factor analysis, I determined and recruited the necessary size sample. A general rule according to Habing (2003) is that one should have a minimum of 50 observations, and at least 5 times as many observations as variables. Considering the fact that the participants in this study were children (ages 10 to 12), the instrument had to be relatively easy and short to fill out. In the questionnaire, there were 32 variables and the minimum sample size I needed was 160. However, I sent the questionnaire to 300 pupils due to the fact that some unusable data is always received. Before collecting the data, I tested the questionnaire with one class of fifth grade pupils and did some small corrections for the questions.

The printed questionnaires were sent the schools, and the classroom teachers in each school asked pupils to fill in the questionnaire. The questionnaire consisted of questions concerning pupils' background and series of motive statements (1-32). For each motive statement, pupils were asked to mark their degree of agreement or disagreement on a Likert scale of 1-4 (1=I fully agree, 4=I fully disagree). At the end of 2009, the data were input into SPSS program by Reija Laukkarinen who also worked on the UPDATE project at that time. I input the first 30 subjects to create the columns for the variables (age, gender etc.) and therefore I also got familiarized with the data. After data input I did an outlier observation for the data as a preparation and to identify anything, such as mistyped values, that would need to be cleaned up or removed from the mass data. After cleaning the data there were 281 suitable responses for the analysis.

Based on the idea that variables would correlate with each other, I believed that factor analysis could be utilised in my study. Therefore, in order to examine the structure of pupils' motivation towards technology education consisting of various motives, I performed an Explorative Factor Analysis (EFA) on the motive statements. My reasoning for using EFA, even though I had an already existing instrument, was that I did some changes to it and adapted it to suit better to technology education. Therefore, there was not a certain predefined structure for the variables. EFA helped me to identify the number of factors by creating new dimensions that were to be visualised as a scree plot and factor rotation matrixes in the SPSS program. After extracting the factors using EFA, mean scores and Cronbach's alphas were computed using the obtained factor structure as a basis. Then independent sample *t*-tests were used to examine gender-related differences in pupils' motives. Also, Cohen's *d* was used to indicate the magnitude of the difference between girls' and boys' means. In all of this work, I was assisted by Eija Räikkönen working as a postdoctoral researcher in the faculty of education at the University of Jyväskylä. Her special field is quantitative methods. This cooperation broadened my understanding of performing factor analysis and reporting its findings. She is also a co-author in the second article included in this dissertation.

In the Study 3, I wanted to broaden my research to include adults, women, who have actually entered a career in a technology-oriented field. The study sought to determine what were the main factors that had an effect on women's decisions and to investigate whether studying craft, and especially technical craft, during basic education affected their decisions. I decided to carry out the collection of empirical data by use of a semi-structured questionnaire. The study group consisted of 12 female technical craft and technology education teachers who graduated from various universities in Finland and 12 female engineering students from the Tampere University of Technology and Aalto University's School of Engineering. My rationale for choosing participants from these different areas of technology was my desire to investigate whether these women shared similar reasons for entering careers in technology-oriented fields.

Potential participants were asked whether they wanted to participate in the study by email or through social media (e.g. the Facebook group of technical craft teachers). Finding female technical craft and technology education teachers in Finland is not easy, because there are not many of them. For example, according to numbers from teacher education departments from 2010 to 2014, an average of 12 female teachers, 42 males, graduated annually with a qualification in teaching technical craft in grades seven to nine. I was lucky to find these female technical craft and technology education teachers that wanted to participate to the study. The reason why I decided to investigate teachers who had already graduated, and who were actually teaching technical craft and technology education, but female engineering students, was the idea of having participants who have definitely chosen a technology-oriented field. This is due to the fact that there are many options for teachers in work life, and after graduation some of them are not working as basic education teachers. The main ethical issues related to this study were to inform participants regarding the principles of the study and to explain my own ethical commitments in handling the data. I personally collected the data and analysed it, so no one else had access to the data. In analysis I used a qualitative theory-oriented content analysis and Schein's (1996) theory of career anchors to provide guidelines for the analysis. However, during the first phase when reading and coding the data, I derived three additional categories from the data and named these categories: familiarity, encouragement and limited options. When Schein (1996) initially developed the career anchors to describe individuals' inner career orientation, but I argue that, especially nowadays, outer factors, such as these three that I added, are also needed to describe peoples' orientation to decide what they want to do in their life.

In the Study 4, I aimed to identify gendered processes that might exist in the area of craft, especially in relation to technical craft. I carried out the study using semi-structured theme interviews for seven female technical craft teachers that were working in schools of basic education. The main ethical principles related to this study were to inform the participants regarding the principles of the study and to explain my own ethical commitments in handling the data. I was aware of my personal interest in the research topic as both a researcher and a teacher. Therefore, in order to minimise the impact of my subjectivities and personal feelings, I closely reflected them and tried not to ask too leading questions. Utilising interviews required caution and ethical awareness due to the fact that interviews usually elicit highly personal information concerning specific individuals. I personally implemented and recorded the interviews at the end of the year 2014 and after collecting the data I transcribed them to my personal computer. After interviewing and transcribing I analysed the material and no one else had access to it.

One of the highly critical ethical principles was to secure the confidentiality of the interviewees and maintain their anonymity in my writings. Even though the sample of seven teachers is rather small, the data provided an informed picture of gendered processes in craft education. Also, as mentioned previously due to the fact that in Finland there is such a small number of a female technical craft teachers, seven teachers who are actually working at school by teaching technical craft is a representative data. In order to do so, my analysis involved only a theory-driven search for meanings, and individual narratives with locations were not used in reporting the results.

5.4 Limitations of this study and suggestions for the future research

In this dissertation, I conducted four separate studies from two perspectives: (i) defining and investigating technology education in Finnish basic education and pupils' motivations towards it, (ii) studying the elements that have an effect on women's interests in entering technology-related careers. What both of these perspectives have in common is the key issue of whether increasing girls' access to and interest in technology education at the basic education level might ultimately increase the number of women who enter technology-oriented fields in Finland. In order to investigate this question and compile a solid knowledge base on this topic in a reasonable time, I worked out four different studies with female pupils at schools and adult women employed or studying in technology-oriented fields.

One suggestion for future research is related to the longitudinal aspect of this dissertation. Although I was able to capture some key issues of technology education and women's career aspirations, widening the scope by carrying out a longitudinal study from childhood to adulthood with same participants might have been preferable. However, the findings of the four studies revealed issues that may be worth addressing in future research.

I will now offer some suggestions for consideration in the area of developing technology education in Finnish education. Firstly, this study reports and discusses the current state of technology education in the Finnish NCCBE 2004 and primary school aged pupils' (5^{th} and 6^{th} grades) attitudes towards and interests in technology education. As discussed in the previous chapters, Finland's new NCCBE 2014 will come into effect in August 2016. It outlines the change in craft into an integrated subject where core objectives and contents of technical and textile craft will no longer be taught or referred to separately in grades one to seven. This dramatic change will end the long tradition of division between technical and textile craft. However, the interpretation of this in practice remains to be seen. It seems that at this moment, teachers all around Finland are working hard with planning the local curriculum and figuring out how to implement the new version of craft education in the future in their schools. It will be fundamentally important to study how this change will affect technology education and interact with the gender-related aspects of crafts, i.e. what will technology education be in the Finland after the reform in craft studies? It will also be important to broaden the research focus on studying technology education in a wider sense, in relation to STEM education, as suggested in the discussion section. It appears that work remains for educators in Finland to define the meaning of technology education and the way it should be guided in the future.

Secondly, this study focused on women studying and employed in technology-oriented fields. Technology education can be a perfect vehicle to promote pupils' skills such as creativity, inventiveness and problem solving, as it is the only subject where pupils can see in three dimensions the result of their own technological decision-making (Martin 2012; NCCBE 2004; NCCBE 2014). In Finland, these objectives are currently present in the NCCBE 2004, but only in technical craft with the understanding of everyday technology and technological concepts, systems and applications. One aim of schools, as institutions, is to respond to global economic challenges and help pupils see the breadth of possible study and career options. Therefore, to answer to this call and interest those girls who do not have first-hand examples of technological professionals in their families or do not see technology as a relevant topic for them in pursuing technology education and careers, it is important that schools take more responsibility for providing all pupils equal opportunities to get experience with and information about technology. Might improved technology and craft education, in the context of career choices of girls, increase the number of students who enter higher education as STEM majors? This study would have benefitted from longitudinal research, focusing on different aspects of the effects of technology education in relation to this question. These four studies could provide only limited findings about these topics, because of the women's lack of experiences of technology education during their own schooling and the traditions of gendered divisions in the study of craft. Another related question is what role female technical craft and technology education teachers can have in this setting.

5.5 Concluding remarks

As a conclusion I wish to note that carrying out four sub-studies by use of mixed methods, or a multi-methodological approach, during this research process has brought me many new perspectives on the possibilities of various research methods. Even though I have not mixed different methodological styles, such as qualitative and quantitative procedures in the analysis of one data set, use of different methods in the separate studies provided me tools for exploring the research problem in multiple ways. A challenge related to the use of a multi-methodological approach was that familiarising with various methods was very time consuming.

During this research process I have also become keenly convinced of the impact or potential that technology education, in basic education, might have on advancing women in technology-oriented fields. In order to achieve this in future, innovative ways of thinking are needed. Firstly, the findings of this study suggest that girls should be provided with equal opportunities to experience technological issues, but it is only a start. Through integrated craft education in Finland, which starts when the new NCCBE 2014 will come into effect, girls will also have the possibility to discover technological topics and gain self-esteem in the field. However, also new and improved practices and activities should be planned and presented in such a way that all pupils would be interested in them and might see technology education as something valuable for them. Also, it is suggested that schools should take more responsibility for providing all pupils' equal opportunities to get experience with and information about technology. Therefore, teachers in the natural sciences and technology-related subjects are the key persons to show and enhance the technology related skills and knowledge that are needed later in working life. This is especially important for girls.

TIIVISTELMÄ (FINNISH SUMMARY)

Tyttöjen kiinnostuksen lisääminen teknologiakasvatukseen naisten teknologia-aloille hakeutumisen edistäjänä

Lukio- ja yliopistokoulutuksen naisistumisesta huolimatta naiset ovat edelleen sekä Suomessa että muualla Euroopassa vähemmistönä teknologia-alojen koulutuksessa ja työelämässä. Tutkimukseni taustalla on kansainvälisesti jaettu huoli siitä, kuinka teknologian ammatit mielletään vahvasti miehisiksi ja naiset jäävät lahjakkuusreserviin. Vaikka sukupuolten välisen tasa-arvon ja yhdenvertaisuuden edistäminen on jo pitkään ollut yksi keskeisimmistä kehitysalueista Suomen koulutusjärjestelmässä, tutkimusta tyttöjen asenteista ja motiiveista teknologiakasvatusta ja teknistä työtä kohtaan tai naisten teknologia-aloille suuntautumisesta on Suomessa kasvatustieteissä tehty vähän. Tämän väitöskirjatutkimuksen aiheena on selvittää miten tyttöjen mahdollisuuksia ja kiinnostusta voitaisiin lisätä teknologian ja teknisen työn opiskeluun perusopetuksessa sekä toisaalta myös pyrkiä laajentamaan ymmärrystä siitä, mitkä tekijät vaikuttavat naisten teknologia-aloille hakeutumisessa.

Tutkimus koostuu neljästä osa-tutkimuksesta, joista on kirjoitettu neljä teknologiakasvatuksen tieteellisissä lehdissä julkaistua kansainvälistä artikkelia. Tutkimuksen empiirinen aineisto muodostuu myös neljästä eri aineistosta: 1) valtakunnallinen POPS 2004 -asiakirja, 2 ja 3) kaksi kyselyaineistoa, ja 4) haastatteluaineisto. Kaikkiaan empiirinen aineisto koostuu 281:n oppilaan vastauksista kyselyyn teknologiakasvatuksesta, 24:n teknisellä alalla opiskelevan tai työelämässä olevan naisen vastauksista kyselyyn, sekä seitsemän teknisen työn naisopettajan haastattelusta. Nämä neljä aineistoa analysoitiin monimenetelmäisesti, jolloin tutkimuskysymystä lähestyttiin useampaa eri analyysimenetelmää hyödyntäen kuitenkin niin, että yhdessä aineistossa on käytetty aina yhtä analyysimenetelmää.

Ensimmäisessä ja toisessa tutkimuksessa tarkasteltiin teknologiakasvatuksen nykytilaa Suomessa voimassa olevan valtakunnallisen POPS 2004 -asiakirjan valossa ja selvittämällä alakouluikäisten oppilaiden teknologiakasvatuksen motivaatioita. Opetussuunnitelma analyysi osoitti, että käsityön opetukseen ja siten myös teknologiakasvatukseen liittyy sukupuolittuneita käytänteitä, sillä käsitöitä voidaan toteuttaa dikotomista traditiota mukaillen, jolloin tytöt opiskelevat usein pääosin tekstiili- ja pojat teknistä työtä. Puhutaan valinnasta, vaikka todellisuudessa osa oppilaista joutuu jättämään pois opinnoistaan yhden tärkeän yleissivistyksen osan, sillä valitessaan tekstiilityön tytöt sulkevat tietämättään pois merkittävän osan perusopetuksen teknologian opetuksesta. Toisen tutkimuksen tulokset osoittivat, että tyttöjen ja poikien teknologiakasvatuksen motiiveissa on eroa. Siten ei siis riitä, että tytöille annetaan tasavertaisesti mahdollisuuksia opiskella teknologiaa, vaan lisäksi käsityön opetusta ja siihen liittyen teknologiakasvatusta tulisi kehittää niin, että tytöt voisivat huomata nykyistä paremmin teknologian merkityksen niin arki- kuin myöhemmin työelämässä.

Kolmas ja neljäs tutkimus keskittyivät tutkimaan naisia, jotka ovat valinneet opinnot tai ovat jo työelämässä teknologiapainotteisella alalla. Kolmannessa tutkimuksessa pyrittiin selvittämään sitä, mitkä tekijät vaikuttavat naisten teknologia-aloille hakeutumisessa ja lisäksi sitä, onko käsityön ja teknologian opiskelulla ollut vaikutusta naisten ura-valinnoissa. Tutkimuksen tulokset osoittivat, että niin nais-diplomi-insinööriopiskelijoilla kuin teknisen työn naisopettajilla alansa korkean tason perusosaaminen eli teknologiakompetenssi ja alan tuntemus olivat merkitsevimpiä tekijöitä heidän alalle hakeutumiselleen. Useat heistä olivat saaneet tietoa ja esimerkkejä teknologia-alojen työelämästä perheeltään jo lapsena tai joku perheenjäsen oli kannustanut heitä hakeutumaan alalle. Neljäs tutkimus teknisen työn naisopettajista ja heidän kokemuksistaan teknisessä työssä paljasti, että aihealueeseen liittyy eriarvoistavia sukupuolittuneita rooleja tai käytänteitä, joita naiset saattavat kokea opiskellessaan ja työskennellessään teknisen työn alueella. Tutkimuksen kaikki seitsemän teknisen työn naisopettajaa olivat kokeneet sukupuolittavia prosesseja liittyen vapaa-aikaan, koulunkäyntiin, yliopisto-opintoihin tai työelämään. Nämä prosessit ovat käytänteitä, ajattelutapoja, mielikuvia tai asenteita joihin liittyy vähättelyä, kyseenalaistamista tai sukupuoleen liittyvää työnjakoa.

Tutkimuksen johtopäätöksenä esitetään, että konkreettisina käytännön toimenpiteinä käsityötä ja teknologiakasvatusta tulisi kehittää sukupuolineutraalimpaan suuntaan niin, että kaikille oppilaille tarjotaan mahdollisuuksia kiinnostua teknologiasta, tasapuolisesti. Lisäksi on tärkeää, että opettajat avaavat nykyistä enemmän eri oppiaineiden yhteyttä teknologiaan, sillä teknologiakasvatuksella on mahdollisuus tarjota oppilaille tietoa teknologiasta ja kehittää heidän tietoisuuttaan sen vaikutuksista eri elämänalueilla. Erityisesti käsityöllä ja teknologiakasvatuksella on oiva mahdollisuus ohjata oppilaita kehittämään käytännön tekemisen ja innovoinnin taitoja konkreettisesti tutkien, kokeillen ja keksien. Näin voidaan lisätä oppilaiden teknologialukutaitoa tavoilla, jotka antavat mahdollisuuden hyödyntää ja kehittää teknologiaa siten, että se vastaa tasapainoisesti ihmisten tarpeisiin nyt ja tulevaisuudessa.

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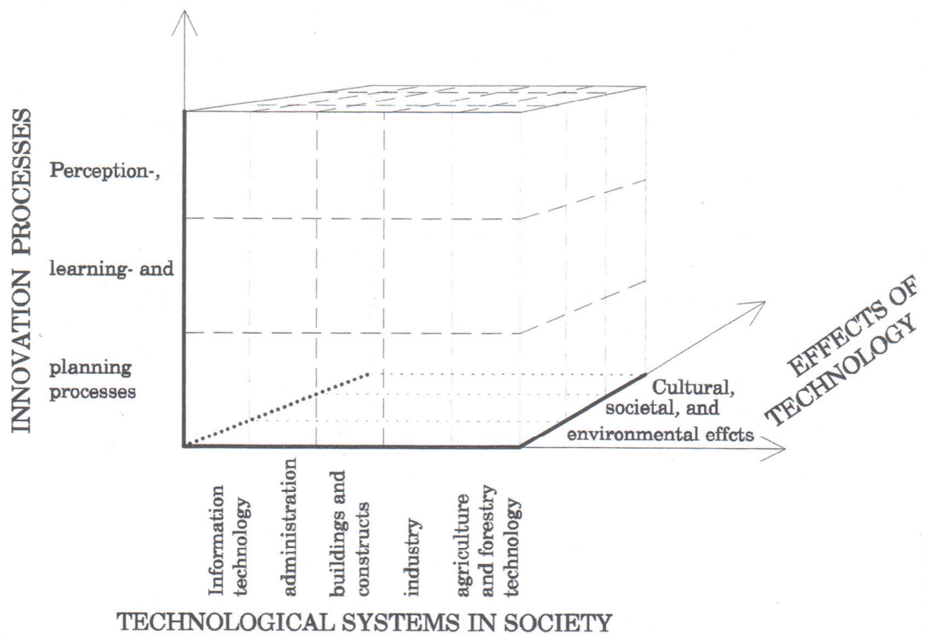
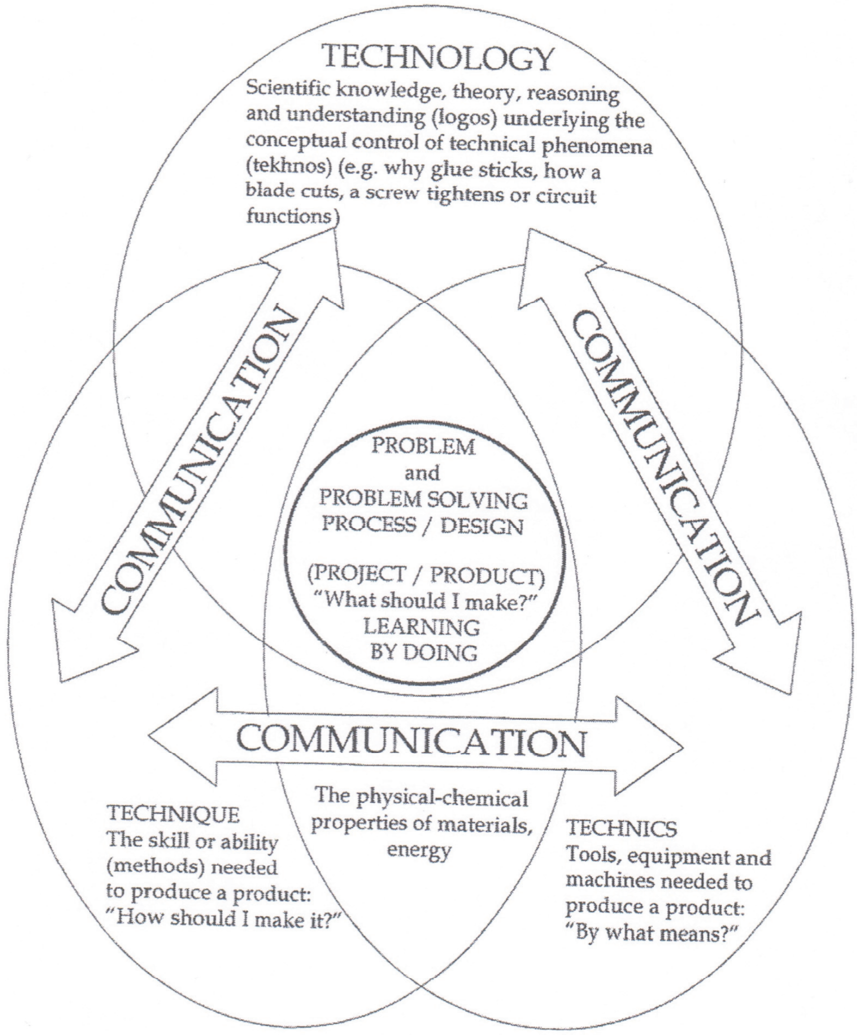
APPENDICES

APPENDIX 1: A cube model for defining the concept of technology (Parikka 1998)



APPENDIX 2: A model for defining technology education (Parikka & Rasinen 1993)



ORIGINAL PAPERS

I

TECHNOLOGY EDUCATION FOR CHILDREN IN PRIMARY SCHOOLS IN FINLAND AND GERMANY: DIFFERENT SCHOOL SYSTEMS, SIMILAR PROBLEMS AND HOW TO OVERCOME THEM

by

Aki Rasinen, Sonja Virtanen, Martina Endepohls-Ulpe, Pasi Ikonen, Judith Ebach &

Janine Stahl-von Zabern, 2009

International Journal of Technology and Design Education 19(4), 367-379.

II

GENDER BASED MOTIVATIONAL DIFFERENCES IN TECHNOLOGY EDUCATION

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III

WOMEN IN TECHNOLOGY-ORIENTED FIELDS

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Women in technology-oriented fields

Sonja Niiranen
Samuli Niiranen

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.

Affiliation

Sonja Niiranen,
University Teacher,
University of Jyväskylä
sonja.k.niiranen@jyu.fi

Samuli Niiranen,
Adjunct Professor,
Tampere University of Technology

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IV

FEMALE TECHNOLOGY EDUCATION TEACHERS' EXPERIENCES OF FINNISH CRAFT EDUCATION

by

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Female Technology Education Teachers’ Experiences of Finnish Craft Education

Sonja Niiranen, University of Jyväskylä, Finland
Antti Hilmola, University of Helsinki, Finland

RESEARCH

Abstract
In order to introduce a more equitable gender balance in education and consequently in the labour market, it is highly relevant to continue to expand our knowledge of technology education and to give attention to gender related issues. The ultimate purpose of this study was to contribute to efforts to get more women to study technology and pursue technological careers by investigating their experiences. To approach this, the aim was to offer an overview of the gendered processes that girls and women may experience when studying and working in the area of technical craft and technology education.

The study was carried out using semi-structured theme interviews, and the data were collected from November to December 2014. The study group consisted of seven female teachers of technical craft and technology education working in basic education schools. A qualitative theory-oriented thematic analysis was carried out through the identification, coding, analysis and reporting of patterns within the data. The findings revealed that all of the participants had experienced gendered patterns in terms of divisions of labour, construction of symbols and images and interactions between women and men. It is hoped that the findings of this study will facilitate the implementation of supportive interventions in the future.

Key words
technology education, technical craft, women, girls, gendered processes, experiences

Introduction

Technology is playing an increasingly important role in all realms of life—in peoples’ private lives, as citizens and consumers and in their work lives (Ardies, 2015). Whenever and wherever each of us was born and spent our early years, we have been profoundly influenced by the technologies we have encountered (Keirl, 2011:237). Therefore, it can be claimed that technology is an important part of our daily lives, and the experiences we have with technology have an impact on personal interests, career aspirations and social role patterns related to technology (Volk, 2007:191). Technology education has been developed to help people with technology by providing them the tools and skills they need to understand and utilise it. It has been suggested that problem-based activities can assist people to become critically literate to address issues through active engagement in both: tool-related hands-on and discursive practices of technology (Wilkinson and Bencze, 2011). Another concept related to technology education is the term STEM (Science, Technology, Engineering and Mathematics), which has become established in the field of education, and technology is one of the subject areas included under the STEM umbrella. All over the world knowledge and understanding of the subjects involved in STEM are considered vital for young people in an increasingly science- and technology-driven society, and STEM education is seen as a new ‘arms race’ that governments are prepared to invest heavily in (Banks and Barlex, 2014). The call for improved STEM education continues under the auspices of strengthening the flow of qualified people into the STEM workforce and enhancing STEM literacy for the general population (Ritz and Fan, 2015).

In Finland, there is still no special subject called technology education in basic education; rather, the education of the topic is currently decentralised and taught through various subjects (Autio et al., 2011; National Core Curriculum for Basic Education 2004 (hereinafter NCCBE 2004); National Core Curriculum for Basic Education 2014 (hereinafter NCCBE 2014)). Technology as a concept was introduced – but not defined – for the first time in the Finnish Framework Curriculum for Comprehensive Schools in 1985 as a component of the craft subject, ‘technical work and textile work’ (Rasinen et al., 2011:99). NCCBE 2004, which is still in effect, introduced seven cross-curricular themes in Finnish education, one of which is ‘Human beings and technology’, that self-evidently addresses *technology education*. Cross-curricular themes are to be integrated into different subjects; thus, it appears that much of the technological content of the ‘Human beings and technology’ theme is studied during crafts lessons, in particular technical craft and they share same specific aims (Järvinen and Rasinen, 2015). In NCCBE 2004, it is stated that the compulsory subject of craft should encompass core technical and textile content for all pupils at grades one to seven. Craft education is a practical subject with hands-on activities, and pupils actively practise experimentation, investigation, invention, problem solving and design skills. In craft education workshops (technical and textile), pupils are working with different materials and techniques when working with their projects.

However, in craft studies, pupils may be given the chance to specialise in either technical or textile craft according to their interests and inclinations after grade four (NCCBE 2004:242). The gendered division in craft creates a situation whereby girls who study textile craft in these grades are often left out of the technology-related activities that are part and parcel of technical craft. In fact, girls in grades seven to nine rarely choose to study technical craft or anymore have the option to study it (Niiranen and Niiranen, 2015). It has been claimed that Finnish basic education is still demonstrating a very traditional image of gender roles to their pupils (Berg et al., 2011:98; Kokko, 2008). In spite of many years of curriculum work around gender equality, craft education is still often gendered because girls mainly study textile craft with a female teacher, while boys study technical craft with a male teacher (Kokko and Dillon, 2011; Niiranen and Niiranen, 2015).

The opportunities women have to shape their own lives have dramatically increased in the past few decades (Quaiser-Pohl and Endepohls-Ulpe, 2012). Technology-oriented fields, however, are still a rather male-dominated area, nor has an effective approach for achieving a higher number of women in natural science and technology careers yet materialised in EU countries. The reluctance of women to enter occupations in the natural sciences or technology has already been established in number of previous studies (e.g. Klapwijk and Rommes, 2009; Mammes, 2004; Sander, 2012; She Figures, 2012). Even though gender equality and non-discrimination have long been critical concerns in Finnish education, there has been little research to date about girls' attitudes or motivations towards technical craft, technology education, nor females' experiences or career aspirations in relation to technology oriented fields. In order to introduce a more equitable gender balance in education and consequently in the labour market, it is highly relevant to continue to expand our knowledge of technology education and to give attention to gender related issues. The current study seeks to identify the inequality women may experience when studying and working in a technology-oriented field. Specifically, the study focuses on investigating the gendered processes that exist in the area of craft, especially in relation to technical craft, as being a representative part of technology education in basic education.

Gender issues

Technology has a deeply gendered history, and the discourses relating to gender and technological activity reflect this fact by labelling it 'masculine' and 'not a place for a woman' (Layton, 1993:35 in Murphy, 2006). In general, Western masculinity is associated with independence, self-reliance, strength and leadership, and femininity with conformity, passivity, nurturing and concern for people (Riggs, 1994). When attempting to represent masculinity and femininity, we tend to place them in opposition; in other words, what one is, the other is not (Murphy, 2007:240). Blaine (2007) argues that even if categories help us to economise our cognitive resources and develop stereotypes, we simultaneously risk discarding a great deal of individual information. Also, these group-based beliefs do not provide very accurate information about the individuals who belong to the group (Blaine, 2007). The concept of gender must be always seen in a socio-cultural context and from that perspective, embedded beliefs, values, stereotypes, prejudices and practices mark what is socially expected from men and women (Madureira, 2012).

Even at a young age, children experience social processes that expose them to ideas of what it means to be a girl or a boy in their society, and they start to construct their identities through observation of others and participation in communities such as peer groups (Paechter, 2007). Additionally, other people in their lives, such as parents and educators, also have an influence on reinforcing the development of early gender-typed attitudes and behaviours or punishing those that contradict gender norms (Turja et al., 2009). When defining gender, we see it as it has been presented in Gendered Innovations (2013:9) as a 'socio-cultural process that refers to cultural and social attitudes that together shape and sanction 'feminine' and 'masculine' behaviours, products, technologies, environments, and knowledge'. We also agree with Goffman (1979), who claims there is no gender identity but a learned capacity to provide and absorb depictions of masculinity and femininity (McDermott, 1996, citing Goffman in Murphy, 2007:240).

All organisations have inequality regimes, which can be defined as loosely interrelated practices, processes, actions and meanings that result in and maintain class, gender and race inequality (Acker, 2006). Acker (1990) argues that an organisation or any other analytic unit, for example, a family, has gendered patterns based on distinctions between masculine and feminine or male and female. These patterns include advantages and disadvantages, exploitation and control, action and emotion, and meaning and identity (Acker, 1990:146). She also describes how these social processes are often complex and gendering occurs in various interacting processes that are parts of the same reality in practice, although analytically distinct (Acker, 1990). According to her, the first set of processes is the *construction of divisions of labour* (Acker, 1990:146). These processes are allowed behaviours, allowed locations in physical space and allowed power, including institutionalised means of maintaining divisions in the structure of labour markets or in the family. The second set of processes is the *construction of symbols and images* (Acker, 1990:146) that explain, express or reinforce divisions between women and men, and take many forms for example in language, ideology, dress. The third set of processes, that produces gendered social structures involve *interactions between women and men* (Acker, 1990:146–147) including all of those patterns that result in the enactment of dominance and submission. These processes help to produce *gendered components of individual identity*, which may include awareness of other aspects of gender such as choice of appropriate work, language use or clothing, and presentation of self as a gendered member of an organization (Acker, 1990:145–147).

Research question and methods

The aim of this study was to examine the inequality that women may experience when studying and working in today's technology-oriented field. Specifically, it focused on investigating the gendered processes that might exist in the area of craft education, especially in relation to technical craft in Finland. The study was carried out using semi-structured theme interviews, and the data were collected from November to December 2014. Potential participants were asked whether they wanted to participate in the study by email or social media (Facebook group of technical craft teachers), and interviews were carried out with those who volunteered. All candidates who were asked to participate in the study decided to do so. The study group consisted of seven female teachers of technical craft and technology education who had graduated from various universities in Finland. All the participants were working in schools of basic education teaching technical craft to pupils in grades three to nine (ages nine to 15). Three of the participants had studied to become primary school teachers (grades one to six; ages seven to 12) in university, and had studied 25 or 60 European Credit Transfer and Accumulation System (ECTS) of technical craft and technology education. The remaining four teachers had studied to become secondary school teachers (grades seven to nine; ages 13 to 15) in university, and had studied 60 to 240 ECTS of technical craft and technology education. The participants were 26 to 54 years old and had been working as technical craft and technology education teachers for between one and 29 years. According to numbers from the teacher education departments from 2010 to 2014, in Finland, an average of 12 female and 44 male teachers graduated annually with a qualification in teaching technical craft to grades seven to nine.

The semi-structured theme interview consisted of questions concerning background information (e.g., age and studies in general), whether participants had studied technical craft, textile craft or both in school from grades three to nine, and to what extent they had studied it. Then participants were asked to reflect on various themes concerning their basic educational studies, and their studies of technical craft and technology education at university. The themes of the questions were: 'How was it like to study technical craft at school and what was your attitude towards it?', 'Why did you want to become a technology education teacher?', 'How were your craft teachers and were they males or females?', 'Did you experience any gendered actions during your studies at school or at the university or later on as a technical craft teacher?'

In the analysis phase, qualitative, theory-oriented thematic analysis was carried out through the identification, coding, analysis and reporting of patterns within the data (Braun and Clarke, 2006). It is a widely used method for examining material with descriptive content, especially in the case of relatively unknown phenomena (Schreier, 2012). In order to achieve a better response to the theoretical assumptions, Acker's (1990) theory of gendered processes was used in the analysis. In the theory-oriented qualitative theme analysis, the first step was to formulate explicit definitions and coding rules for each category by determining which textual examples will be coded under which category. In the second step, the identified themes were listed based on the frequency of their occurrence, and grouped and categorised under headings of gendered processes theory (Acker, 1990). In the abstraction phase, general descriptions of each category were created with original examples from the data.

Results

All seven of the participating female technical craft and technology education teachers had studied technology in the form of technical craft for only short periods during their basic education in grades three to seven. In addition, one of them had chosen or had access to technical craft courses in grades eight to nine. We used Acker's (1990) theory of gendered processes to identify what social structures or processes women might have experienced in relation to technical craft and technology education during their own school time and later on in their role as technology education teachers. It was evident that to some extent, almost all of the participants had experienced gendered patterns as divisions of labour (Acker, 1990:146) at school when choosing textile craft. While all of them had studied textile craft in grades five to seven, many described aspects of allowed behaviours or institutionalised means of maintaining divisions in crafts as follows:

Teacher 1: *I chose textile craft because I felt that it was the way it should be done; however, I also liked textiles a lot.*

Teacher 2: *The atmosphere then was that technical craft was for the boys and something else was for the girls.*

Teacher 3: *I would have needed some encouragement or a friend with me to choose technical craft.*

Teacher 4: *Girls and boys were separate, girls in textile and boys in technical craft.*

Teacher 5: *I did not get much help or encouragement from the technical craft teacher, so I chose textile craft because it was easier for me.*

Teacher 6: *I wanted to choose technical craft, but I was told at home to choose textile craft.*

Teacher 7: *At that time, there was not any decision making about this question.*

The second process category, namely, *construction of symbols and images* (Acker, 1990:146), was also a feature of the women's lives in terms of how divisions between females and males were expressed and reinforced. Almost all (with the exception of one) of the participants remembered having only male technical craft teachers during their basic education (grades one to nine). Two of them had a female technical craft and technology education teacher at university. This result reveals that craft education has been very gendered and undeniably have had a 'male' label. Some of the participants also remembered that the products they were guided towards during technical craft lessons were gendered for female pupils, for example, a doll's bed, and that almost all the products were pre-designed by a teacher (male) and therefore they were perceived to have a male perspective for using them. Some of the women remembered gendered appearing actions by their teachers, such as never receiving help at all from the teacher during the lesson or the teacher's unwillingness to help them solve problems or show them how to do something. One of the participants reported that it was only the teacher who could use the machines, while they as pupils (girls only) used hand tools.

The third set of processes, *interactions between women and men* (Acker, 1990:146–147), appeared to be most evident in terms of the women's own schooling, but also later in their studies at university and while working as technical craft teachers. All seven participants experienced gendered patterns involving the enactment of dominance, submission, questioning or wondering from male teachers, colleagues, technical support staff at school or boys at school. We further divided this set of processes into three sub-categories: 1) *Belittling and questioning:* This describes a situation where a person speaks to another in a way that patronises or belittles the other person on the basis of gender by using questions such as the following: 'Oh my, do you really know how to do this?', 'Do you actually know what this is?', 'Well that should be done this way, you know' or 'Well you don't need it anyway, so I don't have to show you that'. 2) *A request to prove skills*: This describes a scenario where a woman is asked to prove her skills, for example, 'If you can't prove that you are adequately skilled and really able to do this…' or a scenario where someone is looking for specific qualifications but gets 'angry' because a person is qualified but is a woman. In this context, however, some of the participants experienced women being used as a good example of a technology teacher on the basis of their superior skills. 3) *Denial*: This describes the behaviour of a person who will not cooperate at all or will not accept a woman as a colleague without receiving an extra compensation.

In terms of *gendered components of individual identity* (Acker, 1990:147), six of the participants presented the aspects or assumptions of a woman's technical craft identity as a member of that group. The most evident assumption was related to the expectation of having excellent technical skills. As one participant said 'I did not believe that my own skills were good enough to study it' and another one expected that 'all boys must be so dexterous and good in that'. One participant stated that 'there might have been rarely one girl, in technical craft, who was also very skilled'. One participant saw this in a way that 'as I have been a skilled girl who can do all these things, it was not a problem for me to be a girl in technical craft'. Also, possessing traits of masculinity such as being relaxed and not taking things too seriously was mentioned in one participants' response as she expressed that 'I am, myself, quite relaxed and do not stress easily and I also do not want to be with people who take things too seriously. I felt that male students are not like that and knew that many of them were going to study technical craft, so I thought that studying with them would be nice'. Also, one participant said 'often female students were working with a male student in order to get some kind of help and support, but I did not have one to work with. – I wanted to show that I can do it alone and manage without male help'.

Discussion

Based on various studies, it is evident that an increase in the number of women in technical careers has not yet been achieved in EU countries, and the reluctance of women to enter occupations in the natural sciences or technology is still a challenge that many educators confront all over the world (e.g. Klapwijk and Rommes, 2009; Mammes, 2004; Sander, 2012; She Figures, 2012). The ultimate purpose of this study was to contribute to efforts to get more women to study technology and pursue technological careers by investigating their experiences. To approach this, we offer an overview of the gendered processes that girls and women may experience when studying and working in the area of technical craft and technology education.

It seems that many of the women in this study experienced gendered patterns as *divisions of labour* (Acker, 1990:146), when choosing what craft to study (if they even had that choice). Even though all of them studied textile craft, their statements revealed aspects of allowed behaviours or institutionalised means of maintaining the divisions in crafts (see the statements above in the Results section). Kokko and Dillon (2011) state that children's perceptions of craft and the value they place on them are substantially shaped by their experiences at school and at home. The same finding was evidenced in a study of women's career orientation in technology-related fields by Niiranen and Niiranen (2015). Many (11/20) of those women chose textile craft instead of technical craft in primary school due to a tacit assumption at school that girls should automatically choose textile craft or based on other reasons such as parents' encouragement, peers' decisions or group pressure (Niiranen and Niiranen, 2015). Based on a performed re-analysis of the assessment data of Finnish National Board of Education 2010 by Hilmola (2015), many schools in Finland still guide pupils to choose between technical and textile craft after grade four (see also NCCBE 2004). The data of 4,792 pupils revealed that even though the division between technical and textile craft still exists, more girls are choosing technical craft than before, but boys are not choosing textile craft. According to those data, 52.4 % (1,275) of the girls studied only textile craft and 59.4 % (1,444) of the boys studied technical craft. 9.1 % (221) of the girls but only 0.7 % (18) of the boys chose opposite to the prevailing trend for their gender, with the girls opting for technical craft and the boys opting for textile craft. Depending on the school's policies, some pupils did not choose between the crafts but studied both equally. In the data for the 4,792 pupils, 37.6 % (915) of the girls and 38.7 % (940) of the boys studied both crafts. (Hilmola, 2015.) The finding of this study related to the divisions of labour and the numbers of the 2010 assessment data show that evidently girls have been, and still are, prepared to participate in future technologies by choosing textile craft. One might ask whether girls need encouragement to opt for a wider range of technical subjects, rather than those defined by the role of a traditional homemaker. This marked gender difference in crafts must have an effect on girls when they are planning their futures.

In connection with crafts, the guideline in Finland's new National Core Curriculum for Basic Education 2014 is that craft should be a common subject for girls and boys during compulsory lessons in grades one to seven. As a common subject, craft should include both technical craft and textile craft for all pupils at the basic education level. The objectives of the above guideline dictate that it will not be possible to teach craft based only on the contents of either technical craft or textile craft; rather, the contents of both crafts will be needed when NCCBE 2014 is implemented. There is also a distinct argument that in the teaching of a craft, methods relating to both technical work and textile work are used. The main change from NCCBE 2004 is the fact that the core contents of technical craft and textile craft will no longer be taught or referred to separately. Pupils' own interests will be emphasised in the future, but the interpretation of this in practice remains to be seen when the new curriculum will come into effect in 2016. Considering the above mentioned finding on divisions of labour and the numbers of the 2010 assessment data (Hilmola, 2015), this change is a positive one in order to provide girls with equal opportunities to experience technological issues at school.

The set of gendered processes, construction of symbols and images (Acker, 1990:146), take many forms that express and reinforce the division between women and men. Almost all of the participants in this study remembered having only male technical craft teachers during their basic education. A study by Ikonen and Kukila (2015) of Finnish female technical craft teachers'

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experiences and perceptions of crafts revealed similar evidence; all 12 participants reported that they only had male technical and female textile craft teachers (Ikonen and Kukila, 2015). The image of technology as a masculine domain has been striking, but in addition, what pupils do during lessons and how work is pedagogically organised affect girls' perceptions of technology. Some of the participants in our study reported gendered actions on the part of their teachers. One way to develop technology education is to focus on gender-sensitive learning experiences that recognise girls' and boys' different interests as individuals. To achieve this, attention should be paid to assumptions about what girls and boys can and want to do, and pupils should be offered the support needed to develop new learning habits. Furthermore, technical craft should be expanded to include a broader view of technological practices in order to help pupils to see the relevance of their studies (see Murphy, 2007:250). We see teachers playing a key role in dismantling gendered practices and renewing the image of technology education, because they are best placed to alter pupils' perceptions and indeed their whole identity.

The set of gendered processes, interactions between women and men (Acker, 1990:146–147), appeared to be very present during the women's school time but also later in their university studies, job application endeavours and work as technical craft teachers. All seven participants had experienced gendered patterns such as belittling or questioning, being asked to prove themselves or being the victims of denial at some point in their lives. Mainly, the comments were made in situations where female technical craft teachers were applying for a new job or had just started in a new teaching role. Educators should take care of their students and understand that there are individual differences between needs, behaviours and attitudes of girls and boys, women and men. As Kirsti Lonka, a professor of Educational Psychology said on 7th October 2015 at the Women in Tech forum, 'Embrace the difference and diversity between men and women. There is talent in everyone, gender doesn't matter if you master the skills.' (Lonka, 2015).

One aim of schools, as institutions, is to respond to global economic challenges and help pupils see the breadth of possible study and career options. Might improved technology and craft education increase the number of students who enter higher education as STEM majors? Therefore, we argue that in the spirit of the forthcoming NCCBE 2014 in which multidisciplinary issues and integration are addressed, technical craft should be broadened towards the approach of STEM. In Finland this could mean that already project-based craft education would integrate and lean more strongly on using knowledge from science and mathematics in solving real-world technology and engineering problems. The hands-on nature of this subject helps students conceptualise scientific and technological knowledge and bring it into real world uses (see also Ritz and Fan, 2015).

Although this study provided insights of female technical craft teachers' experiences, the study was limited to just seven participants, with varying career lengths. It would have been very interesting to describe gendered issues in a chronological order in terms of experiences in different eras (e.g. in the 1980s, 1990s and 2000s), but the data was too limited for that. However, this process has proved that further investigation in the area is needed. It is clear that the women in this study struggled to establish a firm foothold in a technology-oriented field; as one of them asked, 'Does it have to be such a rocky journey when one has a true will to be a female technical craft teacher?' Finally, we hope that this study will provide some perspectives on girls' and women's experiences of technology, and that these perspectives can be used for the implementation of supportive interventions.

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