How interests in science and technology have taken women to an engineering career

Birgitta MC EWEN
Faculty of Health, Science, and Technology
Karlstad University
SE-651 88 Karlstad, SWEDEN

E-mail: birgitta.mcewen@kau.se

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Contents

- Abstract
- Introduction
  - Purpose of the study
  - Interests for science and technology
  - Out-of-school and home activities in science and technology
  - Self-efficacy and self-esteem
  - Gender and technology
- Method
  - Participants
  - Research design
  - Data analyses
- Results
  - Professions of the fathers and mothers
  - Support from family and relatives
  - Boys as playmates
  - Support from school
  - Interests in mathematics and logical thinking

- **Interests in physics, chemistry and biology**
- **Interest in technology**
- **Discussion**
- **Conclusion**
- **References**

Abstract

This study connects to gender issues within the field of science and technology. Women who had started strongly male-dominated engineering educations at Karlstad University were interviewed to find out why they had chosen these programs. A very clear picture emerged about the professions of the women's fathers. Almost all fathers were engineers or employed in positions that required skills in technology. The women described their fathers as the most important person who had introduced them into the traditionally masculine technology world during childhood. Also other male relatives had influenced the women often in the same way as fathers had done. Mothers had encouraged their daughters for further studies, but not necessarily in the field of science and technology. Mathematics had often been the gateway to studies in science and technology. Thus, these women started early on a trajectory into a technical career. It is discussed if only girls with this strong masculine models and influences can enjoy settings with male norms or if these norms ought to be changed. Results from this study show that it is important to early influence young girls to opportunities that will stimulate their interests in science and technology.

Keywords: Interests in childhood, science, technology, engineering careers, women

Introduction

EqualGrowth

EqualGrowth, a big gender project at Karlstad University, started 2008 and lasted for four years. It had a clear interdisciplinary profile, and its goal was to promote equal and sustainable development in the region of Varmland. One of its subprojects investigated women in engineering programs. It was found - not unexpected – that the share of examined women was low at most of the programs. The two programs

with lowest share were the Mechanical and Computer engineering programs, respectively.

Purpose of the study

Purpose of this study was to investigate why women from the Mechanical and Computer engineering programs had chosen a career in strongly male-dominated fields. The question formulations were as follows:

Was the women's choice a result of an interest in science and/or technology from childhood and adolescence or a choice in manhood? If their interests arose in childhood and adolescence, which circumstances made them interested and influenced them? Could these women describe in which way the interest had arisen?

Interests for science and technology

Girls and boys establish their interests in science and technology (S&T) at young age (Lindahl, 2003):

> "If science shall have a chance in their lives the pupils must have a positive experience of science from the beginning of primary school through all years. Once they have lost their interest it is very difficult to get them back" (p.5).

Several research projects have investigated or are investigating attitudes of children and youths towards S&T, for example the projects Science And Scientists (SAS), The Relevance of Science Education (ROSE), Trends in International Mathematics and Science Study (TIMSS), and the recently started Interests & Recruitment in Science (IRIS).

The SAS-project included 21 countries and 9 300 children of the age of 13 in a cross-cultural study of relevant factors, such as girls' and boys' S&T interests and experiences that impact the teaching and learning (Sjøberg, 2000). Results from the SAS-project showed that both girls and boys in developed countries have experiences with expensive new technologies and that gender differences are rather small. Girls and boys have similar experience with reading scales and using measuring devices. However, boys have more experiences with mechanics, electricity and S&T-related tools. The interests of girls and boys within the field of

S&T vary from topic to topic and with the context in which it is presented. Girls are more interested in learning about health, nutrition and most aspects of biology, while boys are interested in cars and the latest technological developments. Both girls and boys are interested in phenomena such as life in the universe, earth science and other types of natural phenomena. To summarize, both girls and boys are interested in science but in different topics. The interest for technology is higher among boys. According to Sjøberg (2000):

> "The general trend is that girls are 'others-oriented', while boys are more 'ego-oriented'. If S&T is to appeal more to girls than in the present situation, it may be that S&T contents should be given a stronger social and human dimension" (p. 95).

Out-of-school and home activities in science and technology

As research has shown that interests in S&T is established at young age (Lindahl, 2003), attempts to make more young people interested in the world of S&T should address children and youth. Small children may practice scientific thinking long before they meet science lessons in school (Crowley & Galco, 2001). Encouraged by findings of Gottfried, Fleming & Gottfried (1998) suggesting that children's out-of-school activities are linked to motivation and later good results in science in the classroom, Crowley & Galco (2001) analyzed parent-child interactions in an interactive science exhibition at a children's museum. These activities characterized much of parent-child activity that goes on in everyday life, such as parents reading books, constructing buildings out of blocks or cooking food. Children are simply curious, attentive to novelty and trying to make sense of their world as best as they can. Crowley and Galco found that parent participation shaped the path of children's naturally-occurring scientific thinking. The parents provided opportunities for children to engage in scientific reasoning, to develop an interest in learning more science, to provide explanations about causal connections, and to show that one experience could relate to other experiences. The above findings could also lead to explanations of more general principles. The most important outcome of everyday parent-child scientific thinking may be children's interests, habits and identity as someone who is competent in scientific thinking and that scientific thinking is an important priority. Learning scientific facts is perhaps not the most important outcome. The study did not give any gender aspects of parents' engagement with their children.

Motivation to learn is a competence acquired "through general experience but stimulated most directly through modeling, communication of expectations, and direct instruction or socialization by significant others (especially parents and teachers)", as cited by Brophy (1987, p. 40). Children's home environment shapes their initial attitudes toward learning. When parents nurture their children's natural curiosity about the world by welcoming their questions, encouraging exploration, and familiarizing them with resources that can enlarge their world, they are giving their children the message that learning is worthwhile and frequently fun and satisfying. According to Gardner (1975) interests for science is developed early in a child's life if it has access to science-oriented toys, books and magazines and visit museums and zoological parks. It is also an advantage if the father of the family could explain how things work. Gardner specifically points out the father as the master, not the mother.

Self-efficacy and self-esteem

The Swedish National Agency for Education shows in a report (Skolverket, 2003) that the confidence in the own personal capability (self-efficacy) is the most important factor for children's desire to learn. A high degree of self-worth (self-esteem) could increase the performance more than what is expected, and in the same way a low degree of self-esteem could decrease the performance. According to Bandura (1997) the individual shapes her/his own life from what she/he thinks she/he could manage. Bandura also says that women tend to judge their own self-efficacy lower in the S&T-field compared with how they judge their self-efficacy in other areas and subjects. Thus self-efficacy in the S&T-field is more related to gender issues than to women's real capacity in this area. Here the parents' credence to their children and especially to their daughters concerning capability in S&T is very important. Solomon (1994) has shown that parents' expectations seem to be crucial for how well their children will succeed in school. Parents' expectations are the most important factor when compared to other factors such as home material standard. Factors like parents' interests in their children's school-work or literacy in the home are all of less importance than parents' expectations.

Gender and technology

This study is performed in the field of women and technology. Mellström (1995, 1999) points to the strong cultural connection between men and technology.

Traditionally, technical professions have become associated with men, while nursing and caring professions are connected to women. This has affected the recruitment to technology educations and many of them are male dominated. Following from these conditions, the engineering profession sees few women.

Gender research focuses that gender, shared views on men, women and sexuality, is constructed through social relations (Connell, 2009). Through upbringing and socialization, expectations are created on what should count as typically male or female. This has been a matter not only for scientists but has become a matter for politicians as well. As Weiner & Berge (2001) have shown, more energy has been invested in finding out why girls do not take interest in technology than on the more complex issue of how traditional gender patterns, both private and public, form and structure personal interests. Wajcman (2004) noted that what has been missing in the debate on failing to encourage girls and women into the S&T-field, is that their underrepresentation profoundly affects how the world is made.

The complex of power relations in the above described gender research, constitutes a background to this study. However, focus in this study is why female engineers have broken the stereotypic pattern and chosen a strongly male influenced career, despite the traditionally close connection between technology and men.

Method

Participants

Karlstad University

This study was performed in the county of Varmland, which is situated in the south-west part of Sweden. Karlstad is the biggest town in the region and received university status in 1999 when Karlstad University was established. The students mostly come from the region and often have a background in non-academic traditions. The engineering faculty at the university is small compared to engineering faculties at bigger Swedish universities. The university and its students could thus be described as what is quite typical of a university in a rural area.

Engineering programs chosen

Graduated women were invited from two out of 16 available engineering programs at Karlstad University, the Mechanical and Computer Engineering programs,

respectively, both comprising 180 ECTS credits. During the period 2002 to 2010 only 10% and 14%, respectively, of those graduated from the programs were women. These two programs had the lowest share of women of all engineering programs at the university.

Principle of selection of women

All 35 women with a degree, or with only a few requirements left, from 2002 to 2010 were invited to participate in the study. A prerequisite was that they still were living in the county of Varmland, and this reduced the number to 26 women. Six women declined and we were not able to come into contact with seven. To increase the sample size five women from a computer company in Karlstad were added to the group. These five women were all engineers with a degree from a Computer Engineering program, but only two from Karlstad University. Taking all these figures together, twenty women participated in the study. The youngest was 19 and the oldest 38 years old when they started the program.

Information about the study

The women were contacted via telephone and informed about the project. If they agreed to participate they shortly afterwards got a letter with more information about the project, e.g. who were responsible for the project. The letter also contained ethical guidelines from the Swedish Research Council, guidelines that were carefully followed throughout the project. The women were informed that it was of their own free will to participate. Thus the participants could refuse to answer a question or could withdraw from the study whenever they wanted without any explanations.

Research design

As the aim of this study was to investigate women's choice of studying subjects within the S&T-field, women's experiences and feelings from childhood and adolescence were best caught with the qualitative method and therefore the research interview method was chosen.

Interview procedure

Interviews were carried out at Karlstad University or, if it was more convenient for the woman, at her work place. In one case, when the woman was on parental leave, the interview was performed in her home. The interview rooms were chosen with great care, as to have a peaceful and silent setting. One and a half hour was

reserved for each interview, so there would be enough time for all questions. These prerequisites were the same whether the interviews were carried out at the university or in any other place. The participants were informed that it was needed to make tape-recordings in order to catch all information from the interviews. The women were also informed that the interviews would be de-identified later. The interviews took different times to carry out, as some women would like to tell us a lot, while others just shortly answered the questions. As the interviews were part of the big gender project EqualGrowth at Karlstad University, they have been used as data material for other publications as well, e.g. in Holth & Mellström (2011).

Interview guide

The use of an interview guide created structure and made it easier to process and compare the answers (Krag Jacobsen, 1993). The questions were open and directed which made it possible for the interviewers to follow interesting tracks which emerged during the interviews (Lantz, 2007). The interviews were transcribed verbatim and de-identified.

The interview guide was disposed with regard to the women's experiences and feelings from childhood and adolescence. It contained questions about family relationships including fathers' and mothers' professions, siblings and, if the siblings were grown up, their professions today. It also contained questions about hobbies during upbringing, playmates and the atmosphere concerning testing technical advices at home and at homes of relatives. There were questions about teachers and other persons in school who had been important for their interests in S&T. The women were told to try to give accounts of memories from childhood and adolescence, which had been important for their interests in S&T. They were also asked who had been the most important person for their awakening interests in S&T during childhood and adolescence.

Data analyses

Analysis was performed gradually and involved a systematic processing of material using Strauss and Corbins' theory (1998), where keywords and phenomenon were connected to theoretical conceptions. Thus, there has been an interaction between theory and empirical data. The establishment of conceptions and categories has been done through repeated feedback to the material. The specific in the analysis was to look for special and everyday events during the women's childhood and

adolescence, events which the women pointed out as important for their choice of S&T later on.

Results

Most of the women told about an interest in S&T early in life. Some of the women had chosen a technical career for practical reasons, without feeling an interest in S&T early in life. This study shows results only for the group of women who told about an interest early in life.

The results show the very great importance of a childhood and adolescence with a lot of technical stuff and a permitting attitude to test these for stimulating interests in the S&T-field. The women told that especially the fathers, but also other male relatives, have introduced them into a male technical world. Later on teachers have supported them in mathematics, science and technology. Different types of separate occasions, e.g. meetings with female engineers, had in some cases big influences and changed the future career for these women.

Professions of the fathers and mothers

Almost all women agreed to discuss the professions of their fathers and mothers. A very similar picture emerged concerning the professions of their fathers. All fathers except a very few were educated engineers or had jobs where skills in technology were necessary. Diversity was much greater concerning professions of the mothers. The majority worked as teachers and within health- or childcare, a few were shop managers and one mother had been a high-ranking manager at a hospital.

Support from family and relatives

Support for introducing S&T early in the women's life came from different persons. Support came from fathers, male relatives and mothers, but scarcely from female relatives.

Without any doubt support from fathers were the most striking answer, when the women described which persons had made them interested in the S&T-field during childhood. Most of the women reported how their fathers had encouraged them to test different technical stuff at home. The atmosphere was allowable and it was

permitted to test through 'trial and error'. The fathers were often very enthusiastic and cheered on their daughters. One woman told:

> Daddy was an engineer, he built and fixed up and fiddled about with everything, so this was my growth, it just was there …….yes, sure, this was the situation the whole time, so if you wanted to do anything, yes, but there is the stuff, just start and fix it up! So there was a permitting attitude.

There are also stories where women described their fascination about more specific technical processes they participated in. It could be stories about a television or radio to be repaired or to look into the machinery of a car.

> Daddy picked out or replaced something in his Volvo so we took apart, I felt this was very interesting to learn about the different parts, as this is a piston or cam shift and everything, and I know I read some of my Daddy's books about engines and learned about two-stroke engines, four-stroke engines and everything about these things.

Both fathers and mothers have encouraged their daughters for further studies, but not necessarily in S&T, and told them how important school work is. However, the role of the participants' mothers was different from that of the fathers. Together with their mothers the girls participated in more traditionally female activities, such as baking, cooking and sewing. There are only a few stories about mothers doing traditionally male activities. One mother joined the father doing carpentry on the house and easily handled the drilling machine. Another mother attended a computer course together with her own brother and built a computer. The mothers' influences on introducing their daughters into the S&T-field have thus been much lower than the fathers', at least concerning the practice of traditional technical work.

Male relatives influenced the women more than the mothers and often in the same way as the fathers. Male relatives are here defined as paternal and maternal grandfathers, uncles, brothers, brother-in-laws and cousins. Older male relatives introduced the girls into traditionally male activities in much the same way as their fathers did, while younger male relatives were playmates and often introduced the girls to traditional boy games. One of the women told about her father's uncle, who was an engineer in Stockholm, and the only educated person in the family. When he visited the family he was regarded as a king. These memories are from the

woman's age of eleven or twelve. "…… yes, a king who just came and was just raised to something …….. In that moment I knew I decided that engineer you ought to be". Some of the women told memories about when their paternal or maternal grandfathers introduced computers in their lives. Other grandfathers built bark boats and carried out other woodworking project with their grandchildren. In these cases grandfathers introduced the girls in the male technical world. Brothers, who themselves were technically interested and had made a technical career, supported their sisters in their choice of a technical profession. Some of the women told about their brothers, who had been very important in encouraging them to choose a technical career. Brothers and cousins were playmates in the sandpits and they all often played with toy cars.

Interestingly no women reported of other female relatives than their mothers, who introduced them into the S&T-field as girls. No women told about a sister or an aunt influencing them to a technical career. The picture that introduction into the traditionally male technology world is made by men, preferentially fathers but also by other male relatives, is quite clear.

Boys as playmates

Some of the women reported that they played a lot with boys as young girls. Play activities included outdoors games, climbing in trees and playing war. The children could also "sit on an electrical cabinet playing that they drove a helicopter over the savannas of Africa". Indoors they played with lego or racecourses. However, no one reports of more traditionally girl plays when girls and boys played together. "We never played with dolls". When they got older, the women participated in sport activities together with their male friends, activities such as snowboarding, football, ice hockey and bandy, the last a ball sport practiced on ice with skates in the northern countries.

The women attended science classes in upper secondary school often together with a majority of boys. Their description is that they got on well with boys and men as playmates and fellow-students. Often they understood the rules in men's world better than these of the females'. "I have not yet learnt the rules of females ……. The boys I easily understood, I knew what was going on there. These rules I knew". This woman told an example of boys' rules:

> Yes, you were not allowed to be better than the boys. You were not allowed

> to! Had you done a tackling or a nice feint then you were punished afterwards …… Girls should stay on a given level. So I learnt this!

If you understood boys' rules you could be assimilated in the group. Another woman told the following story. In school there was a special room for computers. There was one predetermined time for boys and another for girls. At one occasion the time was over for the girls and some boys urged the girls to leave. "Me too" asked the woman who told this story. "No", was the answer, "you are not counted as a girl". It was obvious that the boys considered her as not belonging to the girls' group. "I was either boy or girl. I just was!" The woman described what would happen if she had been with the girls instead: "There was a lot of drivel, fuss and silly behaviour. It was much more fun to be with the boys as you then could sport and do other things like that". Other women also describe the boys' world as "more to the point", compared to the girls' where "things could go round between ten persons".

The interviews show that these women, who have grown up with boys, in many cases early learnt male game rules both in plays and sports. These women have acquired knowledge they later used in male settings and have felt quite comfortable in this. However, there have also appeared thoughts that it is not only an advantage to be with boys as young, it could also be a benefit to know female game rules.

Support from school

A number of women reported that their teachers engaged in and talked to them about studying science and/or technology when they were pupils at junior high school and upper secondary school. The women remembered their teachers being very competent and interested in their pupils and their engagement has influenced, and in some cases changed, the direction of the women's careers. One woman told us that she and her class-fellows received 'computer license' from their teacher at an age of eight which stimulated their computer interest.

Study advisors also had influence on the women's career choices. One woman told:

> My study advisor forced me to meet her. At first I thought I would follow the main stream to the social science program in upper secondary school. However, nature science is better, deeper, and broader and gives bigger opportunities and it was actually these subjects which interested me most.

Also separate occasions had big importance for some women. They told that they met female students who studied to computer and mechanical engineers, respectively. Those meetings made so deep impressions on these women that the meetings changed their future careers.

Some women participated in summer courses given only for girls. The role of these courses was to engage girls in S&T and was arranged in such a way that girls had a lot of practical experiences. One course included to build playhouses located in city parks. A male carpenter supervised a group of ten to fourteen girls. Another course was for junior high school girls to format computers and to do other related work tasks. Educational visits at the university when the girls were pupils at upper secondary school were important for several of the women. They later became students in those subjects the study visits had dealt with.

Interests in mathematics and logical thinking

A majority of participating women were very interested in mathematics, often as young children. They have been clever in mathematics and have had high school marks. For many of them mathematics have been the best and most funny subject. When they describe why mathematic has such a pedestal standing they use descriptions like: "Mathematics is logic so right is right and wrong is wrong. It is nothing more with that. It feels comfortable to get one answer". Another description was that "A mathematical formula can be used in different ways for solving problems. It is like a key for IKEA-furniture, you have a tool which you can do so much with!" Further description of the big interest for mathematics is that "the very calculation is exciting and it is thrilling to see if your answer is right after a long arithmetical operation". The women noted out that their capacity for mathematical, logical thinking and analyses were closely connected. Mathematics seems to be a gateway to studies in the S&T-field. One woman in the study thought of starting postgraduate studies in mathematics.

Interests in physics, chemistry and biology

Several of the women clearly established that they wanted to study natural sciences instead of social sciences in the upper secondary school. The subjects were regarded as better, deeper, broader and would give bigger opportunities. Some women tried to explain why nature science experienced more attractive than social science and the humanities. "And I remember when I was at intermediate state in

school, we had history and religion, and I did not know which was true and which was untrue …….. for me everything was a fairytale". Another woman told:

> I got answers to the why-questions from natural science. In the humanities, there it was not allowed to ask why, there you should presume and accept things. I am not directly that sort of person. Do I want to know I would like to know exactly how it is.

The overwhelming positive terms for mathematics were not expressed for the three natural science subjects. However, the participants' interests in physics and biology were greater than that in chemistry.

Interest in technology

There were various answers when the women were first interested in technology at school. It is important to keep in mind that technology was first introduced as a school subject in Sweden in 1994. Then, and now, the subject has a low status and teachers complain of small resources for teaching. The answers about the women's interest in technology thus depend on when the women attended school and if the schools then had started to have technology in their curricula. A common answer in the interviews was that computers in school were a gateway for further technology interest. Also woodwork could be a gateway. On the question what was special with technology the answer could be: "I would like to know how things work and that could be the television, a computer or anything". Another answer was: "to be able to do a bit of thinking and to do something yourself".

Discussions

A main result from this study is the great role the majority of women gave their fathers in influencing and introducing them into the world of S&T during childhood. Almost all of the female engineers had a father who was an engineer or was employed in a job where skills in technology were necessary. To have a parent who is working in a similar area is one of the factors encouraging women to choose technical educations (Court & Moralee, 1995). According to Jacobs, Chhin & Bleeker (2006) parents play an important role in their children’s career choices. It was shown that father’s expectations were related to their daughters’ later gender-typed occupational expectations, and that the adult daughters were satisfied

with working in gender-nontraditional fields. Also other male relatives in this study as paternal and maternal grandfathers, uncles, brothers, brother-in-laws and male cousins have influenced the women when they were younger. The older male relatives have introduced the girls into traditionally male activities much in the same way as the fathers, while the younger male relatives have been playmates. The plays have always been traditionally boy games. Together these persons have created masculine settings around the girls. These findings also point to the importance for fathers to bring time together with their young children. Childcare has traditionally been regarded as a female task, but fathers' role in childcare slowly increases in many countries.

The women's stories of their mothers' roles were different compared to their fathers' roles. There are no reports of mothers doing traditional male activities together with their daughters, with the objective of teaching them how to handle different tools or to solve technical problems. Mothers' influences focused on the usefulness of further education, barely in any case to influence into a career in S&T. In addition, no other female relatives did. According to the women's stories, this is a clear distinction compared to the important role other male relatives have had in introducing the women to S&T. These results do not agree with findings by Otto (2000), who showed that mothers were the most important person to discuss career plans with. Of all people to whom youth could turn for help with making career plans, their mothers were the most important persons. Simpson (2003) speculates about the roles of mothers: "most mothers' influence appears to work through more emotional and normative channels" (p. 459). She is the person that is interested in school work, has aspirations for her children's educational attainments, and has an overall impact on her children's lives. This is also in accordance with Mastekaasa & Smeby (2008), who reported of no differences concerning mothers' encouragement for gender traditional and nontraditional programs.

It is interesting to notice that when girls and boys in this study played together they chose traditionally boy games. This was constant during the whole childhood and adolescence. Some women reported of participating in male sport activities when they were older. Thus, the girls early 'learnt' the rules of traditionally boy games and told that they became comfortable in traditional male settings. They later on built upon these experiences in their working lives. Similar results are found by Boyne Coats & Overman (1992), who reported that women in nontraditional professions had more male but fewer female playmates than women in traditional professions. Read (1992) found that students in nontraditional programs had childhood

experiences, which influenced their selection of career. Those could be to test male models and to try boys' activities. None of the women in this study reported their male playmates engaged in traditional girl games. It became obvious from this study, that when women entered traditional male settings they adjusted to and accepted existing male game rules, while boys did not enter or adjusted to girls' rules. However, in another part of the material (not reported here) male engineers reported that when women enter a working community of only men, the ambience will be better and men very much appreciate when females enter into a group.

Experiences early in childhood could have great influences on future interests in science (Osborne, Simon, & Collins, 2003). To feel joy and curiosity in combination with success leads with great probability to an existing interest in science. Small children may practice scientific thinking long before they meet science lessons in school (Crowley & Galco, 2001). Parents' attitude is important for welcoming children's questions and to encourage exploration (Brophy, 1987). Gardner (1975) talks about the importance of science-oriented toys, books and magazines for developing interests in science. Parent's participation shaped the path of children's naturally-occurring scientific thinking in a study of parent-child interactions in a science exhibition at a children's museum (Crowley & Galco, 2001). However, the most important outcome of parent-child scientific thinking could be that children identify themselves as competent in scientific thinking and that scientific thinking is an important priority. This is perhaps more important than the scientific content children encounter. This study shows that the women have experienced one or more of the situations above early in life. They have told about encouraging and stimulating home environments where it was allowed to test different devices. They have had fathers and other male relatives who have introduced them into a technical world. The most important outcome however, could be that they early experienced themselves as competent and that the things they were doing were important. Thus, they early started on a line which they experienced as important and interesting and which took them to a technical career.

Self-efficacy is the most important factor for children's desire to learn (Skolverket, 2003). Bandura (1997) says that women tend to judge their own self-efficacy lower in S&T compared to men but also compared to other areas and subjects. The parent's credence to their children and especially to their daughters concerning capacity in S&T is thus very important. The above study shows that the parents' support probably have given their daughters better self-efficacy concerning S&T than they would have had without support. As the individual shapes her own life from what she

thinks she could manage (ibid.), a higher self-efficacy is positive concerning the future career. Furthermore, parents' expectations seem to be crucial for how their children will succeed in school (Solomon, 1994). In this study it is not possible to deduce how big the parents' expectations have been on their daughters.

Teachers' engagement in their pupils and encouragement about pupils future studies in S&T were reported by a number of women. Results show that interaction between teachers and pupils is the most important factor concerning attitudes to science (Echinger, 1997). Different kinds of separate occasions could also have big importance for the individual (Helldén & Solomon, 2004; White, 1996). Some women told about meetings with female students who studied on the computer and mechanical programs, respectively. These meetings made so deep impressions that these women changed the minds of their future careers.

The women told about their great interests in mathematics, but also of great interests in the science subjects physics, chemistry and biology. Their interests in physics and biology were greater than that in chemistry. Lindahl (2003) shows that both girls´ and boys´ interests in physics and chemistry were lower than those in other subjects. In this study with women engineers it is perhaps not remarkable that their interests in physics are above average.

The abovementioned shows that the women had favorable conditions during childhood and adolescence for developing interests in the S&T-filed. However, to cope with the problem of too few women as engineers, the close connection between men and technology has to be acted on (Mellström, 1995, 1999). Salminen-Karlsson (2003) describes difficulties in changing the education to Master of Engineering but also describes forces which work for a change. The role of an engineer has gradually changed from being a team leader to a co-worker in a group. Gender issues ought to be considered when changing engineers' roles. The technology agenda also ought to include topics that interest girls, who often have other priorities and interests compared to men (Sjøberg, 2000). As an example the simple and cheap device 'Solvatten', 'Book of Water', is mentioned. This device, which helps cleaning water only by use of solar energy, helps preferentially women at the countryside in developing countries. It is designed by a Swedish woman. Probably, additional women would like to join technical areas if there were greater possibilities for women to model close-to-everyday products. However, the women described in this study adjusted themselves after male norms.

A group of nine male engineers, chosen from the same engineering programs and who graduated during the same period as the women, were also interviewed in this study. The whole procedure with interviews, data collection, analyses etc was the same as that for the women. It was found that these men also had had a childhood and an adolescence with much technical stuff, where male relatives had served as models for these men. The presence of technical stuff and male relatives serving as models during childhood and adolescence have thus been important for both female and male engineers participating in this study.

This study focused those women who reported interests early in life for S&T. The result points out that their fathers, and to a lesser extent, other male relatives, introduced the women into a male technology world. There are of course other factors, not in focus of this study and not accounted for here, which in addition have been important for these women in their careers. It is also important to keep in mind that only twenty women participated in the study and it is not possible to generalize from this. However, for those women who were interested in S&T early in life, they reported that their fathers were very important for their technical career.

Most of the women reported of an early interest in mathematics, science and/or technology and pointed out the importance of a home with technical stuff and an allowable atmosphere. One conclusion from this study is the importance of an early contact with the S&T-field. Not all children have parents and other relatives, who are engaged in these subjects. Nevertheless, there is of great importance for society to early take care of those girls (and boys) who show interests for S&T. Teachers in pre-school and primary school have a very important role. Unfortunately, many of these teachers themselves have bad self-efficacy concerning S&T (Roehring et al., 2011). In-service training programs within the S&T-field would be of great importance. In Australia and New Zeeland research has shown that pre-school teachers' lack of scientific knowledge has a great impact on the amount and content of teaching S&T in pre-schools (Fleer, 2009; Garbett, 2003; Smorti, 2005).

An example of how to wake and to take care of children's interests in S&T is the special campaign Karlstad University has done in the so called 'Children's university'. Children at the age of eight to twelve are welcome together with their parents or other adults to take part of a lecture in some exciting subject, specially designed for children. This campaign has been very successful, with hundreds of children attaching the lecture every week, and has got big response in media.

Public knowledge mostly refers to knowledge in the humanistic field, e.g. about famous authors and their classical volumes. Why is not knowledge in S&T, e.g. about exoplanets, regarded as equally important? In discussions it is not uncommon that persons make a point of not knowing any S&T and more or less point out this. This is not the best basis for creating interests for S&T. It is important that S&T for the general public in the future will have the same status as the humanistic field. This S&T alienism could to some extent also be seen in the gender field. In ecofeminism there is a dichotomy between male/science and female/nature (Merchant, 2005). Mies & Shiva (1993) critique modern science, and view the dominant stream of modern science as a projection of Western men's values. Science is related to men, and with this follows power and dominance. In that sense science has a negative flavor. This contrasts to the ambitions to stimulate women to work in the S&T-field. These issues create ambiguity and point to need for further discussions within the gender field.

Conclusions

The purpose of this study was to investigate which circumstances made women interested in S&T early in childhood and adolescence, and what influenced them to choose a technical career. The number of women in this study is small but some comments could be given.

A clear conclusion is the great role the women gave their fathers and other male relatives in stimulating them for S&T. This has not been so clearly reported earlier. The women's mothers have encouraged their daughters for further studies, but barely for studies in S&T. This study emphasizes how important early positive experiences and a permissive attitude from adults are. The women have early been part of male settings and most of them reported that they were comfortable with this. Perhaps the most important outcome was that they may have experienced themselves as competent and felt comfortable in technical settings. These experiences were probably very important later on in their choice of career.

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