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SUMMARY

This report summarises the methodological approach and results of the qualitative research activities performed in the context of the SESTEM project in Germany by the Universität der Bundeswehr München. The qualitative research activities are divided into four studies with pupils, parents, teachers in STEM, and female graduate and post-graduate students in STEM.

The central findings are divided into three parts according to the main research dimensions: the individual level, STEM in general, and consequences of a STEM career pathway. In the following, decisive commonalities and differences between the target groups will be revealed.

With regard to the *individual level*, the educational pathways of the students, STEM-teachers, and parents are similar: they nearly all studied directly after the "Abitur". Most of the interviewed pupils want to study in the future even if they do not know which subject. With regard to values, the most important values are honesty and reliability as well as other values like ambition, work environment, family and friendship. Obvious differences are the fact that according to the age pupils are more focused on friendship and teachers and sometimes students of higher semester are more focused on questions about how to combine family and work. Most of the interviewees reported that they had no direct role models for their career choice. The final factors for the career choice are different but most popular factor is enjoying work in STEM.

The perceptions on *STEM* careers in general were analysed. The most important incentives in STEM according to all four interview groups and the focus groups are enjoying work, interest in STEM, good job prospects and high salary. Regarding the demanded abilities for STEM, all groups agree that a basic STEM-related knowledge or understanding and in particular logical reasoning are necessary in this field. The priorities of the motivational factors are sometimes not similar: female students are more likely to self-realization aspects (meaningful job, joy at work) and parents and teachers are more focused on financial aspects like the payment and job prospects. Analysing the socio-cultural influences, most families are supportive regarding career choice in all groups. However, the final decision was done by the persons themselves in most of the cases. Also, pupils feel free to choose their future career pathways. Other persons could have impact on the interest in STEM e.g. teachers by doing interesting and practical STEM classes. Friends did not play a decisive role in terms of career choice in all groups. To sum up, parents and teachers have the highest impact on pupils' career choice.

The main findings concerning *consequences of a STEM career* will be summarized. In general, all groups observe obstacles with regard to a career in STEM especially for women like the lack of acceptance of women in STEM fields, the lack of female role models, stereotypes of STEM, the under-representation of women in STEM studies and a lower self-confidence of girls in STEM classes regarding their abilities. Further, general barriers are the demanding study in STEM and the change from school level in STEM to university. Differences between the groups concerning obstacles in a STEM career could be distinguished between some parents and pupils in comparison to the other groups: a few parents and male pupils think that there are no obvious obstacles if one wants to study STEM seriously, because if one has the wish to study in STEM they will find a way to make it. With regard to facilitators, all groups agree that schools could promote more (female) role models like STEM professionals. In addition, more courses for girls only in STEM at school were requested. One important suggestion of the group of pupils is that the STEM classes should be more practical-oriented which aims at motivating pupils and increasing their interests for STEM. Further, a lot of STEM initiatives for girls at school could be summarized but all groups consented that there is still a need to improve the facilitating measures for women in STEM.

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1. Aim and Background

This empirical report is developed within the framework of the European project SESTEM which aims at enhancing the gender equality in STEM-related careers and promoting more females in order to take a STEM-career pathway into account. The report describes the research approach and the four qualitative sub-studies in the German context. Finally, the main commonalities and differences will be summarized and discussed.

2. Introduction and Research Approach

The methodological approach of SESTEM is divided into two parts: one qualitative and one quantitative part. The qualitative research includes the definition of variables, for the design of four interrelated qualitative studies according to the target groups of pupils (age cohort 14-20), parents, upper secondary teachers, and female university students enrolled in STEM departments in the National contexts of FR, DE, UK, ES, PL and GR under the scope of enhancing understanding into the decision making process and support requirements regarding STEM related career choices. Based on the findings of the qualitative studies the quantitative studies will be defined and will be distributed to the target groups. This empirical research report will draw the main results of the conducted qualitative studies in each of the participating countries and for each of the four target groups.

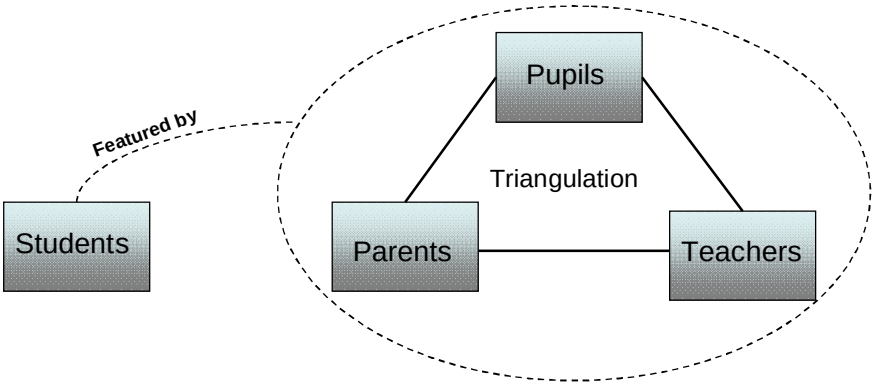

Figure 1. Research Approach of SESTEM

Research Approach. In the following, the research paradigm of the studies regarding the project objectives will be shortly presented. Figure 1 shows the research paradigm for the SESTEM project. It is designed by Universität der Bundeswehr München (UniBw) according to the research objectives according to the SESTEM proposal (see SESTEM Lifelong Learning Application Form, 2009). The research paradigm aims at examining the different perspectives of the target groups concerning the reasons and barriers of an uptake of a STEM career; therefore a method triangulation is foreseen that includes a method mix of different qualitative and quantitative studies for pupils, teachers, and parents. Further, the quantitative studies will be based on the findings of the qualitative studies. According to the results of the literature review the educational biography and the socio-cultural environment (teachers and parents) are important for the career choice of pupils. To get more insights in the career choice process of pupils in particular in those of girls in STEM we will have a closer look beyond the perspectives of teachers and parents as social-cultural environment.

Therefore, it is necessary with regard to the triangulation to focus more on the groups of pupils, teachers, and parents to get more insight to the career choice process concerning STEM by pupils. This triangulation means for the qualitative studies that pupils, teachers, and parents will be interviewed on the one hand and pupils and teachers will additionally take part in focus groups discussion on the other hand. The results of the qualitative analysis will be the basis for designing questionnaires for the four target groups with regard to quantitative studies. Further, the triangulation is featured by the forth target group, female students of STEM-subjects. For this target group interviews and the quantitative study will be also conducted.

3. Procedure of the sample selection for the four sub-studies

In this section the procedure of sample with regard of the four sub-studies in Germany will be illustrated. In preparation of the qualitative studies the Universität der Bundeswehr München has been contacted persons and institutions of previous projects which might be connected to members of target groups. In addition, we provided interview requests via different regional schools and Email distribution list which are related to pupils, parents, teachers in STEM or female enrolled students of STEM-subjects. The highest response rate for being a participant of the qualitative interviews showed up by personal contact persons and by the LEV Bavaria (Landes-Eltern-Vereinigung Bayern) distribution list. The table below shows all media which were used for the qualitative study request.

Table 1. Used media with regard to the participation request for the qualitative study

Study No.	Media for interview request	Target Groups
1	o Personal contact o Recommendation of a contact person o Project Flyer o Deutsche Gesellschaft für begabte Kinder	*Female and male pupils*
2	o Personal contact o Recommendation of a contact person o Project Flyer o LEV-Distribution list o Deutscher Ingenieurinnen-Bund	*Parents*
3	o Personal contact o Recommendation of a contact person o Project Flyer o Teacher Network at Robert-Bosch FOS	*Teachers of STEM-subjects*
4	o Personal contact o Recommendation of a contact person o Project Flyer o Different Student councils in STEM	*Female Students in STEM*

Therefore, most of the sampling of the group of parents is distributed randomly across Bavaria. Some minor problems occurred concerning recruiting interviewees of target group of teachers and female students because a lot of teachers had to prepare their school reports for the half-term during January and February and students were often also busy on these months because of examinations.

4. Qualitative Studies

In the following, the main results of the four sub-studies of the qualitative research in Germany will be illustrated. The results will be presented for each study according to the eight SESTEM research dimensions which are developed and documented in SESTEM Analytical Framework (see Mok & Ertl, 2010). Study 1 describes the findings of the interviews with pupils and the results of the nine focus groups with female pupils, study 2 the findings of the interviews with parents, study 3 the findings of the interviews with STEM-teachers and study 4 the findings of the interviews with female students of higher semesters. Afterwards, the commonalities and difference between the four groups will be analysed. The synthesis will sum up the main results of the qualitative studies and will establish the basis for future measures and good practice guidelines in order to enhance the interest of girls for STEM-related careers.

4.1 Study 1 - Qualitative Study with Pupils

4.1.1 Interviews with Pupils

4.1.1.1 Description of the sample and the methodology

In the following, the main results concerning the qualitative study with female and male pupils will be presented. In this section, the main results of the interviews with female and male pupils of secondary schools will be presented. With regard to the sample, we got 29 pupils from different schools (20 pupils from Fachoberschule (FOS), 8 pupils of Gymnasium, 1 pupil of Realschule) who have been interviewed.

4.1.1.2 Study results

In the following, the main results of the study will be presented which relate to the three main research levels: Individual, STEM in general, and consequences of a STEM career.

4.1.1.3 Individual

According to the research approach the first part of the interview, which includes questions about the educational biography, personal values, and factors for career, belong to the individual level of the interviewee.

- Educational biography

  Most of the interviewed pupils are 15 to 20 years old. All of them attend an upper secondary school (e.g. Fachoberschule or Gymnasium). It could be established that the majority of the pupils want to study after their school graduation but only a few pupils of already know what they will choose as study subject(s).

- Personal value

  The most important personal value is honesty. In addition, there are three other values which are meaningful for the interviewed pupils: reliability, openness, and friendship. With respect to the values it could be established that the majority of pupils have no role models or idols with regard to their career choice. However, some pupils said that their parents or relatives, who are working in STEM field e.g. as engineer on a building site, had influence on pupils' interests in STEM.
  With regard to media influences on career choice of pupils it could be established that some characters of STEM-related media series or the content of the series were also a topic. In general, pupils like series which deal with the work of doctors in hospitals like e.g. "Scrubs" (e.g. I9, I46, I59, I66, I67, I68) but also series about friends and their every-day-lives like "How I met your mother". Pupils like these doctor-series because they appreciate the funny scenes and the reflective moments: *"One the one hand really funny, one the other hand there are also serious scenes in which a little*

moral appears" ["Einerseits sehr witzig, andererseits gibt es aber auch ernste Szenen, in der eine kleine Moral zum Vorschein kommt"], I9, L.26*;"On the one hand [series] are mostly funny but in a other episode it is more that one have to reflect about it. Thus, it has also serious matters" ["Einerseits eher schon witzig, aber in anderen Folgen eher so, dass man nachdenken muss, so dass es auch schon seine ernsten Seiten hat"*, I68, L.49f. One other doctor-series is "Grey's Anatomy" which was named often (e.g. I46, I84) which focuses more on interpersonal relationships but some pupils think that the illustration of the job of a doctor is quite unrealistic and would not become a doctor in real life: *"All the doctors in doctors-series would never become a doctor in real life because they act really dumb sometimes" ["Die ganzen Ärzte in den Arzt-Serien wären im wirklichen Leben niemals Arzt geworden, weil sie sich manchmal schon extrem dumm anstellen"]*, I61. L.70f. Therefore, characters in TV might not have influence on their own career decision. Other TV-series like "How I met your mother" was also named often by the pupils (I49, I59, I67, I68) but has no specific STEM-related job as issue in the series.

Nevertheless, some pupils could imagine that characters of STEM-related series could have impact on younger pupils from 12 to 15 (I46; I68). Few pupils think that series could maybe influence younger children (I74, I80) on career choice. Furthermore, one mentions that this influence appears only in early childhood: *"However, it works only in early age, as it will change later" ["Aber nur in frühem Alter, da sich das später ändert"]*, I78, L.42.

Concerning a STEM-related series, most of the pupils do not think that they could have impacts on pupils' career choice for STEM. One pupil suggests that the STEM series could improve the image of STEM jobs but the series should be not too "dry" (I60). In this way younger pupils might be motivated to get more information about a STEM job profile. However, other pupils could not imagine that series about STEM-scientists could influence younger pupils regarding their career choice in STEM (e.g. I67, I73). One interviewee explains that she would not chose her career based on a TV-series: *"I doubt that I would not suggest my job based on a TV-series" ["Das bezweifle ich jetzt, weil ich nicht von einer Serie her schließen würde, dass ich diesen Beruf ausüben will"]*, I66, L.66f.

- Factors for career choice

  The interviews show that enjoying their future job is the most important factor for the career choice of the major part of the pupils: 15 out of 29 pupils want to enjoy the future job (I9, I16, I23, I47, I48, I59, I60, I61, I66, I68, I69, I70, I71, I73, I74). The second factor for career choice is the opportunity of a high salary in the future job. It could be established that most of the pupils name both factors the joyful work and an adequate or high salary: *"I want fun regarding my profession and the salary should also be fair" ["Ich möchte Spaß in meinem Beruf und das Geld muss auch stimmen"]*, I9, L.31; *"The job should be fun for me and the salary [is important]" ["Der Beruf muss Spaß machen und der Verdienst [ist wichtig]"* I51, L.21. Further, having a comfortable work environment and being well connected with colleagues (I76, I77, I80) as well as security-related factors ("having a safe job", I40, I78, I79) are more subject to girls. In contrast, boys are more focus on financial aspects like high salary (I1, I47, I48, I59, I60, I 70, I71) in the first place regarding career choice. Girls also named the salary (I40, I61, I66, I67, I68, I78) as career choice factor but this aspect is often mentioned secondarily (I61, I67, I68, I78).

4.1.1.4 STEM

- Motivation

  Asking about the motivation for STEM, the major motivational factors are according to the pupils the interest in STEM fields ("*If the interest is already existent in school, then one has got the incentive to have good opportunities during the study" ["Wenn das Interesse schon von der Schule her da ist,*

dann hat man auch den Anreiz gute Chancen im Studium zu haben"], I27, L.33) and to be a part of *"future developments"* (I46, L.58f.). Moreover, other important incentive for choosing STEM is the wish of a high salary (e.g. I40). Other incentives like opportunity of research, practical work in STEM, or the opportunity for women to work in a domain which are usually more attractive to male employees: *"That one could work in a domain which is more reserved to men" ["[d]ass man in einer Domäne arbeiten kann, die mehr den Männern vorbehalten ist"],* I22 (female), L.8. It could be revealed that a lot of the pupils assess the image of STEM professionals as "Nerds" which are fascinated by computers and sometimes have less social skills (e.g. I16, I46).

- Abilities

  According to the interviewees the essential abilities in STEM are interests in STEM subjects (e.g. I9, I16, I22, I27, I 40, I49), logical reasoning in particular in mathematics (e.g. I9, I16, I46, I49, I51), and a general scientific understanding (I9, I27, I59).

- Socio-cultural influences

  With respect to the socio-cultural influences most of the pupils' parents support the career or study choice of their children: *"My parents at least like it and they support us four children. We all want to go in a scientific field" ["Meine Eltern finden es gut und unterstützen uns 4 Kinder, wir wollen alle etwas Naturwissenschaftliches machen"],* I51, L.43f. Pupils report that they could make their own decision regarding their future career. Most of the friends estimate their career choice (in STEM) positively. Teachers could play a decisive role for the development of the interest for STEM by making inadequate annotations about pupils that seem to be less gifted in STEM: *"Because in general it depends a lot on teachers who put it across in a non-verbal way that you have not what it takes [...]" ["Weil prinzipiell viel an den Lehrern liegt, die dieses Nonverbale herüberbringen, dass sie sagen du hast es nicht drauf [...]"],* I66, L.91f. However, female pupils behave sometimes still reservedly in STEM classes e.g. they asked less often questions in comparison to the male pupils (e.g. I46, I51).

4.1.1.5 Consequences

Regarding the consequences of a STEM study or career pathway, it could be differed between obstacles and facilitators in STEM context in particular for women.

- Obstacles

  With regard to potential obstacles pupils name the tough study subject in general. Other obstacles follow like the male-oriented domain in STEM which could impede girls to choose a career pathway in this field or the stereotype related study choice of girls (e.g. they prefer humanities and social sciences). Some male pupils think that there are no obstacles if one began the STEM study once because they decided already for a study.

- Facilitators for STEM

  According to the pupils important facilitators for STEM are an early development of pupils' interest for STEM by support of their parents *("when I was a little child my parents gave me riddle tasks. I did a lot of mathematics-related riddles." ["Als ich klein war haben mir meine Eltern Knobelaufgaben gegeben. Ich machte auch viele mathematische Rätsel"],* I59, L. 58f.*)* and more practical experiments during STEM classes in school (e.g. in chemistry): *"They should bear more practical reference. In school it is too theoretical. However, with practice you could awaken one's interest." ["Man müsste mehr praktischen Bezug rüberbringen. In der Schule ist es einfach zu theoretisch. Mit Praxis weckt man Interesse"],* I40, L.99f. In addition, the support for children's interest seems to increase by STEM-related tasks or technical-related toys like Lego. Thus, one girl mentions these kinds of toys

and how she liked to play with it: *"Yes, I already liked to play earlier and a lot with "Lego"-bricks and "Duplo"-bricks that one could assemble lot. I had always fun with them" ["Ja, ich habe schon früher gerne und viel mit Lego und Duplo gespielt, wo man ja auch viel zusammenbauen muss und das hat mir schon immer viel Spaß gemacht"],* I61, L.32-33. Boys who want to pursue a career in STEM had this interest already in early childhood: *As a child I was already interested in engines and remote-controlled cars" ["Ich habe mich schon als Kind für Maschinen und ferngesteuerte Autos interessiert"],* I49, L.16.

4.1.1.6 Main results and Discussion

To sum up, regarding the **individual level** all pupils attend an *upper secondary school*. The results of the interviews with pupils show clearly that most of the pupils want to study after their graduation from school but a lot of them do not know what they will choose as subject. Most of the pupils think that *honesty* is the most important personal *value*. In addition, there are three other values which are meaningful for the interviewed pupils: *reliability, openness, and friendship*. It could be establish that the majority of pupils have *no role models* or idols with regard to their career choice. However, some pupils say that their *parents or relatives, who are working in STEM* field e.g. as engineer on a building site, had influence on pupils' interests in STEM. With regard to media influences of TV-series on career choice of pupils it could be established that some *characters of STEM-related media series* or the content of the series were also a topic but have *no influences* on their own career decision. However, some pupils could imagine that STEM-related series might have impact on younger pupils' career choice. Further, it could be revealed regarding factors for career choice that *a joyful job* (first response) is even more important to the interviewees than a *high salary* (second response). With regard to gender differences, having a comfortable work environment as well as security-related factors is more important to girls than to boys. In contrast, boys are more focus on financial aspects like high salary in the first place. Girls also mentioned the salary as career choice factor but this aspect is often secondarily for most of the girls.

With respect to **STEM** careers in general, building an early *interest* for STEM seems to be the *best motivational factor* for a STEM career decision. *Being part of future developments and a high salary* are also popular incentives for choosing STEM among pupils. Asking about necessary *abilities* for STEM, the interviewees name the specific *interest for STEM, logical reasoning, and general scientific understanding* for these subjects. Most of the pupils are supported by their parents in respect of their career choice which the pupils probably will choose in the future. With regard to their preliminary choice of career pathways the major part of the pupils has got the feeling that they could *decide their career pathway by their own*. In addition, most of the friends respect their career decision.

Asking about the **consequences** of a STEM career, pupils think that the biggest *obstacles* are the *tough study in STEM* and the *male-oriented domain* for women. With regard to *facilitators* an *early development of pupils' interest for STEM* as well as *practical teaching methods in STEM* class seem to be very decisive for pupils to taking a STEM career pathway into account.

	Interviews with Pupils
Educational biography	• Upper secondary school (FOS or Gymnasium)
Values	• Honesty • Reliability, openness, and friendship • No role models but some parents working in STEM • No media influences
Factors for career choice	• Enjoying their future job; • High salary • Comfortable job environment • Security of employment
Motivation	• Interests in STEM • Being part of future developments • High salary
Abilities	• Logical reasoning • General scientific understanding
Socio-cultural influences	• Support by parents • Making own career choices • Positive estimation of career choice by friends • Reserved behaviour by females in STEM class
Obstacles	• Tough study subject • Male-oriented domain • No specific obstacles for women (according to a few pupils)
Facilitators	• Early development of pupils' interest for STEM • Practical teaching methods in STEM class

Figure 2. Most frequent replies of the interviews with pupils according to the research dimension

4.1.2 Focus Groups with female Pupils

4.1.2.1 Description of the sample and the methodology

The Universität der Bundeswehr participated in the program of the national "Girls' Day" on 14th of April 2011 which aims at enhancing girls' interest for STEM subjects and career pathways. In total, 44 female pupils from different Gymnasien that are located in Munich have been involved in the Workshop "Concept Mapping and reflection of STEM careers" for girls. The female pupils are in the age of 14 to 16. All of them attended to the Concept Mapping workshop which was developed under the scope of gender reflexion about STEM career pathway in particular STEM-related studies.

After a short introduction about the Concept Mapping method as learning strategy and structuring aid, the 44 girls built nine groups and reflected about the question *"Why should women pursue an academic study in STEM subjects?" (yellow)*. Thereby, they generated a lot of concepts why women should study STEM (green) and why they will not study in these fields (red). Further, they cluster the concepts which belong together to a neutral category of concepts (blue). The arrows (or lines) illustrate the relation between to concepts and the thickness of the arrows defines the intensity of the relation that means the thicker the more intense. Moreover, dash lines could be use in order to show interactions in terms of relations between the concepts. For more details about the method of Concept Mapping see the Analytical Framework SESTEM (2010). All in all, the female pupils find various positive and negative aspects for girls in STEM study. A reflexion session by presenting two Concept Maps by the responsible groups in front of the other girls in the end of the workshop gives the girls the opportunities to think about gender stereotypes in STEM. After the Concept Mapping workshop and some of the girls might take a career choice or study in STEM into account.

4.1.2.2 Focus group results

In the following, the results of the focus groups based on the all nine groups and their Concept Maps (see Annex A) will be shown. For this report only the Concept Map of one group could be taken into account and will be described as an exemplary guide how to apply the Concept Mapping method.

In the following, the procedure of the Concept mapping will be shown. First of all, the girls collected positive and negative concepts which are relevant to the question *"Why should women pursue an academic study in STEM subjects?"* and write them down. They clustered the positive and negative concepts in four neutral categories which structured the different concepts (see figure 3): Academic study, family, reputation, and future. The category "Academic study" is related to "education" as well as to "often too sophisticated subjects". The category "family" could be divided into two negative (lack of time and financial problems) and one positive concept (future for children), that means choosing a STEM study could provide on the one hand financial problems and lack of time during the study for the family, and one the other hand pupils see a good future for children by choosing STEM. The category "reputation" is divided into two positive ("esteem" and "not a day-to-day phenomenon") and two negative concepts ("stereotypes" and "oppression"). According to the girls a high esteem could be achieved by a STEM study which is not a usual study subject for them but they consider also the stereotypes in STEM and perceived an oppression of women in these fields. The category "future" is divided into "gender-related problem upon applying for employment" on the one hand, and "employment opportunities" which is again linked to remuneration and education on the other hand that is also linked to the category "Academic study". With regard to this category, the girls receive gender-related problems concerning the applying process for a job but they are also aware of the high employment opportunities and salary in STEM.

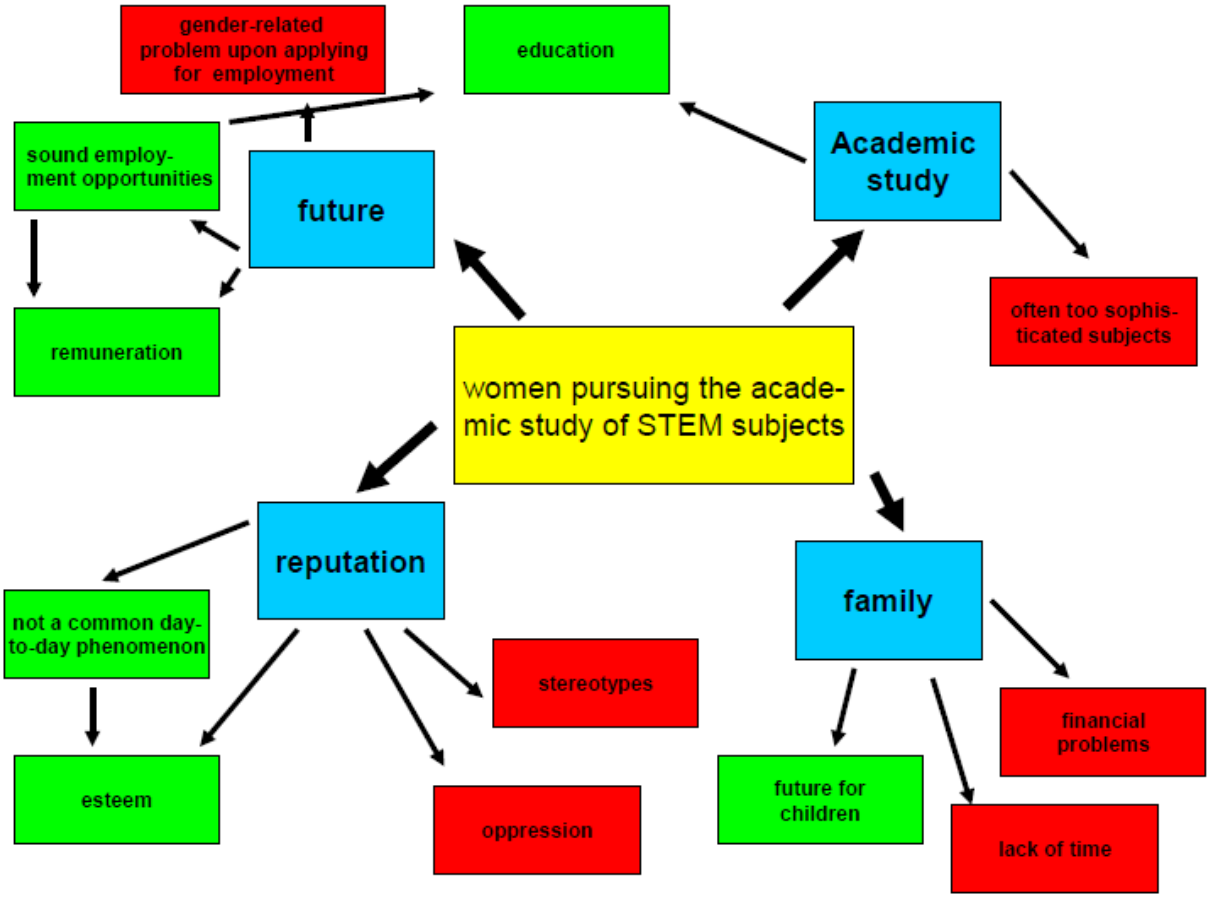

Figure 3. Concept Map of group A

To sum up, the female pupils are aware of the positive and negative aspects with regard to the question "*Why should women pursue an academic study in STEM subjects?*" and they are able to reflect the stereotypes of women in STEM on a higher level after the Concept Mapping workshop, thus they could link different concepts together and to a higher category.

4.1.2.3 Main results of the focus groups with pupils

In this section, all positive and negative concepts of the nine Concept Maps which are collected by the all female pupils of the "Girls' day" are listed in table 2. This table will give the reader an idea what the pupils think about women in STEM studies. The numbers how often the concepts have been named by the pupils are written in brackets. The most important positive concepts are "better chances upon recruitment" (4), "capability to concentrate on several concurrent things at the same time" (3), "women are doing better than men with regard to the course of studies" (2), "career opportunities" (2), "equal rights of men and women" (2), and "different points of view" (2). These aspect show that the girls think they could study STEM as good as men do or even better because they can do several concurrent things at the same time or are better in courses of studies. In addition, they know about the good career opportunities in STEM. With regard to the negative concepts the most important concepts are: "insufficient time for children & family" (5), "women's indifferentism to STEM" (5), "too many men" (4), "sparse leisure time" (3), "stereotypes" (2), "intensive learning" (2), and "underestimation" (2). With regard to negative aspects it could be established that the pupils see problems in combining family, child care, and job as well as low leisure time. Additionally, women's indifferentism to STEM could play a role in terms of career choice. With respect to the work environment, they mention the dominance of men, stereotypes in STEM, intensive learning in STEM subjects, and the

underestimation of women in these fields. The following table 2 illustrates all positive and negative concepts mentioned by the pupils according to the frequency.

Positive concepts	Negative concepts
• better chances upon recruitment (4) • capability to concentrate on several concurrent things at the same time (3) • career opportunities (2) • different points of view (2) • equal rights of men and women (2) • remuneration (2) • women are doing better than men with regard to the course of studies (2) • a lot of still unexplored things, new discoveries • better private tutoring options for children in natural sciences • child care • discovering new interests and talents • education • persistence & perseverance • enhanced abstract thinking • extensive knowledge • female intuintion • future for children • incentive for companies to provide support and thus to allow for a greater variety of options • intensification of the competition on the labour market • large-scale recognition • many male colleagues • more jobs for women • motivation through workshops • not a common day-to-day phenomenon - esteem • promotion prospects • standing out against other women • several job opportunities • strain limit 9x higher than among men • The future lies in the STEM – subjects • variable and interesting everyday-life • Women orientated towards natural sciences have the opportunity to dare to pursue a profession, if more women will be orientated towards natural sciences (role model character)	• insufficient time for children & family (5) • women‘s indifferentism to STEM (5) • too many men (4) • sparse leisure time (3) • intensive learning (2) • stereotypes (2) • underestimation (2) • boys are on average doing better with regard to these subjects • discrimination • financial problems • gender-related problem upon applying for employment • intensification of the competition on the labour market • lacking manual dexterity • minor prospects upon recruitment • often too sophisticated subjects • oppression • professions for women (elementary school teacher) cannot be pursued any more • sparse recognition • study period (pregnancy) • The remuneration is lower than in the case of men

Table 2. Positive and negative concepts of the focus groups

In the following table 3 the positive and negative concepts of the focus groups will be classified into the eight SESTEM research dimensions. Based on this new arrangement of concepts the results of the interviewed pupils and the results of the focus groups will be better comparable with each other. The large number of reported obstacles is related to the question of the focus group *"Why should women pursue an academic study in STEM subjects?"*. Therefore, pupils reflected positive and negative reasons at first before they started to cluster the related reasons in order to answer the question.

	"Why should women pursue an academic study in STEM subjects?"
Educational biography (Individual level)	• N/A
Values (Individual level)	• Education • Future for children
Factors for career choice (Individual level)	• Better chances upon recruitment • Career opportunities • Intensification of the competition on the labour market • Not a common day-to-day phenomenon – esteem • Promotion prospects • Several job opportunities
Motivation (STEM)	• Remuneration • Women are doing better than men with regard to the course of studies • A lot of still unexplored things, new discoveries • Discovering new interests and talents • More jobs for women • Standing out against other women • The future lies in the STEM – subjects • Variable and interesting everyday-life
Abilities (STEM)	• Capability to concentrate on several concurrent things at the same time • Different points of view • Persistence & perseverance • Enhanced abstract thinking • Extensive knowledge • Female intuition • Large-scale recognition • Strain limit 9x higher than among men

Socio-cultural influences (STEM)	• Better private tutoring options for children in natural sciences

Obstacles
(Consequences)
	• Insufficient time for children & family
	• With regard to academic study:
	  • Women‘s indifferentism to STEM
	  • Too many men
	  • Sparse leisure time
	  • Intensive learning
	  • Often too sophisticated subjects
	  • Study period (pregnancy)
	• With regard to career:
	  • Stereotypes
	  • Underestimation
	  • Discrimination/ oppression
	  • Gender-related problem upon applying for employment
	  • Intensification of the competition on the labour market
	  • Minor prospects upon recruitment
	  • Professions for women (elementary school teacher) cannot be pursued any more
	  • The remuneration is lower than in the case of men
	• With regard to skills:
	  • Lacking manual dexterity
	  • Boys are on average doing better with regard to these subjects
	• With regard to social factors:
	  • Financial problems
	  • Sparse recognition

Facilitators (Consequences)	• Incentive for companies to provide support and thus to allow for a greater variety of options • Many male colleagues • Motivation through workshops • Role model →Women orientated towards natural sciences have the opportunity to dare to pursue a profession, if more women will be orientated towards natural sciences

Table 3. Focus group results according to the eight SESTEM research dimensions (see Ertl & Mok, 2010)

4.2 Study 2 - Interviews with Parents

In this section, the main results concerning the qualitative study with parents will be presented.

4.2.1 Description of the sample and the methodology

In the following, the main results of the interviews with parents will be described. With regard to the sample, 22 parents with at least one or more children at the age of 14 to 19 years were interviewed. Six of the interviewees are fathers and 16 were mothers. The majority of the parents (15 of 22 parents) got an email via the LEV Bayern distribution list. Based on this email request for interview participants, parents who are interested in the SESTEM study have been contacted the project team of the Universität der Bundeswehr München and have been part of the qualitative study.

4.2.2 Study results

In the following, the main results of the study will be presented which relate to the three main research levels: Individual, STEM in general, and consequences of a STEM career.

4.2.2.1 Individual

According to the research approach the first part of the interview, which includes questions about the educational biography, personal value, and factors for career, belong to the individual level of the interviewees.

- Educational biography

  Most of the interviewed parents have "Abitur" and additionally some of the parents have a university diploma. A further result is that some of the parents were also professionals in the STEM fields. In order to get a better understanding for usual and unusual STEM-related career pathways of women a few examples will be illustrated:

  > *"Volksschule (school type which includes primary and secondary school for basic education) with high school diploma of a Hauptschule, vocational training as structional draftwomen, technical school, then construction management" ["Volksschule mit Abschluss der Hauptschule, Lehre als Bauzeichnerin, Technikerschule, dann Bauleitung"]*, I24, L.3f.

  > *"With the aid of BMW and their facilitation for women. They set value on the fact that women could achieve higher positions. Then I made myself self-employed as industrial engineer" ["Über BMW über Förderung von Frauen. Die haben Wert darauf gelegt, dass Frauen auch höhere Positionen erreichen können. Dann habe ich mich [als Wirtschaftsingenieurin] selbständig gemacht"]*, I44, L.12ff.

  > *"I have graduated with Abitur and studied physics afterwards. After a children break, I have done my doctor's degree. Subconsequent to the second children's break I started to work. […] Now, I […] work at a research institute which is affiliated to an University" ["Ich habe Abitur gemacht und danach Physik studiert. Dann nach einer Kinderpause habe ich promoviert. Nach einer zweiten Kinderpause habe ich dann gearbeitet. [...] [Jetzt bin] [i]ch [...] an einem Forschungsinstitut, das an eine Universität angegliedert ist"]*, I45, L.7ff.

  Therefore, as some of the female interviewees are working in STEM fields themselves, they might be particularly motivated to be part of the qualitative study of the SESTEM project. Some of the parents point out that they made their career decision by their own: *"I chose it by myself because I wanted to do something with technology" ["Ich habe mir das selbst herausgesucht, weil ich etwas mit Technik machen wollte"]*, I44, L42.

- Personal value

With respect to the personal values, parents estimate the values honesty and reliability the most. They also name trust, ambition as well as social skills as values. Similar to the group of pupils, parents had no idols or role models for their specific job wishes (e.g. I9, I20, I21). Only a few participants remember that they admired a person regarding their job: e.g. the father of a friend who was engineer: *"The father of a friend was an engineer at Siemens" ["Der Vater von einer Freundin war Ingenieur bei Siemens"],* I15, L.17*)* or a famous professional in STEM who impressed them regarding their career choice: *"[...] Regarding construction engineering there were some famous architects as role models" "[...] für das Bauingenieurswesen gab es namenhafte Architekten als Vorbilder*"], I13, L.19. Further, some parents try to be a role model for their own children e.g. by showing their children sports activities which base on technical devices (*"Yes, the father took the children already early to the gliding airfield and therefore the children are always interested in it" ["Ja, der Vater der Kinder hat sie schon früh mit auf den Segelflugplatz genommen und somit interessieren sich die Kinder schon immer dafür"],* I20, L.54f.) or by the profession of family members *("The grand-father was also pilot during the war and thus he was an role model" ["Auch der Opa war Kriegsflieger und somit ein Vorbild"],* I20, L.56*).*

- Factors for career choice

With respect to the factors for career choice interesting results could be observed. According to the parents three aspects should be taken into account regarding the decision for a career in STEM: First, they think that in these fields one could gain a high salary. Second, STEM fields provide an innovative and interesting range of job content. Third, the joy regarding STEM is also one reason for a career. In addition, they wish their children also to find a career pathway which lets them enjoy their job in general. An adequate salary is also an important factor of career choice to some of the parents.

4.2.2.2 STEM

- Motivation

With regard to the motivation why one should pursue a career in STEM a high salary and to enjoy the work seems to be important. Some parents also mention that a STEM-related career pathway offers a lot of career prospects. In general, they reflect a positive image of STEM jobs: these jobs have great range of job opportunities, exciting job fields and offer important future developments.

- Abilities

Asking what are the important abilities in STEM the answers were logical reasoning and persistence regarding the handling of a difficult study subject of STEM. Other specific science-related skills like mathematics or scientific understanding were also named by parents. Further, most of the parents think that students could study a STEM-related subject if they work hard during the study and practice more.

- Socio-cultural influences

Analysing the socio-cultural influences on the target group of parents, there was no direct influence from their own parents on career choice. Most of them were supported by their parents regarding their decision. With respect to their own children nearly all parents talk and discuss the career choice or at least the job orientation with them at home. Sometimes, they pointed specific STEM initiatives, STEM fairies for pupils, or practical offers for female pupils in STEM (e.g. initiatives like "Girls' day" or "Mädchen machen Technik", see Mok & Ertl, 2010).

4.2.2.3 Consequences

- Obstacles

  With regard to obstacles in STEM there are clearly stereotypes of women in society *("There are prejudges in society" ["Es gibt Vorurteile in der Gesellschaft"]*, I11, L.50) which might provide a traditional career choice: girls enrol for social studies and boys a more like to choose sciences. These stereotypes are linked to the gender prejudges of STEM classes: Girls show less self-confidence in STEM in comparison to boys: *"[...] however, these [girls] have a wrong self-perception and therefore they are lack of self-confidence [...]" "[...] jedoch haben diese ein falsches Selbstbild und somit fehlt das Selbstbewusstsein [...]"*, I15, L.48f. However, some parents mentioned that those who seriously want a STEM career will be able to handle obstacles no matter if it is male dominated or not.

- Facilitators

  As suggestion what would be a measure for promoting more girls in STEM, parents think that there could be more (female) role models from universities and from the field of STEM professionals which aim at clarifying the vague job profile of a STEM professional or scientist for pupils (*"But women with practical experiences should go into schools and they should reveal available opportunities for girls " ["Aber Frauen aus der Praxis sollten schon an die Schulen gehen und den Mädchen zeigen welche Möglichkeiten es gibt"]*, I24, L.93ff.), and more STEM-specific courses only for girls to encourage girls for STEM (*"Women should be promoted. If one offers a course only for girls, then these girls will probably be more encouraged to pursue a career in STEM" ["Frauen sollten unterstützt werden. Wenn man Kurse für Mädchen macht, haben diese wahrscheinlich mehr Mut, um in eine MINT-Karriere zu gehen"]*, I19, L.76f.). By this means, in particular female pupils could be enhanced and encouraged to consider a STEM career pathway. Further, some parents wish that schools increase information about different study subjects at universities and want pupils have to expect from study requirements. From the perceptive of parents, they feel responsible for the support of their own children regarding their career decision e.g. by offer financial support for university which concerns accommodation, tuition fees, etc. (*"We enhance our children financially but they also going to work. However, they got their "Kindergeld"(child allowance). We do not want that the burden of the part-time job will be too high." ["Wir helfen den Kindern finanziell, aber sie gehen auch arbeiten. Aber sie bekommen auch ihr Kindergeld. Wir wollen nicht, dass die Last mit dem Nebenjob zu groß wird"]*, I26, L.85f.), on the one hand and to give them the freedom to let their children make their own free decision regarding their future career on the other hand (*"They had the freedom to choose without any impact" ["Sie hatten die Freiheit der Wahl ohne Beeinflussung"]* ,I5, L.71).

  Further, some parents are currently working in STEM-fields and say that they probably promote their children's interest for STEM-subjects in early childhood by e.g. by showing them their STEM-workplace:*"I promoted this by taking him already to the construction site at Kindergarten age" ["Ich habe das gefördert, indem ich ihn schon im Kindergartenalter mit auf Baustellen genommen habe. Er hat auch schon auf der Baustelle gearbeitet"]*, I18, L. 39ff. In addition, it was mentioned a few times that the family should be a significant part with regard to support of children's career choice: *"Also, the family has to support their children" ["Auch die Familie muss die Kinder unterstützen"]*, I20, L. 92.

4.2.3 Main results

In the following, the main results of the interviews with parents will be shown. The first part describes the **individual level** of the interviewees. Most of the parents achieved an *average educational standard* by graduate from secondary school with a study qualification ("Abitur"). Further, some of the parents attended a university. Most of the parents of the study who have an average or high educational

background are engaged to be part of the SESTEM studies. The educational background could be the reason for the parents to participate in the study in order to share their own experience. The main results regarding the individual dimension are that some of the interviewed mothers have been *successful as female STEM professionals* themselves and want to support young girls in STEM. Further, most of the parents explain that they had *no direct role models* for their career choice but for their own children's career choice they enhance them by showing their STEM workplace. Regarding the values, parents estimate the *values honesty and reliability* the most. The most important *factors for career are a high salary, an interesting range of job content, and the joy* regarding STEM.

With respect to **STEM** in general, parents see the *positive image and job prospects* in STEM, In addition, a high salary and to *enjoy the work* seems to be important as *motivational factor* concerning career choice. Asking what are the important *abilities* in STEM the answers were *logical reasoning and persistence* regarding a STEM study. Other specific science-related abilities should be a basic STEM-related understanding. Regarding the *socio-cultural influences* of parents, there was *no direct influence from their own parents* on their career choice. Most of them were supported by their parents regarding their decision. With respect to their own children nearly all parents talk and discuss questions of career pathways or at least the job orientation at home. Besides, some of the parents suggest them to go to a STEM fairs or try practical STEM-offers for pupils.

With regard to the **consequences** of a STEM career, the main *obstacles* in STEM *are stereotypes of women in society, gender prejudges in STEM classes, and the low confidence of girls* in STEM subjects. With respect to *facilitators*, parents show a lot of effort in this context. Some parents probably *promote their children's interest for STEM*-subjects in *early childhood* by e.g. by showing the children their STEM-workplace. In addition, it was mentioned a few times that the family should be a significant part with regard to support of children's career choice. In general they would suggest more (female) role models from universities and from the field of STEM professionals which aim at clarifying the vague job profile of a STEM professional or scientist for pupils and more STEM-specific courses only for girls.

Interviews with Parents	
Educational biography	• Average educational standard • Some mothers are female STEM professionals
Values	• Honesty • Reliability
Factors for career choice	• High salary • Interesting range of job content • Enjoying work
Motivation	• Positive image • Job prospects • High salary
Abilities	• Logical reasoning • Persistence
Socio-cultural influences	• No direct influences • Support by parents • Discuss job orientation at home with children
Obstacles	• Stereotypes of women • Gender prejudges in school • Low confidence of girls
Facilitators	• Early development of pupils' interest for STEM • Family should support children's career choice • More (female) role models

Figure 4. Most frequent replies of the interviews with parents according to the research dimension

4.3 Study 3 - Interviews with Teachers

In this section, the main results concerning the qualitative study with STEM teachers will be presented.

4.3.1 Description of the sample and the methodology

In the following, the main results of the interviews with the teachers will be described. With regard to the sample, 20 STEM teachers were interviewed on telephone (7 males and 13 females).

4.3.2 Study results

In the following, the main results of the study will be presented which relate to the three main research levels: Individual, STEM in general, and consequences of a STEM career.

4.3.2.1 Individual

According to the research approach the first part of the interview, which includes questions about the educational biography, personal value, and factors for career, belong to the individual level of the interviewee.

- Educational biography

  With regard to the educational pathways of the nearly all teachers followed the educational training for teachers at university and started teaching directly at school. Only a few of the participants have graduated with a "STEM"-related diploma and worked in industry before they changed the career plans to become a teacher.

- Personal value

  Regarding the personal values the most important values are reliability, honesty, and family according to the interviewees. In this group the value "family" was named more often than in the other target groups. Asking about role models some of the teachers say they had no direct role models. The major part of teachers declares that at least one parent or member of the family was already a teacher in general (e.g. I42) or in a STEM-related subject (e.g. I7, I37, I41, I47).

- Factors for career choice

  Asking about the important factors for the teachers' career choice, the interviewees name a lot of different factors. Some of the teacher prefer to work with children or young people (I7, I31, I42) and other teachers like to explain STEM-related content: *"Previously, I gave private lessons and I enjoyed Explaining things to others" ["Ich hatte früher mal Nachhilfe gegeben und hatte Spaß daran Leuten etwas zu erklären"]*, I43, L.22. In addition, it could be revealed that for some of the teachers especially females the job guarantee in STEM or by teaching STEM at school is decisive. This argument is linked to the wish of women to combine family and career e.g. one female teacher says that she could return to her teaching job after she has been taken a break for 12 years which was the indicator for a right career choice: "Yes, the decision was right. You could re-entry nowhere else after 12 years of a break" [*"Ja, die Entscheidung war richtig. Nirgends kann man nach 12 Jahren Pause wieder einsteigen"]*, I38, L.12f. Similar to the other target groups, some teachers say that the interest (I.32, I37, I42) and enjoying the work (I4, I37, I41) are also important factors for the career decision.

4.3.2.2 STEM

- Motivation

  With regard to the motivation or incentives why one should pursue a career in STEM the teachers name the high payment in STEM, good job prospects for teachers in STEM, and the passion in these subjects. Some of the teachers also think that being part of future developments and the opportunity to be creative in the job are important reasons for a career in this field.

- Abilities

  Taking about requested abilities in STEM, the teachers give a lot of different answers which could divided into two categories: One the one hand, STEM students should have built a certain knowledge base in the related STEM subject (at school). This knowledge includes logical reasoning, a general understanding for mathematics or physics (STEM) as well as ambition. On the other hand, if one starts a STEM career pathway they should develop skills like enjoying the work, persistence, and frustration tolerance in order to master the difficult STEM study or career.

- Socio-cultural influences

  Analysing the socio-cultural influences on the target group of teachers, there was no direct influence from their own parents on career choice. In general, a major part of the interviewees were supported by their parents. However some interviewees mention that one of the parents did not appreciate the choice for a teaching career which is related to their low socio-economic background of the family. One female interviewee explains that her family with no academic background would rather like her to start a vocational training instead of studying because of the financial aspect: *"They blocked everything because they wanted me to earn money" ["Die haben alles abgeblockt, weil sie wollten, dass ich Geld verdiene. Da die finanzielle Unterstützung von meinen Eltern nicht gewährleistet werden konnte"]*, I31, L. 38f. Moreover, one other teacher explained that she has a low socio-economic background, thus she chose the STEM teaching job because of the job guarantee: *"Yes, I come from a working class family, therefore, the income was important and I decided based on the job guarantee for sciences" ["Ja, ich komme aus einer Arbeiterfamilie, deshalb war das Einkommen wichtig und ich entschied mich wegen der Jobsicherheit für die Naturwissenschaften"]*, I38, L.29f. One male teacher mentions that his career choice based among others on the fact that he came from a family which belongs to middle-class and he wanted to climb up socially: *"However, I think that I would simply like to climb up from middle class and thus the teacher job came into consideration for me" ["Ich denke aber, dass ich damals einfach aus der Mittelschicht aufsteigen wollte und da kam der Lehrer für mich in Frage"]*, I43, L.22ff. This might also be an indicator of a lower socio-economic status of the family. Friends did not play a big role in the decision process for a STEM career. In addition, in the opinion of most of the teachers they figured their interest and skills for STEM out by their own or in school, so that they are confident enough to choose a STEM career and the parents have to accept it.

4.3.2.3 Consequences

- Obstacles

  With regard to obstacles in STEM careers or studies, it becomes clear that the teachers had two different opinions: on the one hand, they perceive general obstacles and especially specific obstacles for women in STEM, on the other hand, some teacher think that if one would like to pursue a career in this field, he or she will be able to handle minor problems. Regarding general barriers, the demanding study in STEM particularly at the beginning of the study is one of the most important barriers: "*The beginning of the study is so much frustrating" ["Der Beginn des Studiums ist sehr frustrierend"]*, female, I37, L.76) or (e.g. I 41, I55). Some teachers remember that the STEM study was difficult and very theoretical (*"It has less to do with practice because at the beginning everything is very theoretical" ["Es hat wenig mit der Praxis zu tun, denn am Anfang ist alles sehr theoretisch"]*, female, I41, L.70). With regard to career plans female and male teachers agree that teaching at school allows women to combine family and job and the re-entry in the work environment after a break: "*As a woman you choose a job when you have children that you are ensured and got the opportunity to take a break as well as to find the re-entry" ["Als Frau wählt man sich einen Beruf, wenn man Kinder bekommt, dass man dann abgesichert ist und die Möglichkeit hat eine Pause zu machen und den*

Wiedereinstieg zu finden"], I47, L.88f. On the contrary, some teachers think that in the industry STEM female professionals might have problems to combine both: Further, women still have to handle a lack of acceptance in STEM field and they are confronted by gender stereotypes and prejudges in STEM at school and at work. Some teachers also observe that female pupils still have less confidence than male pupils in STEM class. One other obstacle is that there is a lack of female role models.

- Facilitators

  As suggestion what would be a measure for promoting more girls in STEM, teachers elaborate that schools could go more after (female) role models from the field of STEM professionals which aim at clarifying the vague job profile of a STEM professional or scientist for pupils. Further, some teachers estimated that it is up to them to share their own study experiences with their pupils to encourage them. Some of the teachers suggest gifted pupils to take a STEM career into account. By this means, in particular female pupils could be enhance and encouraged to consider a STEM career pathway. Regarding the current STEM initiative they suggest that the offers (e.g. STEM job fairs or the "Girls' Day") and for girls in STEM should be obligatory for a class during school, otherwise pupils are not motivated enough to attend such an event facing the long school day.

4.3.3 Main results

In this section, the main results of the interviews with STEM-teachers will be summarized. The findings concerning the **individual level** are that teachers tend to have chosen the *direct way of teaching profession*, a few exceptions only. A significant value besides *reliability and honesty* is *family* according the interviewed teachers. Family is more subject to female teachers who are thinking about child care and job prospective. Asking about role models the major part of teachers declares that at least *one parent or member of the family was already a teacher* of a STEM-related subject. With regard to *factors of career choice* three decisive reasons for the teaching profession could be revealed: *job guarantee* and opportunity of *combine family and job* which is in particular interesting for women, and the wish of three teachers to *climb up socially*.

With respect to **STEM** in general, the most popular motivational factors for STEM careers are the *high payment in STEM, good job prospects* for teachers in STEM, and the *passion* in these subjects according to teachers. Regarding STEM abilities, the most important ones are *logical reasoning*, a *general understanding for STEM subjects*, and *ambition*. Analysing the socio-cultural influences on the target group of teachers, there was *no direct influence of parents* but in some cases where both parents do not have academic background, they did not appreciate the choice for a teaching career because their children may inhibit to earn an adequate salary during the study phase. This might also be an indicator of a *lower socio-economic status* of the family. The influence of friends seems to play a minor role. In addition, some teachers *figured their interest and skills* for STEM out *at school.*

Taking the **consequences** of a STEM teaching career into account, difficult obstacles came up during the STEM study for most of the teachers. In particular *the demanding study in STEM* could be seen as problem for many students because the studies in STEM are very theoretical. One positive aspect of teaching STEM is the *opportunity for women to combine family and job*. The barriers in STEM industry are different to those of teaching fields e.g. women have to deal with a *lack of acceptance* in STEM field and they are confronted by *gender stereotypes*. Thus, the *barriers are established more in STEM industry* in comparison to the teaching profession according to the teachers.

Facilitation measures for promoting more girls in STEM could be according to teachers *(female) role models* from the field of STEM professionals which aim at *clarifying the vague job profile* of a STEM professional or scientist. Further, teachers *share their own study experiences* with their pupils to

encourage them. One further suggestion is that specific extracurricular activities or offers for girls in STEM should be obligatory for a class during school.

Interviews with Teachers	
Educational biography	• Mostly direct way of teaching profession
Values	• Honesty • Reliability • Family (More important in this group) • Role model: Family members are already teachers
Factors for career choice	• Job guarantee • Combining family and job • Opportunity to climb up socially → *Indicator for low social-economic status of the family*
Motivation	• High salary • Good job prospects • Passion
Abilities	• Logical reasoning • General understanding for STEM subjects
Socio-cultural influences	• No direct influence of parents • Some teachers' parents did not appreciate the choice • Development of their interest for STEM at school
Obstacles	**In STEM industry**: • Stereotypes of women • Lack of acceptance **In school as teacher:** • Minor problems with regard to combining family and job
Facilitators	• (Female) role models in STEM → clarifying the vague job profile • Sharing own study experiences with pupils • Specific, obligatory extracurricular activities in STEM only for girls

Figure 5. Most frequent replies of the interviews with teachers according to the research dimension

4.4 Study 4 - Interviews with females Students

In this section the central findings of the qualitative study with female graduate students and postgraduate students in STEM will be presented.

4.4.1 Description of the sample and the methodology

In the following, the main results of the interviews with the female students will be described. With regard to the sample, the interviewees were contacted by personal contact, email and via STEM-related distribution list. In total, 11 female students of STEM subjects like mathematics, physics, engineering, and STEM-related teacher training from three different universities were interviewed on telephone: Technische Universität München (TU) in Munich, Ludwig-Maximilians-Universität München (LMU) in Munich, and University of Mainz. In addition, this sample includes three post-graduate students in mathematics and two Master-students in physics. Remarkable in this target group is the fact that three out of 11 interviewees attended to a single-sex school (Gymnasium) for girls.

4.4.2 Study results

In the following, the main results of the study will be presented which relate to the three main research levels: Individual, STEM in general, and consequences of a STEM career.

4.4.2.1 Individual

According to the research approach the first part of the interview, which includes questions about the educational biography, personal value, and factors for career, belong to the individual level of the interviewee.

- Educational biography

  With regard to the educational pathways of female students in STEM, most of the students attended the Gymnasium and graduated with "Abitur" and started a STEM study to achieve a Diplom or Master degree in STEM. A few of the female students attended to a teacher training course in STEM field. As it was mentioned above, three out of eleven interviewees attended to a single-sex school (Gymnasium) for girls. One of them thinks that girls from those schools are probably more likely to choose a STEM subject if they are interested in. It could be established that nearly all interviewees enjoyed mathematics or other STEM-related subjects already in their childhood or in school. Most of the interviewees explain that they were (highly) gifted in these subjects: *"Ich war ein Mathe-Genie" ["I was always a Genius in Maths"]*, I6, L.36*; "STEM was always easy for me in school and I have never to put effort on it" ["Das ist mir in der Schule immer leicht gefallen und musste nie etwas dafür tun"]*, I53, L.16.

- Personal value

  Regarding the personal ideals the most important values are honesty, reliability, and an agreeable work environment. In addition, the female students name various self-realization arguments like e.g. identification with a job, meaningful work, achieving work-life-balance, and following personal ideas: e.g. *"So, I do not want to forsake myself totally for my future job" ["Also ich will mich nicht komplett aufgeben für mein späteren Beruf"]*, I54, L.47. In this group the identification and self-realization is higher than in the other target groups. Some students say that a good environment is more important than amount of salary: *"Salary is important but more important is a fair treatment and an agreeable work environment" ["Gehalt ist wichtig, aber wichtiger sind eine faire Behandlung und ein angenehmes Arbeitsklima"]*, I1, L.8f. In this respect it should be considered that the question of salary seems not that important because it might be well-known among the target groups and in general that STEM-professions are well-paid.

With respect to idols for career choice, some students say they had no idols but most of the students explain that their parents work in STEM area *("Both of my parents are teachers but my father has also studied physics and got a diplom [...]" ["Meine Eltern sind beide Lehrer, aber mein Vater hat auch Physik auf Diplom studiert [...]"]*, I57, L. 47f.*)* or they had some good teachers who gave practical and impressed them: *"There was a teacher who has assigned extra tasks to me" ["[Es][...] gab [...] einen Lehrer, der mir extra Aufgaben gegeben hat."], I14, L.47f; "My godaunt is a very dedicated teacher who was a role model for me" ["Meine Patentante ist eine sehr engagierte Lehrerin, die für mich ein Vorbild war"], I53; L. 36f.* Other important role models were teachers at school who impressed three of the students that they choose teacher training at university (I14, I29, I53).

- Factors for career choice

  Asking about the important factors for the career choice most of the students reported factors like enjoying work *("I want to enjoy it" ["Es muss mir Spaß machen"], I29, L.12 or e.g. I6, I35, I14, I30, I83)*, challenging STEM *("Also, the challenge is important to me" ["die Herausforderung ist mir auch wichtig"]*, I35, L.24 or e.g. I14, I57), and the fact that STEM fields offer a big range of opportunities *("The job has to be diversified" ["Der Beruf muss vielseitig sein"], I1, L.12 or e.g. I29, I57)*. Other factors are high salary (e.g. I1, I2, I83) and having time for friends and family were also reported: *"So, I still would like to have got enough time for myself, family, and friends" ["Also ich möchte noch Zeit für mich haben und Freunde und Familie"]*, I54, L.47f. However, one student explained that the salary is important but the job environment seems to be more decisive: *"The salary is important but more important is a fairly treatment and a comfortable work environment" ["Gehalt ist wichtig, aber wichtiger sind eine faire Behandlung und ein angenehmes Arbeitsklima"]*, I1, L.7f. Further, social factors like family and friend, and work-life-balance are stronger in this group.

4.4.2.2 STEM

- Motivation

  Regarding the motivation or incentives, why one should pursue a career in STEM, the interviewees name interest for STEM *("I am interested in mathematics" ["Ich habe Interesse an Mathematik"]*, I2, L.79 or e.g. I35; I57), the joy regarding STEM *("I always enjoyed mathematics the most" [Mir hat Mathematik immer am Meisten Spaß gemacht"], I6, L.12)*, the fact that STEM provide, good job prospects (I57, I83), future of STEM subjects *("The STEM-related subjects have also future and constancy " ["Die MINT-Fächer haben auch eine Zukunft und Bestand"]*, I6, L.21f.), job guarantee *("The job guarantee is very high by studying a STEM-related subject. Further, one is not committal to a higher extent that it is still possible to become a teacher afterwards or go to economy"["Jobsicherheit ist sehr groß, wenn man ein MINT-Fach studiert, legt man sich noch nicht so fest, man kann später immer noch Lehrer werden oder in die Wirtschaft gehen"], I30, L.25ff.)*, and the significance of future STEM jobs. The importance of the salary is only mentioned a few times in this target group (I1, I2, I83).

- Abilities

  In this section, the required abilities for pursue a STEM study or career will be shown. According to the students, decisive abilities are a general STEM-related understanding ("mathematisches Verständnis") in particular logical reasoning. Further, most of the interviewees mention that a certain gift for STEM-subjects should be given: *"One should be extraordinary gifted" ["Man muss eine ausgeprägte Begabung haben"], I6, L.27).* On the other hand, students in STEM should put more effort maintain in the study by showing more "willingness to learn" and "frustration tolerance".

- Socio-cultural influences

Analysing the socio-cultural influences on students career choice, it could be seen that most of the parents supported the career decisions or have positive impact. That means that most of parents let the students choose their own career pathway or they encourage them to take up a STEM study: *"My environment had positive impact on me. My parents let me freely choose." ["Meine Umgebung wirkte sich positiv aus. Meine Eltern haben mich frei entscheiden lassen"],* I14, L. 38f. Some parents appreciate the their daughters' choice in STEM: *"My father was happy for me and my mother too." ["Mein Vater hat sich sehr gefreut und meine Mutter auch"],* I57, L.59. In particular parents who work as STEM professional are very encouraging with regard to an uptake of a STEM career: *"The parents enhance the STEM-career because they are working in this field themselves" ["Die Eltern unterstützen die MINT-Karriere, da sie selbst in diesem Bereich tätig sind"],* I1, L. 41. However, a few parents were skeptical at the beginning of the study if their daughter could handle a STEM study but after some exams he changed his mind: *„My dad told me afterwards that he ever thought that this is the right thing for her […] because I have a already an understanding for logical correlations but I have not an all-embracing one" ["Mein Papa hat mir im Nachhinein erzählt, dass er nicht gedacht hätte, dass das Richtige für mich ist. [...] [w]eil ich schon Verständnis habe für logische Zusammenhänge, aber kein umfassendes"],* I54, L.105 ff.

The opinions of the friends are different: Most of the female students report that their friends know that they are good in STEM-related subjects and accept the study or career choice (I54; I57). Other people could not establish an adequate understanding for the career choice in particular by women: *"Some are shocked by the fact that I am studying mathematics" ["Manche sind schockiert, dass ich Mathematik studiere"],* I2, L.99f. Further, some friends of the students were surprised by the career choice: *"They were quite surprised" ["Die waren schon erstaunt"],* I54, L.99.

4.4.2.3 Consequences

- Obstacles

Asking about general obstacles in STEM, nearly all the students agree that their STEM study was a difficult study subject: they perceived a high pressure concerning the drop out-quote (*"It is quite hard. They eliminate, so that one has to go through it" ["Es ist schon hart. Da wird aussortiert, dass man erst mal durchkommt"],* I54, L.122ff.) and they missed social contacts sometimes *("Actually, there are no obstacles but social issues and soft skills miss out a lot" ["Eigentlich gibt es keine Hindernisse, aber soziale Sachen und Softskills kommen viel zu kurz"],* I35, L.67f.*)*.With regard to obstacles for women in STEM careers, most of the female students observe the greatest obstacles in the lack of acceptance for females in *STEM ("The problems are bigger for women [in STEM] e.g. to be accepted in particular in the construction domain. There you need particularly technical knowledge and you have to know how to behave" ["Bei Frauen ist das Problem natürlich noch größer, dass man später akzeptiert wird, besonders in der Baubranche, da braucht man besonders fachliches Wissen und man muss wissen wie man auftritt"],* I54, L.124ff.*)*. Other perceived obstacles are the lack of female role models/ contact persons e.g. female professors (*"There are less female professors" ["Es gibt wenige Professorinnen"],* I 30, L.69), prejudges against women in STEM *("Prejudges are still possible if there are professors who prefer men" ["Es kann sein, dass es noch Vorurteile gibt. [..]Wenn es Professoren gibt, die Männer bevorzugen"],* I14, L.54ff.*)*, feeling alone under male students *("Ein Hindernis ist, dass viel zu viele Männer da sind"* I83, L. 95f.*)* and lower self-confidence of female pupils in STEM *("Women are able to do something in the same manner as men are but they are often not confident enough" ["Die Frauen können genau so viel wie die Männer, sind aber meistens nicht selbstbewusst genug"],* I6, L.41f.*; "If one has a lower self-confidence so he or she will give up faster" ["Wenn man zu geringes Selbstbewusstsein hat, gibt man schneller auf"* I14, L.53ff.*)*. One student notices that women think they are not good enough in STEM which leads back to unfavourable attributions pattern of women regarding their STEM abilities:

"Women are always thinking about what they could not do and men are thinking about what they could do" ["Frauen denken immer an das, was sie nicht können und Männer denken an das, was sie können", I14, L.22f.). However, one student reported that she enjoyed the presence of more men than women which was related to the relaxed atmosphere: *"On the one hand, keeping company with men is quite positive because there are no "bitchy girls" ["Der Umgang mit Männern ist zwar einerseits ganz positiv, weil der ganze Zickenterror nicht da ist"], I83, L.96f.*

Asking about the problems with the combination of family and STEM career pathways which could hinder women in STEM careers most of the students think this depends on the employer e.g. some students could imagine that it is more difficult for women to match family issues with job requirements of long working hours *("I do not know. It depends on what one is doing e.g. if one goes to the government it would be quite good. It probably would not be that easy in particular concerning the working hours." ["Weiß nicht genau. Kommt, darauf an, was man macht. Wenn man z. B. zum Staat geht, wird's ganz gut sein. Sonst wahrscheinlich nicht so [einfach]. Vor allem wegen den Arbeitszeiten"],* I 54, L.136f. *In addition, some students perceive obstacles for women in the free market economy with regard to STEM: "With regard to the free market economy I do not know but it depends on the employer" ["In der freien Marktwirtschaft weiß ich es nicht, aber das hängt bestimmt vom Arbeitgeber ab"],* I57, L.95f.*).* One student mentioned that research positions are more difficult for women because of limited contracts and lower salary: *"In the economy it is very difficult because you get a limited position from the very first and the payment is not that good" ["In der Wissenschaft ist es sehr schwierig, weil man am Anfang nur befristete Stellen hat und die Bezahlung nicht so toll ist"],* I57, L.96f. On the other hand, some female students do not see serious problems for women in STEM *("I do not see bigger problems for women than for men" ["Für Frauen sehe ich keine größeren Probleme als für Männer"],* I57, L.88*).* Moreover, one interviewee thinks that girls sometimes have an advantage in STEM-subject at university: *"As a woman you would not treat more badly in STEM. I have got the feeling the women receive a little of a special treatment" ["Als Frau wird man in MINT nicht schlechter behandelt. Ich habe das Gefühl, dass Frauen eine kleine Sonderbehandlung bekommen"],* I53, L.79f.

- Facilitators

The students generated a lot of suggestions what would be successful measures for promoting e.g. more girls in STEM, mentoring programs (*"I would wish these mentoring programs" ["Ich würde mir diese Mentoring-Programme wünschen"],* I35, L.73), and more female professors *("Direct contact persons and more female professors were desirable" ["Wünschenswert wären direkte Ansprechpartnerinnen und mehr Professorinnen"],* I14, L. 60f.), networks, more open days in STEM. They had some of the measures already at university. Some of the students say that they do not need a facilitation program (e.g. I1 or "*No, I applied once during the frist semester for a mentoring program but i did not make it in. However, now I do not need it anymore" ["Nein, ich hab mich mal im 1. Semester mal für ein Mentoring-Programm beworben, bin aber nicht mehr reingekommen. Aber jetzt bräuchte ich es auch nicht mehr"],* I54. L. 208f.). At home some of the students had stronger support with regard to homework for school by their parents who work in STEM fields: *"[…] I had the opportunity to ask my father of course if I had e.g. pretty problems in mathematics or physics and he was able to help me" ["[...] ich konnte natürlich meinem Vater befragen, wenn ich zum Beispiel ziemliche Probleme in Mathematik hatte oder in Physik und er konnte mir dann helfen"],* I54, L.28ff. However, it also seems important to have an early encouragement by parents to increase the interest for STEM e.g. one student reports that had an electronics experiments kit in her childhood: *"That my parents had already impacts on me because I also had got eletronics experiments kits as a child" ["[...] dass meine Eltern schon auf mich eingewirkt haben, weil ich als Kind auch Elektronikbaukästen bekommen habe"],* I30, L, 19f. One other student remembered the support by her

father who gave her special arithmetic problems on computer during primaray school: *"My father had wrote a computer program that provides us arithmetic problems when we attend at primary school" ["Mein Vater hat als wir in der Grundschule waren ein Programm geschrieben, das uns dann Rechenaufgaben gestellt hat"],* I57, L 36f.

4.4.3 Main results

In the following, the main results of the interviews with female students of STEM subjects will be shown. Regarding the **individual level**, the central results with regard to the individual context of the interviewees will be summarized. Most of the female students are graduates or postgraduates in STEM-subjects.

Analysing the educational biography of the students nearly all of them enjoyed mathematics or other STEM-related subjects in their childhood or in school. Some of the female students explain that they were gifted in these subjects especially mathematics.

With respect to *values and factors for career choice* of female STEM students, interesting aspects could be revealed. Regarding *role models* for career choice most of the students had no direct role models but in fact some of the *parents* do work in STEM fields and supported their children concerning homework and answer further questions. In addition, three students explained that they had some good *STEM-teachers* who gave practical exercises and impressed them. The results of the interviews with female students underline which impacts parents and teachers could have on pupils during the process of future career choices. Thus, the significance of the influence and encouragement of parents and teachers regarding the STEM interest is very important for the career choice of pupils. Even if the students explained that the parents had no direct impacts on their career choice, the interest for STEM was influenced indirectly by their parents STEM profession, thus STEM-subjects were ever-day issues at home. Therefore, the collaboration between school teachers and parents should be improved that pupils were complementary supported in the context of school and home in terms of career opportunities and decisions. Concerning *values* a lot of the interviewees underlined that self-realization aspects like e.g. identification with work, getting a meaningful work, achieving work-life-balance, and following the own ideas in life are more important than the financial aspect of a job. Further, in this group the identification and self-realization is higher than in the other target groups. With regard to these self-realization aspects, it should be mentioned that STEM-related job are well known as well-paid jobs. Maybe therefore, the graduates and postgraduates might not that worried about the salary because the STEM-jobs are anyway of an adequate amount e.g. an agreeable work environment attach more value to some students than a high salary. Asking about the important factors for the career choice are enjoying work, challenging STEM field, and the fact that STEM fields offer a range of opportunities and contents. Other factors are high salary and having time for friends and family. Further, social factors like family, friends, and work-life-balance were more important to this group.

In the following, the most important results with respect to **STEM**-subjects will be illustrated in the following. Regarding the motivation or incentives why one should pursue a career in STEM, the interviewees name in particular the interest for STEM, the joy regarding STEM, the fact that STEM are the most meaningful subjects, good job prospects, job guarantee and the significance of future STEM jobs. The salary is mentioned less often in this target group. *Logical reasoning and a certain gift for STEM* seems to be important abilities for STEM. Analysing the socio-cultural influences on students career choice, it could be seen that most of the parents support the future decisions or have positive impact on it. That means that most of parents let the children choose their own career pathway or they encourage them to take up a STEM study. In particular parents who work as STEM professional are very encouraging with regard to an uptake of a STEM career. However, a few parents are sceptical if their child made the right decision to start a STEM subject. The meanings of the friends are different: Most of the female students report that their friends know that they are good in STEM-related subjects and accept

the study or career choice. Other people could not establish an adequate understanding for the career choice in particular by women.

In this section, the results regarding the **consequences** of a STEM career will be revealed. Asking about general obstacles in STEM, nearly all the students agree that their STEM study was a difficult study subject: they have high pressure concerning the drop out-rate and miss social contacts. With regard to obstacles for women in STEM the greatest perceived problem is the lack of acceptance for females in STEM. Other possible obstacles were: lack of female role models/ contact persons e.g. female professors, prejudges against women in STEM, feeling alone under male students and lower self-confidence of female pupils in STEM.

In addition, some students reported regarding the low self-confidence of females that women think they perceived that women often think that they are not good enough in STEM. Asking about the *problems with the combination of family and STEM* career pathways which could hinder women in STEM careers most of the students think this *depends on the employer* or work field (industry versus public service). In contrast, one interviewee thinks that girls sometimes have an advantage in STEM-subject at university.

In the following, the main results regarding future facilitators and promoting measures which were helpful for students' interest and career decision will be described.

The students generate a lot of suggestions e.g. more courses for girls in STEM, mentoring programs, networks, and more open days in STEM. They had some of the measures already at university. Some of the students say that they do not need a facilitation program. The main result is the support by parents who enhance the technical socialization by given STEM-related toys or tasks. Therefore, it is important to have an early encouragement by parents to increase the interest for STEM e.g. one student report that had an electronics experiments kit in her childhood.

	Interviews with female students
Educational biography	• University graduates or postgraduates in STEM • Giftedness in STEM
Values	• Values related to self-realization: e.g. identification with work • Role models for Career choice: • e.g. parents (STEM-professionals) • STEM-teachers
Factors for career choice	• Enjoying work • Challenging STEM field • Range of opportunities
Motivation	• Interest in STEM • Joy • Meaningful subjects • Good job prospects
Abilities	• Logical reasoning • Gift for STEM
Socio-cultural influences	• Support and enhancement by parents • Positive and negative reaction of friends concerning the STEM career • Impressed by good teachers

Obstacles	• Difficult study in general
	• Obstacles related to women:
	  • Lack of acceptance for women
	  • Lack of female role models/ contact persons
	  • Low self-confidence of girls
	  • Problems with the combination of family and STEM depends on employer or work field

Facilitators	• Early encouragement of girls for STEM interest by:
	  • STEM-Courses for girls only
	  • Technical socialization by parents

Figure 6. Most frequent replies of the interviews with female students according to the research dimension

5. Synthesis

In the following, the main commonalities and differences between the four studies of the qualitative interview studies will be illustrated.

5.1 Commonalities between the four Studies

Individual level

First, the main commonalities will be shown with respect to the individual level, STEM in general, and consequences of a STEM career. The educational pathways of the students, STEM-teachers, and parents are similar: they nearly all studied a STEM subject directly after the Gymnasium. The major part of the parents studied too. Nearly all interviewed pupils want to study in the future even if they do not know which subject. This could be a hint that most of the participants have a higher educational class background. With regard to values, the most important values are honesty and reliability as well as other values like ambition, work environment, family and friendship. Obvious differences are the fact that according to the age pupils are more focused on friendship and teachers and sometimes students of higher semester are more focused on questions about how to combine family and work. Most of the interviewees say that they had no direct role models for their career choice. The final factors for the career choice are different but most based on joyful work in STEM which is more subject to pupils and students. Further, opportunities of a high salary (mostly by parents) as well as the job guaranty (mostly by teachers) were also mentioned.

STEM

The perceptions on STEM careers in general were analysed. The most important incentives in STEM according to all four interview groups and the focus groups are enjoying work, interest in STEM, good job prospects and high payment. Regarding the demanded abilities for STEM, all groups agree that a basic STEM-related knowledge or understanding and in particular logical reasoning are necessary in this field.

Analysing the socio-cultural influences, most families are supportive regarding career choice in all groups. However, the final decision was done by oneself in most of the cases. Also, pupils feel free to choice their career pathways. Other persons could have impact on the interest in STEM. Thus, teachers had an important role model function for a lot of the interviewees in particular students and STEM teachers. They impressed them by motivational and practical STEM classes and sometime they also encourage them. Friends did not play a decisive role in terms of career choice in all groups. Only some of the students mention that few of their friends valued their career choice in STEM negatively. To sum up, parents and teachers have the highest impact on pupils' career choice.

Consequences of a STEM career

The main consequences of a STEM career will be summarized. In general, all groups observe obstacles especially for women in STEM like the lack of acceptance of women in STEM fields, the lack of female role models, stereotypes of STEM, the under-representation of women in STEM studies and a lower self-confidence of girls in STEM classes regarding their abilities in STEM. General obstacles are the demanding study in STEM (in particular at the beginning of the study) and the change from school level in STEM to university.

With regard to facilitators, all groups agree that schools could go more after (female) role models from the field of STEM professionals which aim at clarifying the vague job profile of a STEM professional or scientist. More specific courses for girls only in STEM at school were also requested. One important suggestion of the group of pupils is that the STEM classes should be more practical-oriented which aims at motivating pupils and increasing their interests for STEM. Especially students would appreciate more courses for girls in STEM, mentoring programs, network activities, and more open days in STEM areas. In addition, a lot of STEM

initiatives for girls at school could be summarized but all groups consented that there is still a need to improve the facilitating measures for women in STEM.

5.2 Differences between the four Studies

Individual level

In this section, the main differences between the groups regarding the individual level will be shown. With regard to values, the impression after analysis was that the only obvious difference between the groups is that pupils are more focused on friendship which might relate to the young age (age of 14 to 20 years). In comparison, teachers and sometimes students of higher semester are more focused on questions about how to combine family and work.

STEM

In this section, the main differences between the groups regarding the STEM in general will be presented. The assessment of STEM careers in general was analysed. The priorities of the motivational factors are sometimes not similar: female students are more likely to self-realization aspects (meaningful job, joy at work) and parents and teachers are more focused on financial aspects like the payment and job prospects. This result could be interpreted that the job content and identification is more important to students than the salary. With respect to abilities in STEM, the group of female students think that if one is less gifted with regard to logical reasoning it could be difficult to persist in STEM and they would not recommend those pupils to study in STEM. Analysing the socio-cultural influences, most families are supportive regarding career choice in all groups. Some exceptions are given in the group of teachers and female students. Some parents of the teachers, who did not study, said that their children should start working instead of studying. This is a hint for a low socio-economic background which could hinder one to pursue a STEM study or career. Further, few parents of female students were sceptical if her daughter is good enough for study a STEM subject.

Consequences of a STEM career

Asking about possible obstacles in a STEM career it could be distinguished between some parents and pupils in comparison to the other groups: a few parents and male pupils think that there are no obvious obstacles if one wants to study STEM seriously, because if one has the wish to study in STEM they will find a way to make it. Female graduates, post graduates, teachers, and the major part of parents on the contrary could imagine that there could be obstacles in a STEM career in general and sometimes in particular for women in this field.

With regard to facilitators, it becomes clear that parents support their children by giving STEM specific toy or tasks could increase the interest for these subjects. Parents give their children also financial support during the study. A STEM profession of a parent could be also a facilitator by showing the workplace which aims at increasing children's interest and motivation for a STEM career choice. In addition, teachers could be a facilitator as job role model by sharing their own study experience with pupils or by making an interesting STEM-class that fascinates pupils.

5.3 Triangulation of the four Studies within each Dimension

In the following section, the main results with regard to commonalities and differences between the four groups of the qualitative studies and the results of the focus groups with pupils will be summarized.

First, the central findings will be illustrated with respect to the **individual level**, STEM in general, and consequences of a STEM career. The educational pathways of the STEM-students and teachers of STEM subjects are similar: they nearly all studied a STEM subject directly after the Gymnasium. The major part of the parents also achieved an average educational level ("Abitur"); some of them achieved a high educational level (university degree). Nearly all interviewed pupils want to study in the future by tendency even if they do not know which subject yet. This could be a hint that most of the participants have a higher educational class background. With regard to values, the most important values are honesty and reliability as well as other values like ambition, work environment, family and friendship. Obvious differences are the fact that according to the age pupils are more focused on friendship and teachers and sometimes students of higher semester are more focused on questions about how to combine family and work. Most of the interviewees say that they had no direct role models for their career choice. The factors for the career choice are different but most based on joyful work in STEM which is more subject to pupils and students. Opportunities of a high salary are more often named by parents the job guaranty more often by teachers.

Further, the assessment of **STEM** careers in general was analysed. The most important incentives in STEM are enjoying work, interest in STEM, good job prospects and high payment in all groups. With respect to the results of the focus groups with pupils, positive aspects could be revealed that these girls mostly feel confident, thus they think they will be doing well in studying STEM and they know about the career opportunities and high salary in this field. Some pupils agree that there might be problems that women have to encounter in STEM e.g. regarding difficulties in combining family and job, stereotypes, and the male-dominated environment. The priorities of the motivational factors are sometimes not similar among the interviewees: female students are more likely to self-realization aspects (e.g. meaningful job, work-life-balance, and joy at work). In contrast, parents and teachers are more focused on financial aspects like the payment and job prospects. This result could be interpreted that the job content and identification is more important to the female students than the salary in comparison to the group of parents and teachers.

Regarding the demanded abilities for STEM subjects or careers, all groups agree that a basic STEM-related knowledge or understanding and in particular logical reasoning is necessary in this field. If one is less gifted in logical reasoning it could be difficult to persist in STEM-related fields.

Analysing the socio-cultural influences, most families are supportive regarding career choice in all groups and some of them discussed job orientation at home. With respect to their own children, parents and teachers talk about job orientation and career opportunities. However, the final career decision will be done by oneself in most of the cases. Some exceptions are given in the group of teachers and female students. Some parents of the teachers, who did not study, said that their children should start working instead of studying. This is a hint that a low socio-economic background which could hinder one to pursue a STEM study or career. In addition, a few parents of female students were doubtful if her daughter is good enough for study a STEM subject. Teachers had an important role model function for a lot of the interviewees in particular students and STEM teachers. They have been impressed by motivational and practical STEM classes of their teachers and sometime these teachers also encourage them to choose STEM. Friends did not play a decisive role in terms of career choice in all groups. To sum up, parents and teachers have the highest impact on pupils' career choice and direct in questions of interest and career in a certain field. Thus, strengthening a "home-school"-collaboration between parents and teachers concerning content of STEM classes that fits pupils' needs and exchange about information and initiative regarding job orientation in STEM could enhance more pupils in STEM.

The main **consequences** of choosing a STEM career will be summarized. In general, all groups observe women specific obstacles like the lack of acceptance of women in STEM fields, the lack of female role models, stereotypes of STEM, the under-representation of women in STEM studies and a lower self-confidence of girls in STEM classes regarding their abilities in STEM. General obstacles are the demanding study in STEM and the change from school level in STEM to university. A few interviewees of parents think that there are no obstacles if someone wants to study STEM seriously he or she will find a way to make it.

With regard to facilitators, it becomes clear that parents support their childrens' career choice by giving STEM specific toys or tasks could. These measures could increase the long-term interest for these subjects. Parents give their children also financial support during the study period. A STEM profession of a parent could be also a facilitator by showing the workplace for children's interest and motivation regarding a STEM career choice. Teachers could be a facilitator by sharing their own study experience with pupils and by motivating the pupils.

All groups agree that schools could go more after (female) role models from the field of STEM professionals which aims at clarifying the vague job profile of a STEM professional or scientist for pupils. Further, more specific courses for girls in STEM at school are also named. One important suggestion of the groups is that the STEM class should be more practical which aims at motivating pupils and increasing their interests for STEM-studies or jobs in this area. Especially students suggest more courses for girls in STEM in order to enhance the self-confidence of girls in STEM, mentoring programs, networks, and more open days in STEM. To sum up, a lot of STEM initiatives for girls at school (e.g. Girls' day, mentoring for students) could be remarked but all groups agree that there is still a need to improve the facilitating measures for girls.

5.4 Summary and Discussion

To sum up, the results of the qualitative studies with the different target groups reveal that the group of STEM-teachers and STEM graduates students had a similar educational pathway (Gymnasium and STEM study at university). Most of the pupils want to study in the future and most of the parents graduated at least with Abitur. With regard to the values and factors for career choice the answers of the groups were quite similar. However, female students in STEM are focused more on self-realization aspects (e.g. meaningful job, joy at work). In contrast, parents and teachers are more focused on financial aspects like the payment and job prospects. With respect to the socio-cultural influence, it could be shown that teachers and parents of STEM profession might play a decisive role in the career choice process of pupils. The main consequences of a STEM career will be summarized. In general, all groups observe obstacles especially for women in STEM like the lack of acceptance of women in STEM fields, the lack of female role models, stereotypes of STEM, the under-representation of women in STEM studies and a lower self-confidence of girls in STEM classes regarding their abilities in STEM. General obstacles are the demanding study in STEM. With regard to facilitators, all groups agree that schools could introduce more (female) role models from the field of STEM professionals, promote more specific courses for girls only in STEM, and improve STEM classes by increasing the practical-oriented part in STEM-subjects during the lessons. To sum up, the results showed that that the interest of pupils for STEM career could be increased by more practical STEM-lessons and by role models like teachers and parents. Therefore, good practice guidelines in STEM will be developed in this project.

6. Quantitative Studies

In the following, the main results of the four sub-studies of the quantitative research in Germany will be described. The results will be presented for each study according to the eight SESTEM research dimensions which are developed and documented in the SESTEM Analytical Framework (see Mok & Ertl, 2010). Study 1 describes the findings of the questionnaires completed by pupils; Study 2 describes the findings of the questionnaires completed by parents; Study 3 describes the findings of the questionnaires completed by teachers of STEM subjects; and Study 4 describes the findings of the questionnaires completed by students in higher education (university). In Section 5, the commonalities and difference between the four groups will be analysed. The synthesis will sum up the main results of the quantitative studies and will establish the basis for future measures and good practice guidelines in order to enhance the interest of girls for STEM-related careers.

6.1 Pupils Questionnaires

6.1.1 Description of the sample and the methodology

Figure 7 shows the number of girls (61) and boys (28) who took part in the survey; Figure 8 shows the distribution of the years in which pupils who took part were born. It can be seen that the majority of pupils were between 16 and 18 years old.

Pupils mostly completed the questionnaires online, with a few completing paper questionnaires which were then entered into the database. The online version did not allow respondents to move on from a page without completing all the questions, and those who answered on paper completed almost all questions so there was almost no incomplete data.

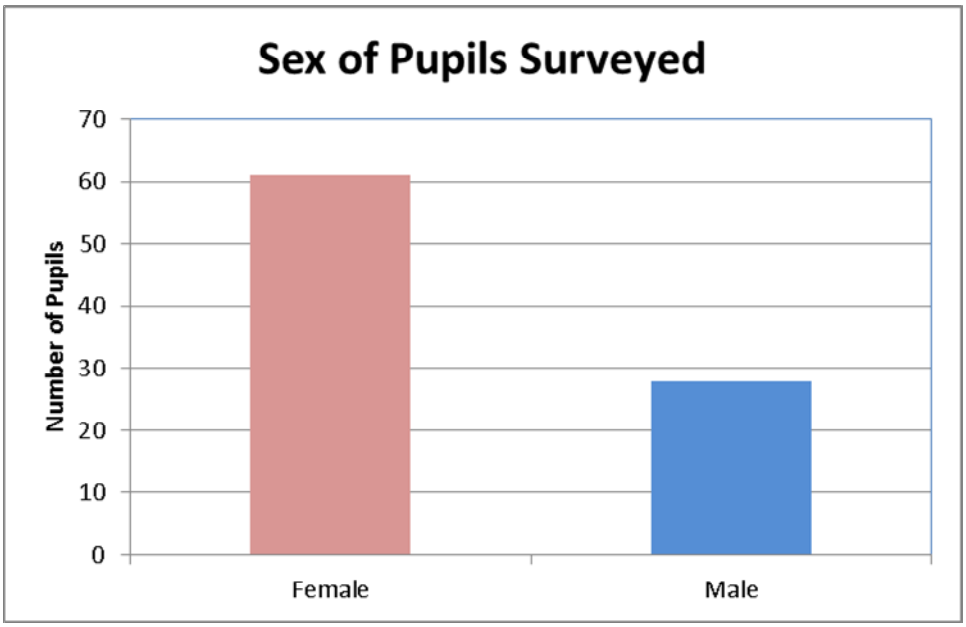

Figure 7. Pupils' sex distribution

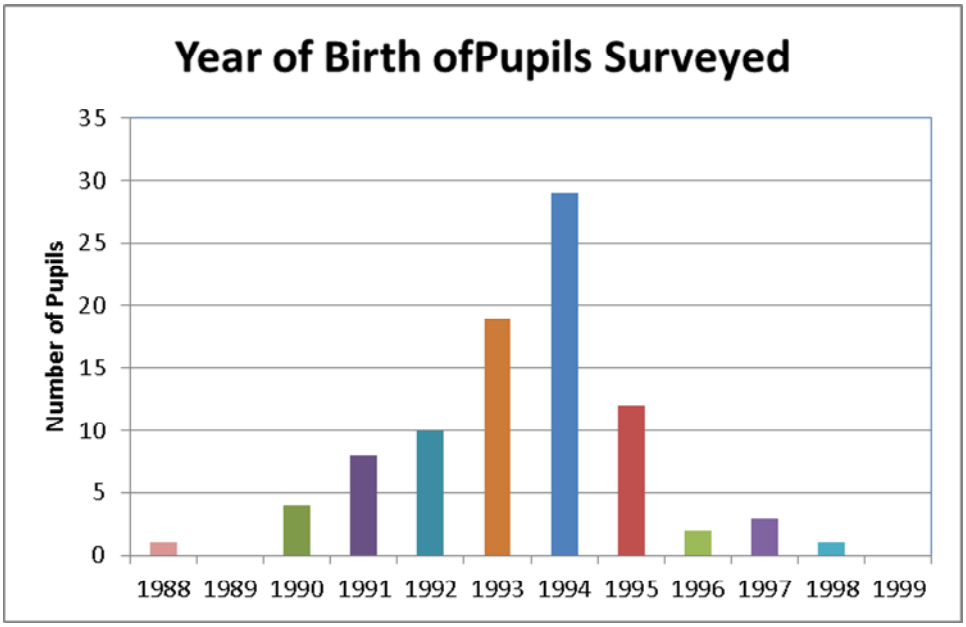

Figure 8. Pupils' age distribution

Figure 9 and Figure 10 show the professions of the pupils' parents. In the current sample, most mothers were housewives and clerks while most fathers were engineers. Particularly the latter may have influenced pupils answer patterns towards STEM.

Figure 9. Pupils' mothers profession

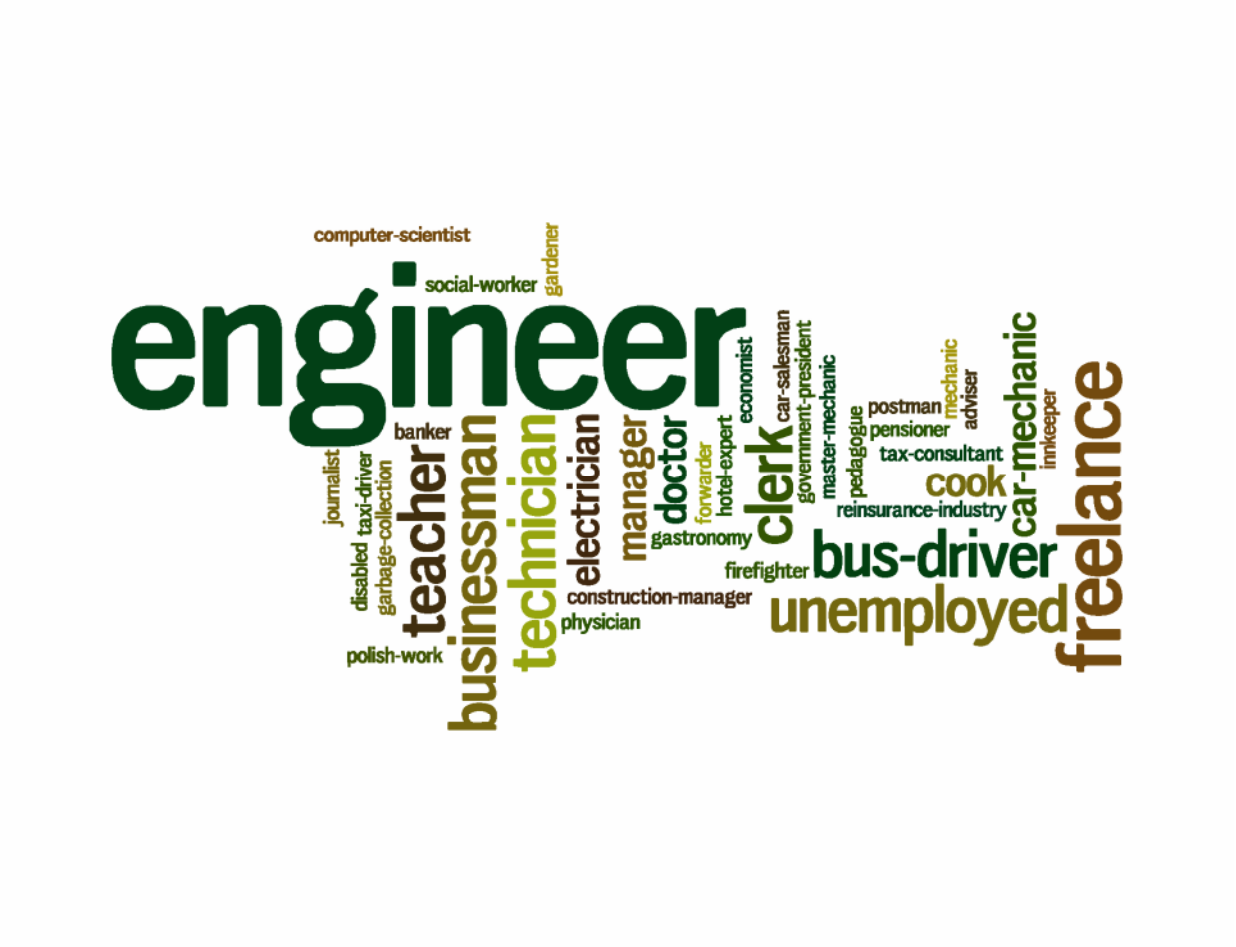

Figure 10. Pupils' fathers profession

6.1.2 Understanding the Analysis

SESTEM collected data in order to draw some conclusions about the factors that are associated with choosing or not choosing to take STEM related courses. One way to do this is to look at the responses from different groups – for instance, girls who choose to take courses in STEM and girls who do not. If we find noteworthy and significant differences between the responses of different groups (e.g. that girls who do not take STEM courses are more likely to agree with the statement "women who work in STEM have to be like men than are girls who do take STEM courses"), we can take this a pointer to some action that might be taken – here, this might be presenting feminine STEM role models in materials written for schools.

A key question arises – what is a noteworthy and significant difference? This is harder to answer than it seems! Let us start with significant difference.

If you look at any sets of measures – say the heights of girls on STEM courses and those on non-STEM courses – the averages will (almost) never be the same. So how can we tell when things are significantly different? The simple answer is to define significantly different to mean unlikely to occur by chance. Statistical techniques have been created to calculate how often an observed difference (say in the heights of two groups) would occur by chance – say, 1 in 20, 1 in 100, 1 in 1000 times. Here, we will not discuss any differences between groups that would occur by chance more often than 1 in 20 times (written $p <= 0.05$).

What about noteworthy? Noteworthy seems clear enough – but noteworthy compared to what? Here we use the idea of effect size.

Effect size = (average score of the non-STEM girls – average score of the STEM girls) / (spread of scores of all the girls)

So as the difference in the average scores of the two groups gets bigger, the effect size gets bigger, and as the difference in the average scores of the two groups gets smaller, the effect size gets smaller (assuming there is no change in the spread of scores).

And as the spread of scores of the girls gets bigger, the effect size gets smaller, and as the spread of scores gets smaller, the effect size gets bigger (assuming there is no change in the average scores of the two groups).

How noteworthy is noteworthy? We will adopt Cohen's description, paraphrased below.

Effect size less than 0.3 is small – don't bother trying to explain it

Effect size 0.3 to 0.8 is medium – do try to explain it

Effect size 0.8 or above is strong – you need a good story

We can now define a noteworthy and significant difference as an effect size greater than or equal to 0.3, that is unlikely to have arisen by chance.

Why is this important? Because both factors must be taken into account when you decide how meaningful results are. It is possible to have a big effect size that has arisen by chance (say you only measured the height of just 3 girls in the STEM and non-STEM groups – sometimes you would get very big differences in average height) and it is possible (in fact very common when you have very large numbers of people in each group e.g. all the men and all the women in the country) to have results that are highly unlikely to arise by chance, but where the effect size is very small. Wikipedia provides a good description of effect sizes and tests of differences that are unlikely to occur by chance (called tests of 'statistical significance').

The graphical displays show comparisons between a number of different groups in terms of their responses to items on the questionnaire. Responses to each question were made on a 5-point scale 'strongly agree' to 'strongly disagree'. Here we have coded the responses -2 = strongly disagree to 2 = strongly agree (so a mean of 0.4 would indicate that the group were, on average, slightly in favour of that statement, and a completely neutral average response would give a mean of 0).

The **groups' comparisons** are as followed:

> Girls who are considering STEM courses at university **(SG)** with girls who are not considering STEM courses at university **(NSG)**
>
> Everyone who is considering a STEM course at university **(S)** with everyone who is not considering a STEM course at university **(NS)**

For each group, 4 columns are provided. The first column reports the effect size between the responses of the two groups, and the second and third column show the mean scores for each group on each questionnaire item. The fourth column shows how often the result would occur by chance. Where the responses of two groups show a noteworthy and significant difference, the effect size cell has been colour coded. Effects where the first comparison group report stronger agreement with the statement than does the second group are on a red scale, and where the second group is more in agreement it will be on a blue scale. The intensity of the colour reflects the size of the effect. The brightest colours correspond to effect sizes of 1 and -1. The value of stronger effect sizes can be read in the cell, but the colour corresponds to an effect size of 1. Where comparisons between groups are statistically significant, the t-test column is coloured green. To guide interpretation, where results are not noteworthy and significantly different the back ground colour in the effect size cell is white.

6.1.3 Study results

In the following, the main results of the study will be presented which relate to the three main research levels: Individual, STEM in general, and consequences of a STEM career.

6.1.3.1 Individual

- Educational biography

All of the pupils attend upper secondary schools. The majority of the pupils want to go to university to study after they complete school and many of them already know what they will choose as to study there – at least in broad terms (detailed course descriptions and titles vary a lot between universities in Germany). These findings are consistent with the outcomes of the corresponding qualitative study.

Figure 11 shows the subjects that all the pupils surveyed are considering taking at university: respondents could say yes to as many of the options as they wanted to, so the sum of all the responses is much greater than 100%, and it does not reflect the subject that they will eventually go on to study. For this sample, the distribution is quite evenly between 20 and 30 per cent except for agricultural sciences, geography, law, mathematics, and informatics which are below 20 per cent. This does not reflect the pattern of university admissions, nationally. Figure 12 shows the courses being considered by girls and boys separately. Art and design, education and teacher training, humanities, languages, and medical sciences are more popular with girls than with boys, while engineering, law, and informatics show quite strong gender differences in favour of boys; mathematics, medical and natural sciences are also more popular with boys than girls, but the differences are less marked.

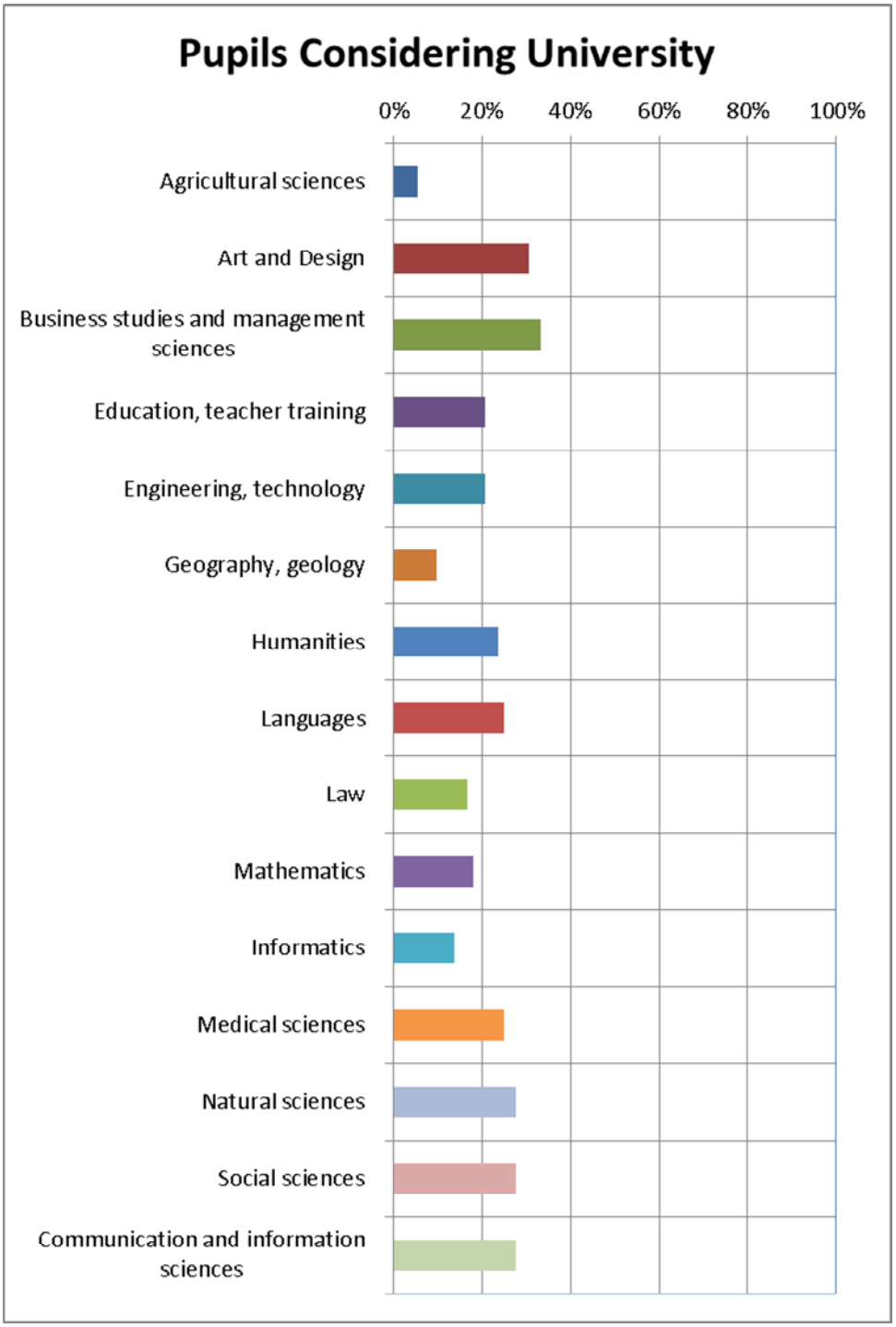

Figure 11. All university choices by pupils

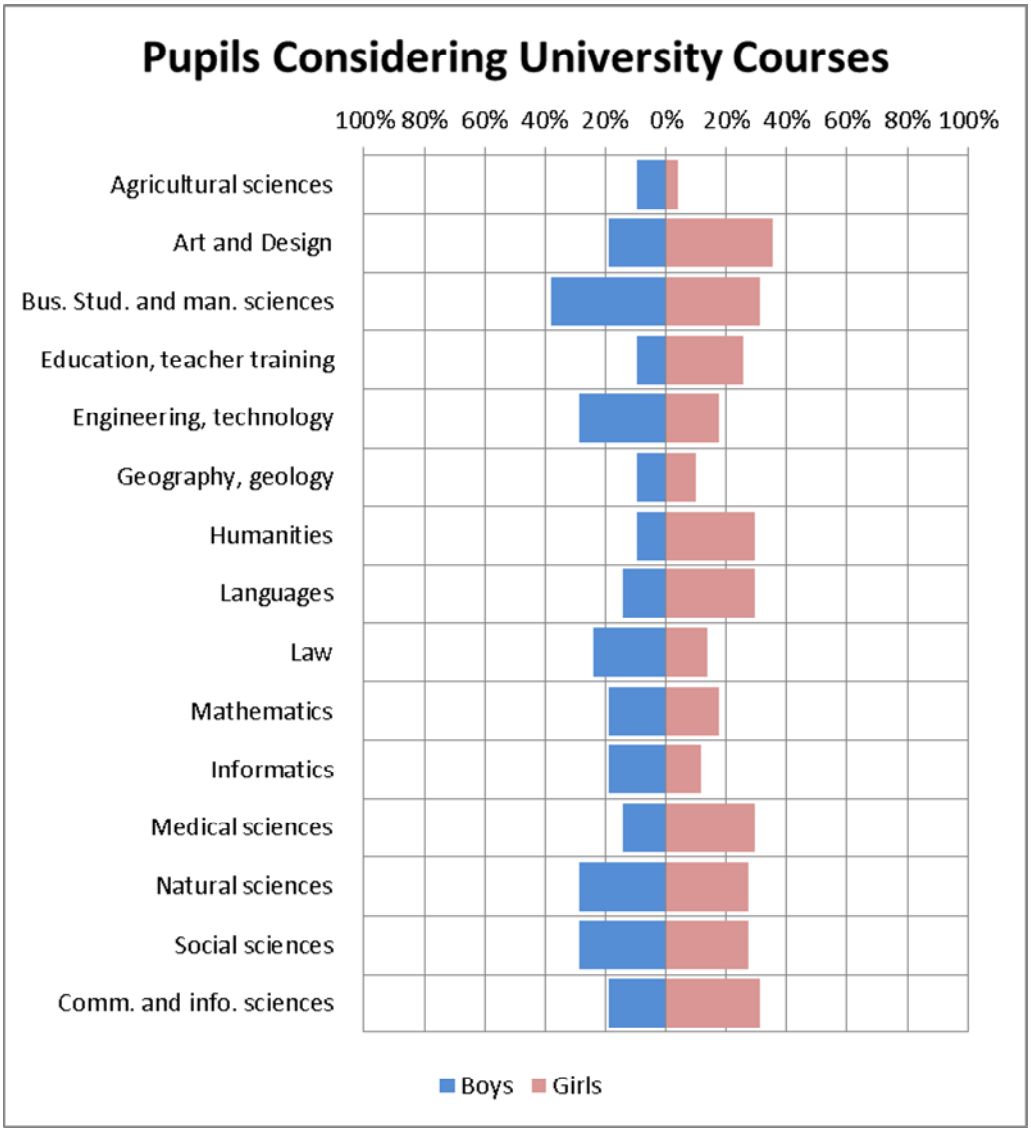

Figure 12. Gendered university choices

Figure 13 - 15 below show the responses to questions about who helps with homework in maths, science and in other subjects. The most common response in all subjects for both boys and girls is 'no-one', for boys 20 per cent more than for girls, but when help is sought friends are most common for both boys and girls.

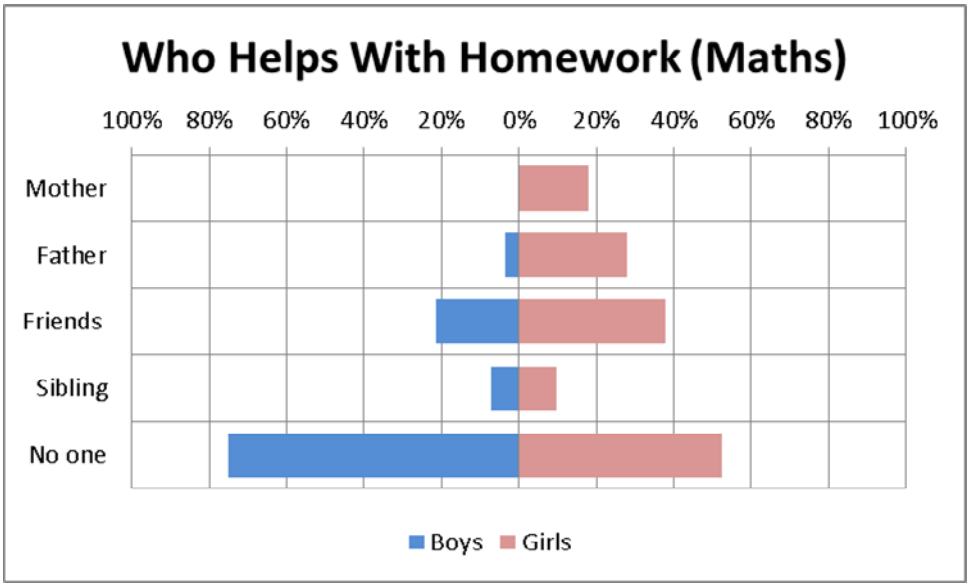

Figure 13. Persons who help with maths homework

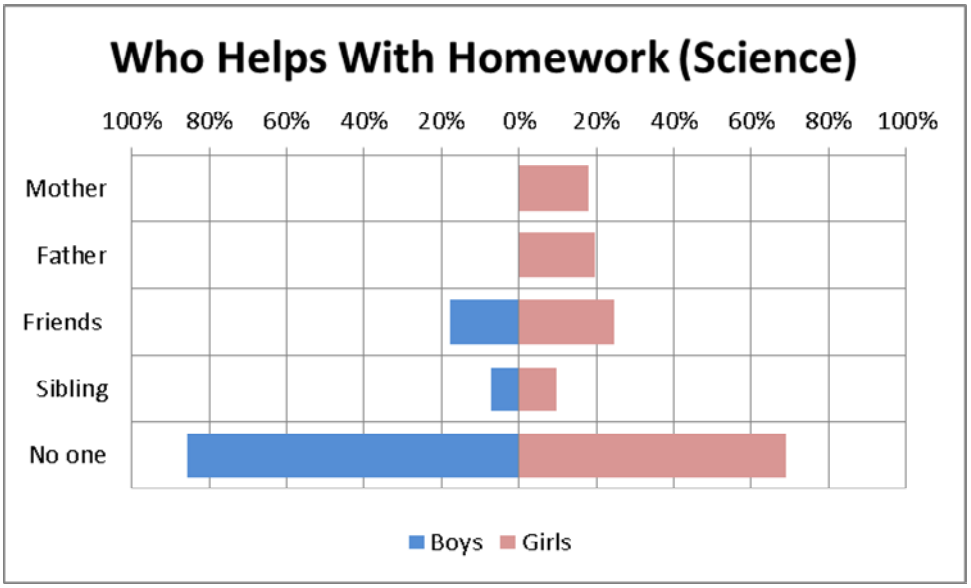

Figure 14. Persons who help with science homework

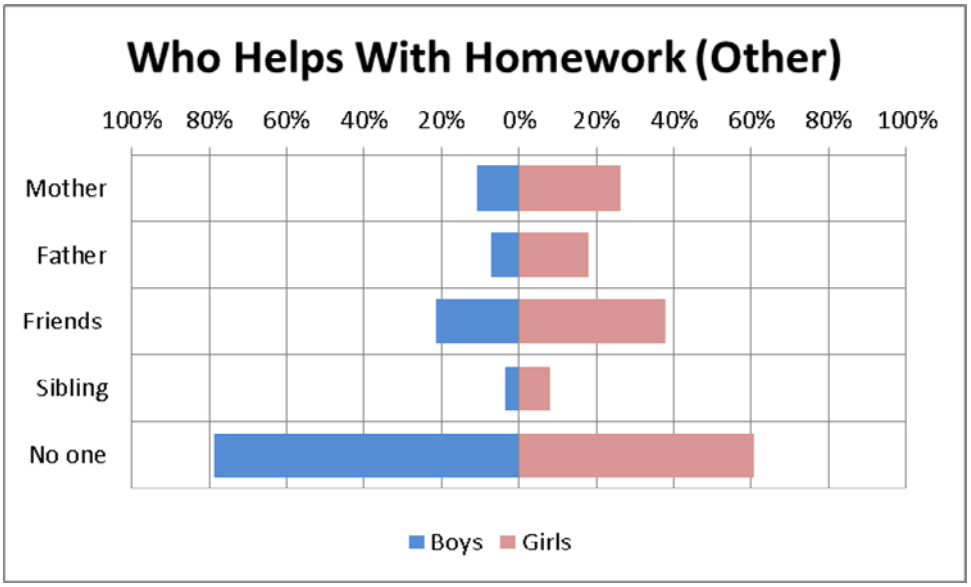

Figure 15. Persons who help with other homework

- Personal values and influences

Figure 16 shows that there are no strong gendered differences in the responses to questions aimed at identifying personal values and influences – boys tended to enjoy practical problems a little more than girls and to think that going to university is important for someone to be successful in life while girls head more for enjoyable work and work-life balance. Yet, calculating specific subgroup differences one can see significant effects: Thereby, Figure 17 shows differences between boys and girls on a five per cent significance level ($p < .05$). Girls do significantly prefer to work more with people and want much more to enjoy their work. Both effect sizes are medium to strong indicating that it is a big effect. Splitting subgroups for their interest regarding to STEM (see Figure 18), pupils with interest to STEM prefer more to try new things ($p < .05$), enjoy to solve practical problems ($p < .01$) and prefer to enjoy their work ($p < .01$). All of these effect sizes are medium. The effect of enjoyment also persists for girls in STEM ($p < .05$, see Figure 19)

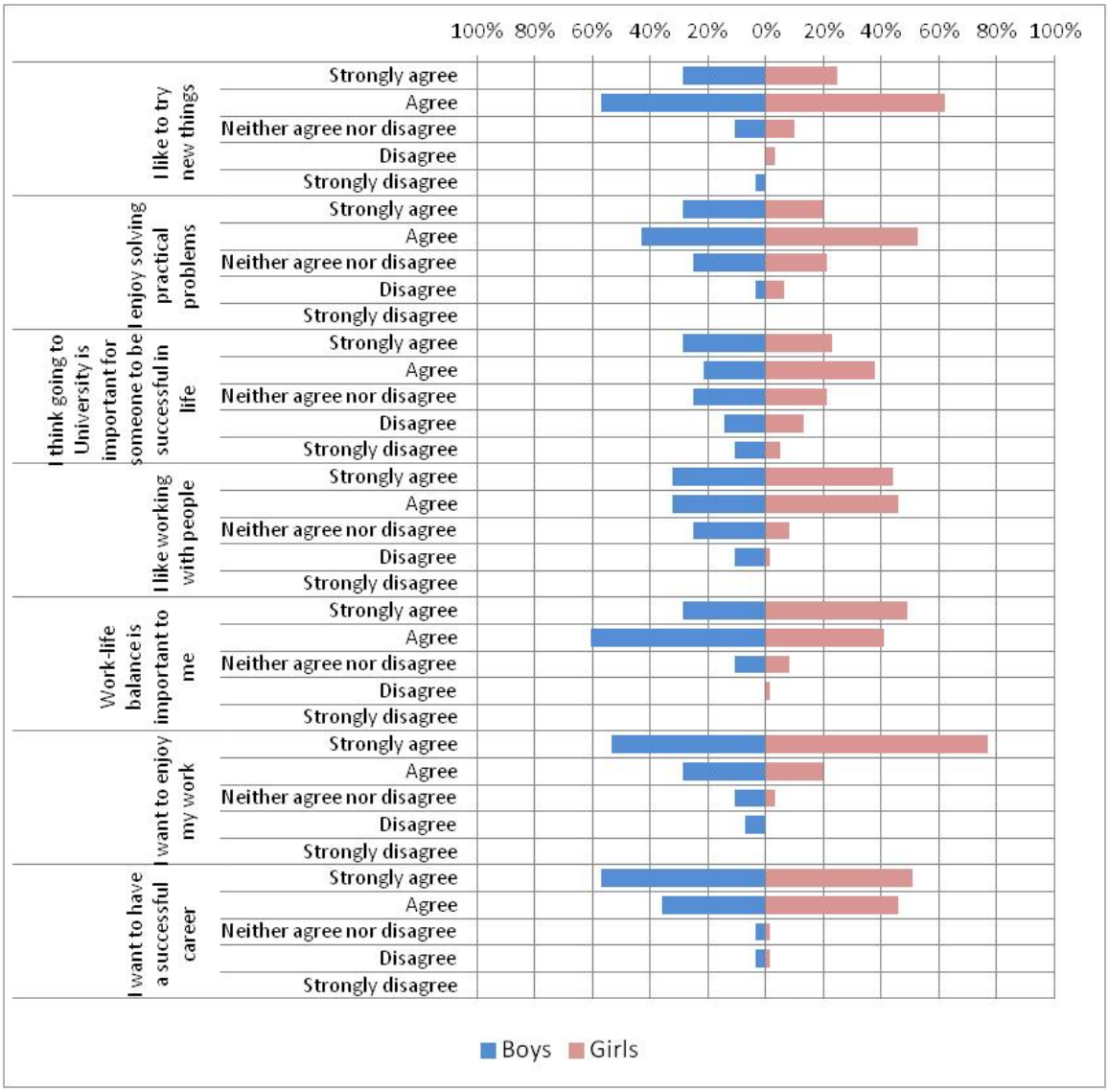

Figure 16. Descriptive statistics for items relating to personal values and influences

		Girls	**Boys**	
	Effect Size	Mean	Mean	t-test (P value)
I like to try new things	0,01	1,08	1,07	0,95
I enjoy solving practical problems	-0,14	0,85	0,96	0,56
I think going to University is important for someone to be successful in life	0,15	0,61	0,43	0,55
I like working with people	0,59	1,33	0,86	0,03
Work-life balance is important to me	0,30	1,38	1,18	0,18
I want to enjoy my work	0,71	1,74	1,29	0,02
I want to have a successful career	-0,01	1,46	1,46	0,97

Figure 17. T-tests for items relating to personal values and influences, split by sex

		All Stem (S)	All Non Stem (NS)	
	Effect Size	Mean	Mean	t-test (P value)
I like to try new things	0,45	1,22	0,90	0,05
I enjoy solving practical problems	0,56	1,08	0,64	0,01
I think going to University is important for someone to be successful in life	0,21	0,66	0,41	0,34
I like working with people	0,17	1,24	1,10	0,45
Work-life balance is important to me	0,02	1,32	1,31	0,93
I want to enjoy my work	0,66	1,78	1,36	0,01
I want to have a successful career	0,07	1,48	1,44	0,76

Figure 18. T-tests for items relating to personal values and influences, split by interest for STEM

		Girls STEM (SG)	Girls Non STEM (NSG)	
	Effect Size	Mean	Mean	t-test (P value)
I like to try new things	0,18	1,19	1,07	0,47
I enjoy solving practical problems	0,29	1,00	0,77	0,26
I think going to University is important for someone to be successful in life	-0,07	0,58	0,67	0,78
I like working with people	0,18	1,36	1,23	0,47
Work-life balance is important to me	-0,01	1,36	1,37	0,97
I want to enjoy my work	0,57	1,86	1,60	0,05
I want to have a successful career	-0,30	1,39	1,57	0,23

Figure 19. T-tests for items relating to personal values and influences, girls split by interest for STEM

- Factors for career choice

Figure 20 to 22 show that there are no strong gendered differences in the responses on careers advice, information or activities, except that boys seemed to look less for information and advice in than girls; respondents could tick all that applied in these questions. Almost all pupils took advice from someone, with boys more from fathers and girls more from mothers. The internet is now a major source of information with over two thirds of the girls and boys citing it. There does seem to be an appreciation that the world of work is changing and that newer careers need to be explored alongside the more traditional options. In fact, considerably more of both boys and girls listed newer careers than listed traditional careers but this might be partially explained by some pupils feeling they already had good information on traditional careers they might be interested in.

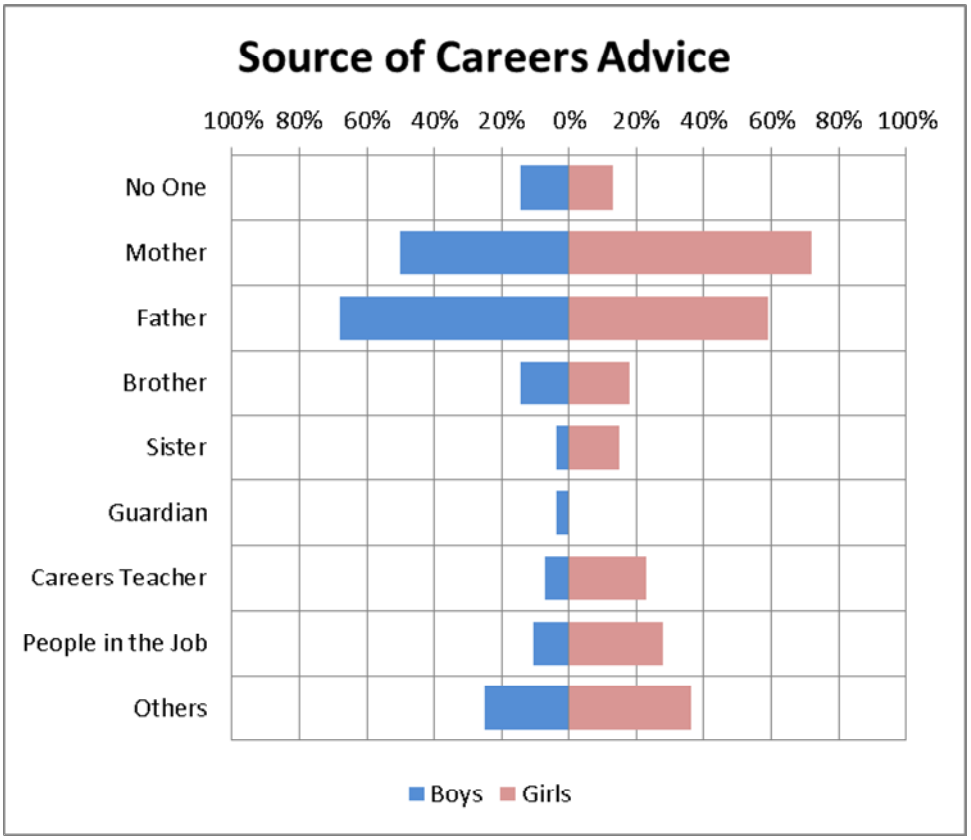

Figure 20. Gendered responses about sources of careers advice

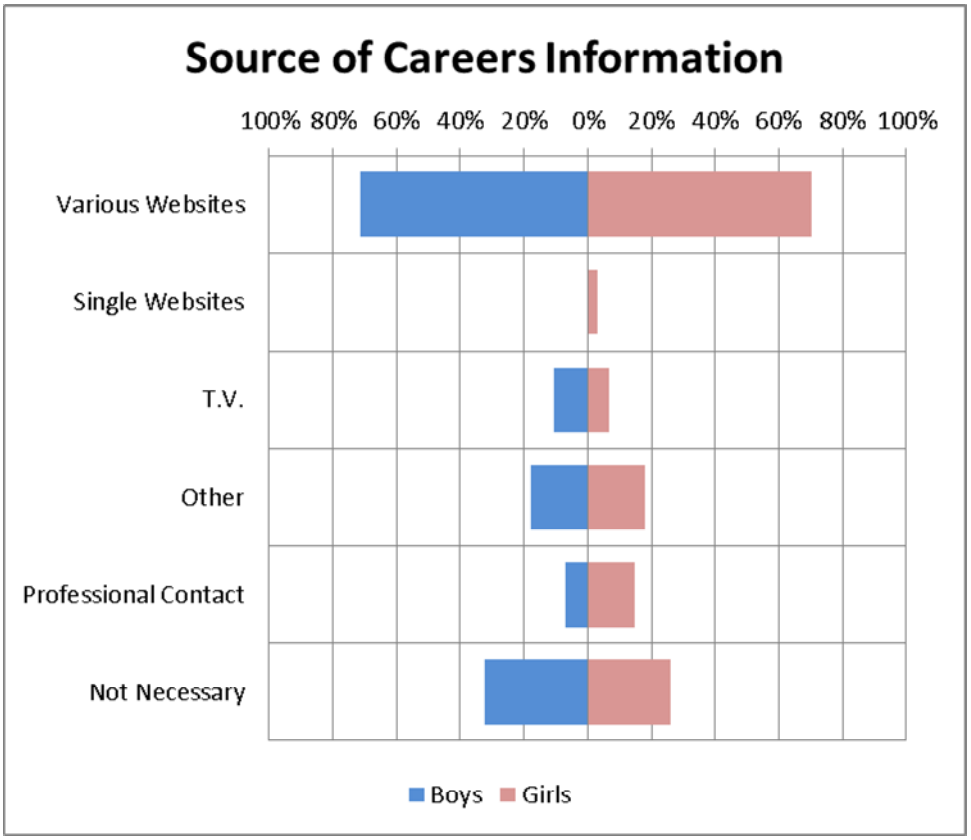

Figure 21. Gendered responses about sources of careers information

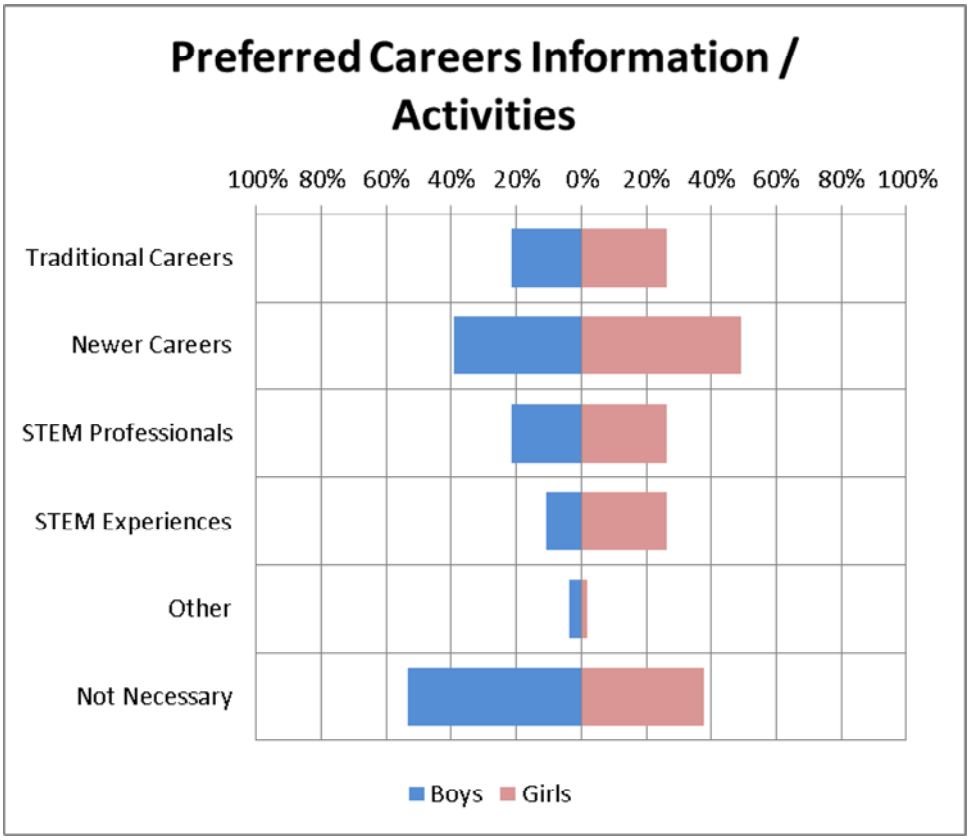

Figure 22. Gendered responses about preferences in careers information / activities

6.1.3.2 STEM

- Motivation

The block of items in Figure 23 sought to identify perceptions of the value of careers in STEM in a very general sense. It is evident that few of these items provoked any strong response from pupils. Generally there seems to be a moderately positive view of STEM careers as offering prestige and good prospects, an interesting work environment and to contribute to the development of society though that environment may be pressured and competitive. The patterns of boy and girl responses are similar. Calculating specific subgroup differences one can see significant effects: Firstly, Figure 24 shows that there are no significant differences between boys and girls on a five per cent significance level. Splitting subgroups for their interest regarding to STEM (see Figure 25), one can see that pupils with interests in STEM estimate STEM careers much better than other pupils. Thereby, all differences except for the item of pressure show significant differences with medium to high effect sizes. The effect of dynamic and changing work environment also persists for girls in STEM ($p < .05$, see Figure 26)

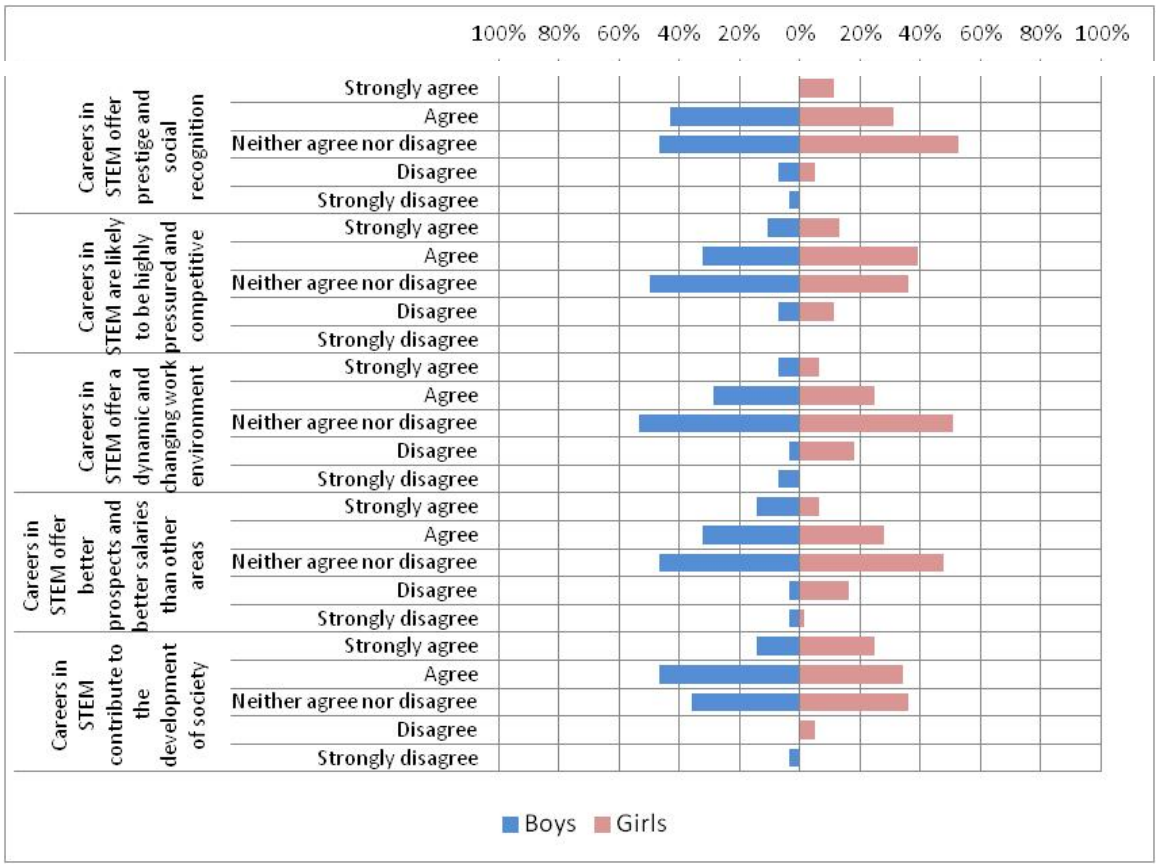

Figure 23. Gendered responses to items about the value of careers in STEM

		Girls	**Boys**	
	Effect Size	Mean	Mean	t-test (P value)
Careers in STEM offer prestige and social recognition	0,27	0,49	0,29	0,24
Careers in STEM are likely to be highly pressured and competitive	0,09	0,54	0,46	0,68
Careers in STEM offer a dynamic and changing work environment	-0,06	0,20	0,25	0,80
Careers in STEM offer better prospects and better salaries than other areas	-0,33	0,21	0,50	0,17
Careers in STEM contribute to the development of society	0,12	0,79	0,68	0,59

Figure 24. T-tests for responses to items about the value of careers in STEM, split by sex

		All Stem (S)	All Non Stem (NS)	
	Effect Size	Mean	Mean	t-test (P value)
Careers in STEM offer prestige and social recognition	0,67	0,64	0,15	0,00
Careers in STEM are likely to be highly pressured and competitive	0,40	0,66	0,33	0,07
Careers in STEM offer a dynamic and changing work environment	0,71	0,46	-0,10	0,00
Careers in STEM offer better prospects and better salaries than other areas	0,52	0,50	0,05	0,02
Careers in STEM contribute to the development of society	0,81	1,04	0,38	0,00

Figure 25. T-tests for responses to items about the value of careers in STEM, split by interest for STEM

		Girls STEM (SG)	Girls Non STEM (NSG)	
	Effect Size	Mean	Mean	t-test (P value)
Careers in STEM offer prestige and social recognition	0,46	0,67	0,33	0,07
Careers in STEM are likely to be highly pressured and competitive	0,12	0,64	0,53	0,63
Careers in STEM offer a dynamic and changing work environment	0,61	0,47	0,00	0,03
Careers in STEM offer better prospects and better salaries than other areas	0,29	0,39	0,13	0,25
Careers in STEM contribute to the development of society	0,38	1,00	0,67	0,13

Figure 26. T-tests for responses to items about the value of careers in STEM, girls split by interest for STEM

The block of items in Figure 27 sought to identify career aspirations that pupils have. The strongest support was for a job that they felt they were good at for girls, and a job they earn a lot of money for boys. Calculating specific subgroup differences one can see significant effects:

Firstly, Figure 28 shows that there is a big effect that girls want to get a job which they are good at ($p < .01$). Splitting subgroups for their interest regarding to STEM (see Figure 29), one can see that pupils with such interests want to improve peoples' lives and a job that is intellectually challenging and estimate themselves as gifted for STEM. Girls with STEM aspirations distinguish from non-STEM girls by their estimation that they want a job in that they are good at and that they estimate themselves as gifted in STEM ($p < .05$, see Figure 30).

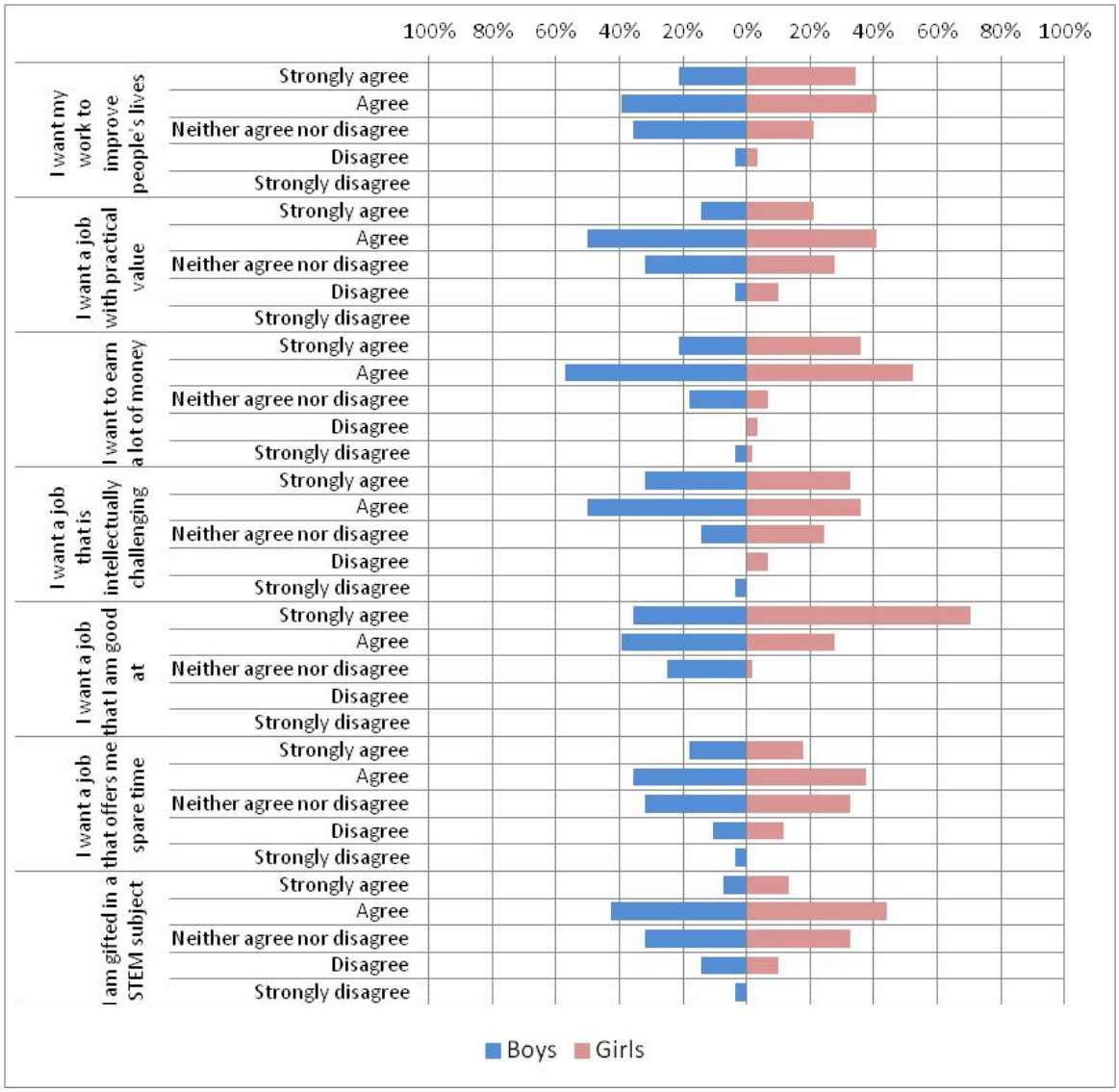

Figure 27. Gendered responses to items about the career aspirations

		Girls	**Boys**	
	Effect Size	Mean	Mean	t-test (P value)
I want my work to improve people's lives	0,34	1,07	0,79	0,15
I want a job with practical value	-0,01	0,74	0,75	0,95
I want to earn a lot of money	0,30	1,18	0,93	0,20
I want a job that is intellectually challenging	-0,13	0,95	1,07	0,56
I want a job that I am good at	1,00	1,69	1,11	0,00
I want a job that offers me spare time	0,09	0,62	0,54	0,70
I am gifted in a STEM subject	0,29	0,61	0,36	0,24

Figure 28. T-tests for responses to items about the value of careers in STEM, split by sex

		All Stem (S)	**All Non Stem (NS)**	
	Effect Size	Mean	Mean	t-test (P value)
I want my work to improve people's lives	0,70	1,22	0,67	0,00
I want a job with practical value	0,16	0,80	0,67	0,46
I want to earn a lot of money	0,05	1,12	1,08	0,81
I want a job that is intellectually challenging	0,55	1,20	0,72	0,02
I want a job that I am good at	0,41	1,62	1,36	0,07
I want a job that offers me spare time	0,20	0,68	0,49	0,35
I am gifted in a STEM subject	0,89	0,84	0,13	0,00

Figure 29. T-tests for responses to items about the value of careers in STEM, split by interest for STEM

		Girls STEM (SG)	Girls Non STEM (NSG)	
	Effect Size	Mean	Mean	t-test (P value)
I want my work to improve people's lives	0,47	1,28	0,90	0,07
I want a job with practical value	-0,09	0,72	0,80	0,72
I want to earn a lot of money	-0,04	1,14	1,17	0,89
I want a job that is intellectually challenging	0,27	1,11	0,87	0,29
I want a job that I am good at	0,84	1,83	1,43	0,00
I want a job that offers me spare time	0,14	0,69	0,57	0,56
I am gifted in a STEM subject	0,54	0,83	0,40	0,04

Figure 30. T-tests for responses to items about the value of careers in STEM, girls split by interest for STEM

The next blocks of statements, shown in Figure 31 to Figure 33 were seeking to draw out pupils' perceptions of STEM careers from a more personal standpoint than the statements reported on earlier in this section.

Many of the statements showed very similar gender profiles in the responses, and for a number of them 'neither agree nor disagree' was the modal response with strong agreement or disagreement occurring rarely, and we will not comment further on those statements.

There were some significant gender differences on a $p < .05$ level, all with effect sizes between medium and high (see figure 34). In particular, girls were less eager to contribute to scientific and technical developments, but they were more likely to receive support from their friends and family to work in STEM industries and to reject that they would have to act like a man for pursuing a STEM career.

Pupils with interest in a STEM (see Figure 35) career stated on the one hand that they were better in other subjects than in STEM, however they also acknowledged that they have appropriate skills and motivation for pursuing a STEM career. They particularly liked the STEM prospects, wanted to contribute to scientific and technical developments, enjoyed the high salaries, solving practical problems, the teamwork and various job

prospects and they estimated themselves to fit well in STEM environments. Furthermore they also appreciate support from their friends and families to work in STEM.

Looking particularly at girls with interest in a STEM career (see Figure 36), they also stated that they have appropriate skills and motivation for pursuing a STEM career. They particularly liked the STEM prospects, and they estimated themselves to fit well in STEM environments. Yet, they emphasized that they want to have a good work-life balance. Furthermore they also appreciate support from their friends and families to work in STEM.

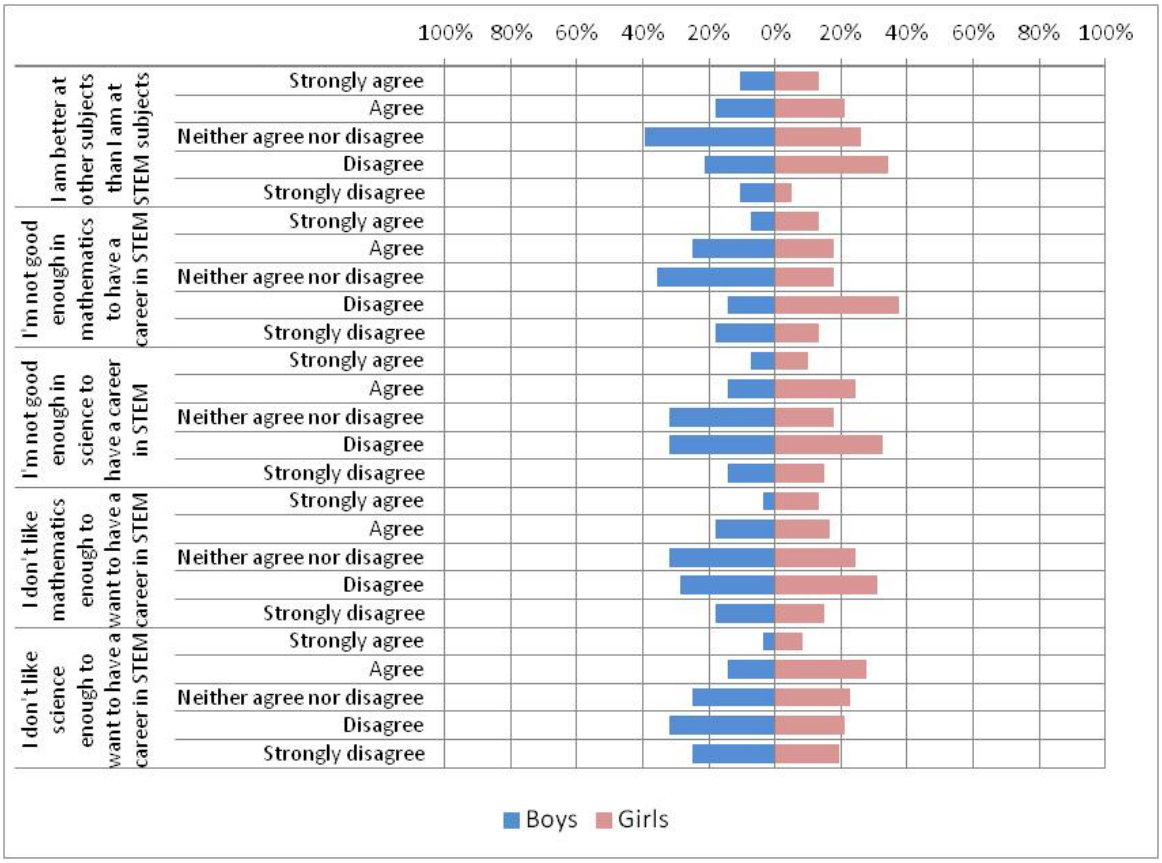

Figure 31. Gendered responses to items about the personal value of careers in STEM

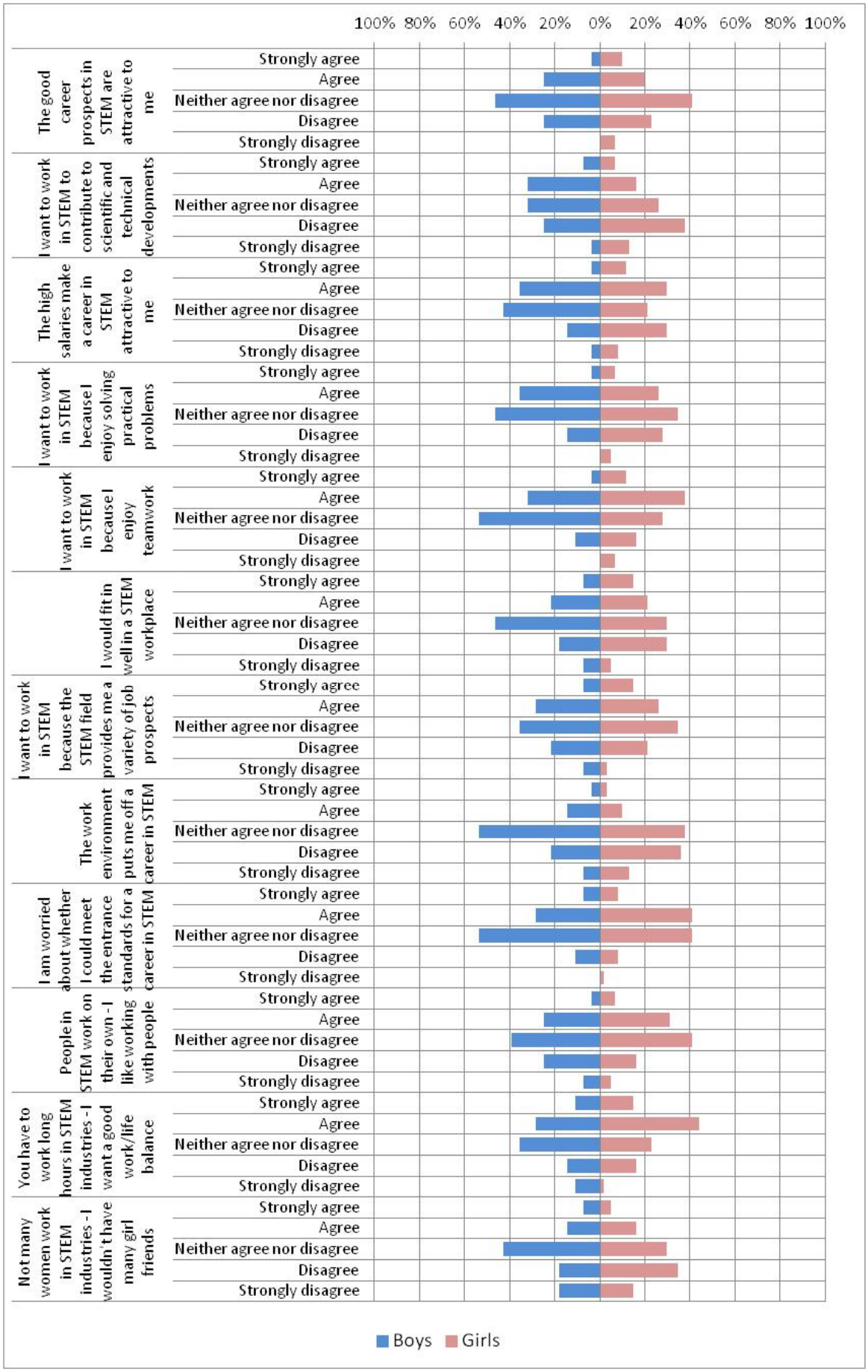

Figure 32. Gendered responses to items about the personal value of careers in STEM

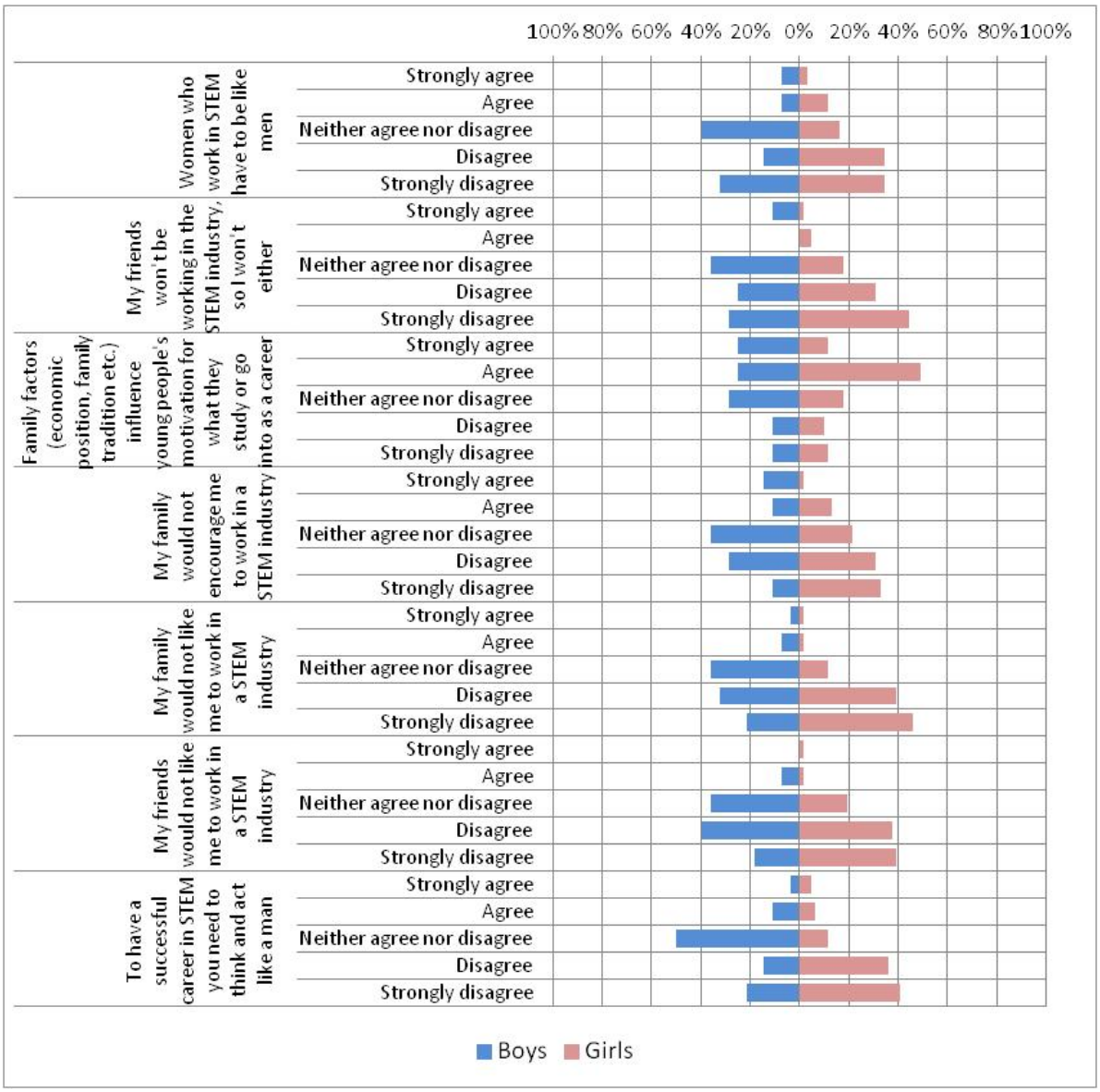

Figure 33. Gendered responses to a range of socio-cultural influences

		Girls	Boys	
	Effect Size	Mean	Mean	t-test (P value)
I am better at other subjects than I am at STEM subjects	0,06	0,03	-0,04	0,79
I'm not good enough in mathematics to have a career in STEM	-0,07	-0,20	-0,11	0,75
I'm not good enough in science to have a career in STEM	0,12	-0,18	-0,32	0,60
I don't like mathematics enough to want to have a career in STEM	0,18	-0,18	-0,39	0,42
I don't like science enough to want to have a career in STEM	0,36	-0,16	-0,61	0,10
The good career prospects in STEM are attractive to me	-0,04	0,03	0,07	0,85
I want to work in STEM to contribute to scientific and technical developments	-0,45	-0,34	0,14	0,04
The high salaries make a career in STEM attractive to me	-0,14	0,07	0,21	0,51
I want to work in STEM because I enjoy solving practical problems	-0,29	0,02	0,29	0,17
I want to work in STEM because I enjoy teamwork	0,03	0,31	0,29	0,89
I would fit in well in a STEM workplace	0,07	0,11	0,04	0,74
I want to work in STEM because the STEM field provides me a variety of job prospects	0,19	0,28	0,07	0,39
The work environment puts me off a career in STEM	-0,34	-0,46	-0,14	0,13
I am worried about whether I could meet the entrance standards for a career in STEM	0,17	0,46	0,32	0,45
People in STEM work on their own - I like working with people	0,26	0,18	-0,07	0,26
You have to work long hours in STEM industries - I want a good work/life balance	0,38	0,54	0,14	0,12
Not many women work in STEM industries - I wouldn't have many girl friends	-0,12	-0,38	-0,25	0,62
Women who work in STEM have to be like men	-0,24	-0,85	-0,57	0,31
My friends won't be working in the STEM industry, so I won't either	-0,48	-1,11	-0,61	0,06
Family factors (economic position, family tradition etc.) influence young people's motivation ..	-0,03	0,39	0,43	0,90
My family would not encourage me to work in a STEM industry	-0,62	-0,80	-0,11	0,01
My family would not like me to work in a STEM industry	-0,72	-1,26	-0,61	0,01
My friends would not like me to work in a STEM industry	-0,49	-1,11	-0,68	0,03
To have a successful career in STEM you need to think and act like a man	-0,56	-1,02	-0,39	0,01

Figure 34. T-tests for responses to a range of socio-cultural influences, split by sex

		All Stem (S)	All Non Stem (NS)	
	Effect Size	Mean	Mean	t-test (P value)
I am better at other subjects than I am at STEM subjects	0,70	0,34	-0,41	0,00
I'm not good enough in mathematics to have a career in STEM	-0,72	-0,54	0,31	0,00
I'm not good enough in science to have a career in STEM	-0,76	-0,60	0,26	0,00
I don't like mathematics enough to want to have a career in STEM	-0,70	-0,60	0,21	0,00
I don't like science enough to want to have a career in STEM	-0,73	-0,68	0,18	0,00
The good career prospects in STEM are attractive to me	0,91	0,40	-0,41	0,00
I want to work in STEM to contribute to scientific and technical developments	0,68	0,12	-0,59	0,00
The high salaries make a career in STEM attractive to me	0,63	0,40	-0,26	0,00
I want to work in STEM because I enjoy solving practical problems	0,77	0,40	-0,28	0,00
I want to work in STEM because I enjoy teamwork	0,47	0,50	0,05	0,03
I would fit in well in a STEM workplace	0,58	0,36	-0,26	0,01
I want to work in STEM because the STEM field provides me a variety of job prospects	0,60	0,48	-0,13	0,01
The work environment puts me off a career in STEM	-0,19	-0,44	-0,26	0,37
I am worried about whether I could meet the entrance standards for a career in STEM	0,07	0,44	0,38	0,75
People in STEM work on their own - I like working with people	-0,14	0,04	0,18	0,50
You have to work long hours in STEM industries - I want a good work/life balance	0,36	0,58	0,21	0,09
Not many women work in STEM industries - I wouldn't have many girl friends	-0,09	-0,38	-0,28	0,67
Women who work in STEM have to be like men	-0,15	-0,84	-0,67	0,48
My friends won't be working in the STEM industry, so I won't either	-0,62	-1,24	-0,59	0,01
Family factors (economic position, family tradition etc.) influence young people.	0,26	0,54	0,23	0,22
My family would not encourage me to work in a STEM industry	-0,47	-0,82	-0,28	0,03
My family would not like me to work in a STEM industry	-0,45	-1,24	-0,82	0,04
My friends would not like me to work in a STEM industry	-0,64	-1,22	-0,67	0,00
To have a successful career in STEM you need to think and act like a man	-0,08	-0,86	-0,77	0,71

Figure 35. T-tests for responses to a range of socio-cultural influences, split by interest for STEM

		Girls STEM	Girls Non STEM	
	Effect Size	Mean	Mean	t-test (P value)
I am better at other subjects than I am at STEM subjects	0,41	0,31	-0,17	0,10
I'm not good enough in mathematics to have a career in STEM	-0,56	-0,56	0,13	0,03
I'm not good enough in science to have a career in STEM	-0,53	-0,53	0,13	0,04
I don't like mathematics enough to want to have a career in STEM	-0,65	-0,61	0,17	0,01
I don't like science enough to want to have a career in STEM	-0,64	-0,58	0,20	0,01
The good career prospects in STEM are attractive to me	0,69	0,39	-0,30	0,01
I want to work in STEM to contribute to scientific and technical developments	0,41	-0,03	-0,50	0,11
The high salaries make a career in STEM attractive to me	0,40	0,33	-0,13	0,11
I want to work in STEM because I enjoy solving practical problems	0,44	0,31	-0,13	0,09
I want to work in STEM because I enjoy teamwork	0,37	0,53	0,13	0,14
I would fit in well in a STEM workplace	0,55	0,42	-0,20	0,03
I want to work in STEM because the STEM field provides me a variety of job prospects	0,48	0,53	0,00	0,06
The work environment puts me off a career in STEM	-0,43	-0,64	-0,23	0,11
I am worried about whether I could meet the entrance standards for a career in STEM	-0,10	0,42	0,50	0,69
People in STEM work on their own - I like working with people	-0,06	0,11	0,17	0,83
You have to work long hours in STEM industries - I want a good work/life balance	0,66	0,78	0,13	0,01
Not many women work in STEM industries - I wouldn't have many girl friends	-0,02	-0,36	-0,33	0,92
Women who work in STEM have to be like men	-0,15	-0,94	-0,77	0,54
My friends won't be working in the STEM industry, so I won't either	-0,52	-1,33	-0,80	0,04
Family factors (economic position, family tradition etc.) influence young people's motivation for what they study or go into as a career	0,19	0,53	0,30	0,45
My family would not encourage me to work in a STEM industry	-0,77	-1,11	-0,27	0,00
My family would not like me to work in a STEM industry	-0,72	-1,50	-0,87	0,01
My friends would not like me to work in a STEM industry	-0,91	-1,44	-0,70	0,00
To have a successful career in STEM you need to think and act like a man	0,06	-1,00	-1,07	0,81

Figure 36. T-tests for responses to a range of socio-cultural influences, girls split by interest for STEM

6.1.3.3 Consequences of a STEM career

Figure 37 shows the proportions of boys and girls who responded ‘yes’ to the questions which related to potential obstacles or facilitators for engagement with STEM. Many of the experiences reported are similar

for boys and girls, but girls reported more involvement in specific STEM school activities and encouragement of teachers in secondary school while boys reported higher values in all other categories.

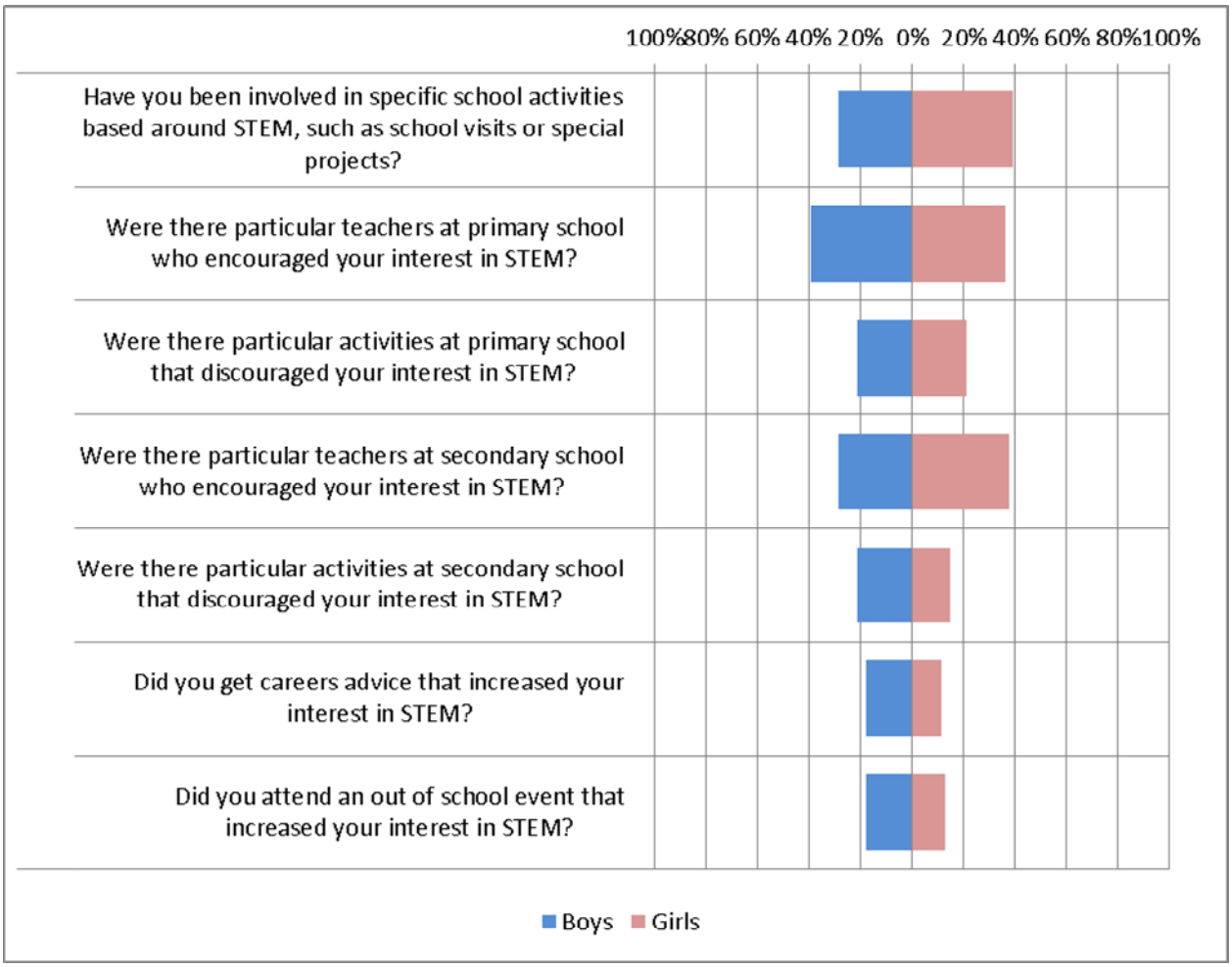

Figure 37. Facilitators and obstacles to the uptake of STEM

Many of the statements reported on earlier in this section can be looked in terms of acting as obstacles or facilitators for engagement with STEM, and we will try to identify the strongest messages here (see Figures 38 - 40).

In general, boys were mainly indecisive and thus the category “neither agree nor disagree got the strongest hits. In contrast, girls’ answers were distributed more evenly. Therefore, girls agreed that they enjoy studying other subjects and also that they are better at other things, they disagreed that STEM subjects are taught better to boys and that girls might have less natural ability in STEM. They disagreed that their parents and friends don’t want them to have into STEM careers – yet they agreed that boys are more likely to have hobbies with STEM subjects and to do practical things.

Looking into differences between subgroups, girls distinguish significantly from boys that they agreed more that girls are better in other subjects and disagreed that more boys take courses in STEM and that STEM subjects are taught better to boys, that girls receive obstacles for STEM careers from their parents and teachers and friends (see Figure 41).

Pupils with interest in STEM distinguish from other pupils that they receive encouragement by their relatives, friends and the father and that they disagree that girls are not as interested in STEM subjects as boys – an effects that remains stable if choosing only girls interested in STEM (see Figure 42 and 43).

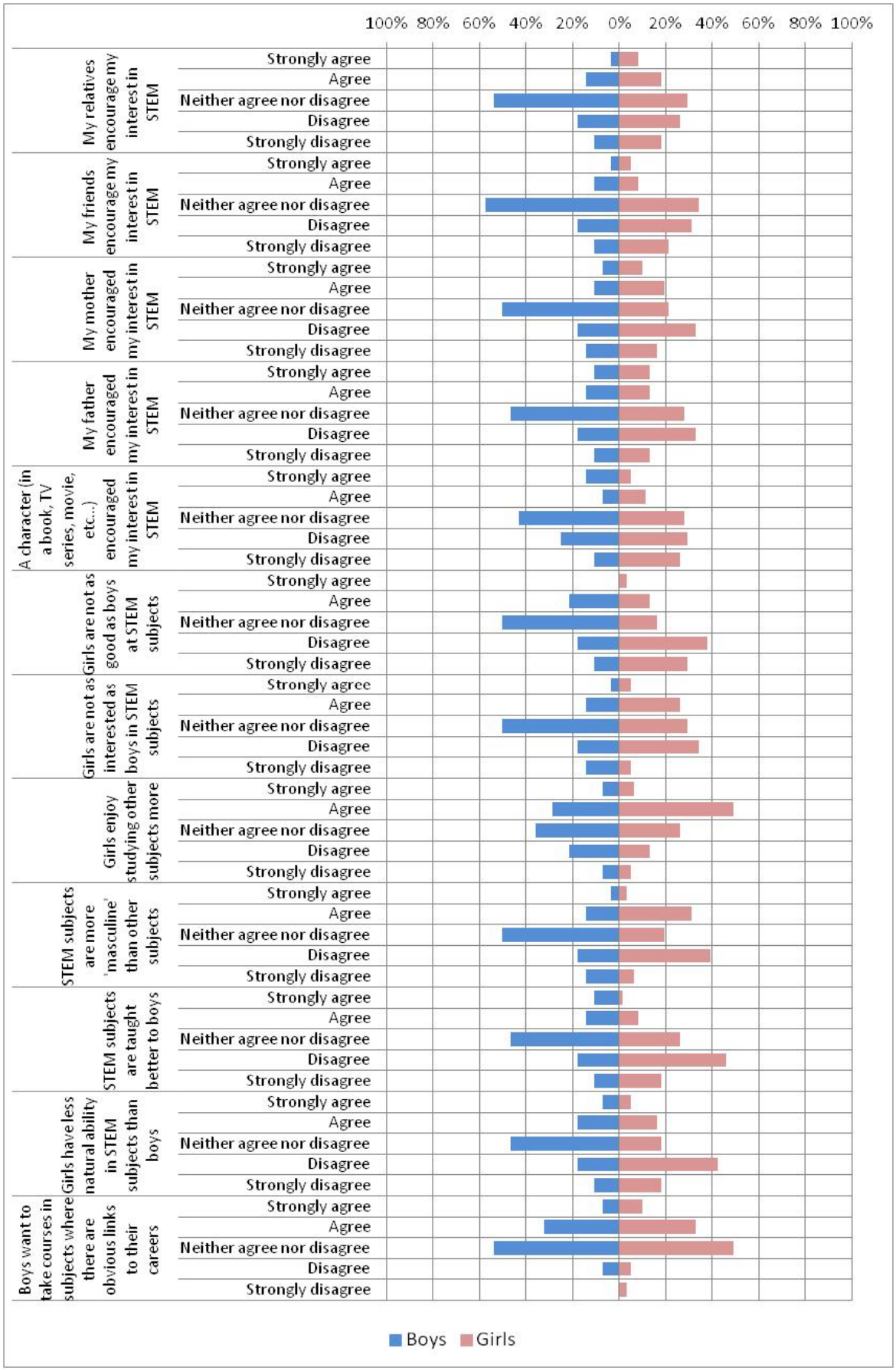

Figure 38. Facilitators and obstacles to the uptake of STEM

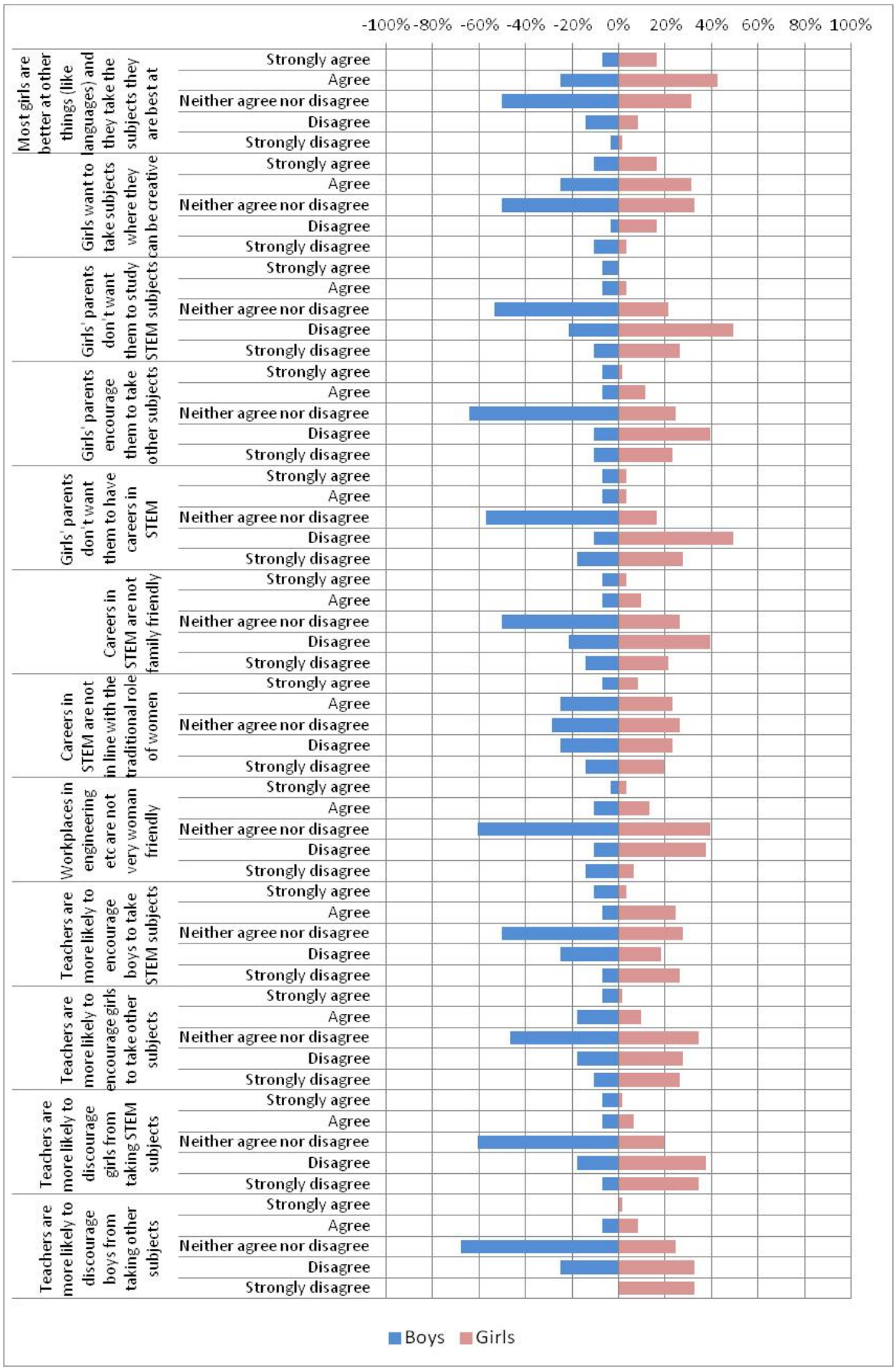

Figure 39. Facilitators and obstacles to the uptake of STEM

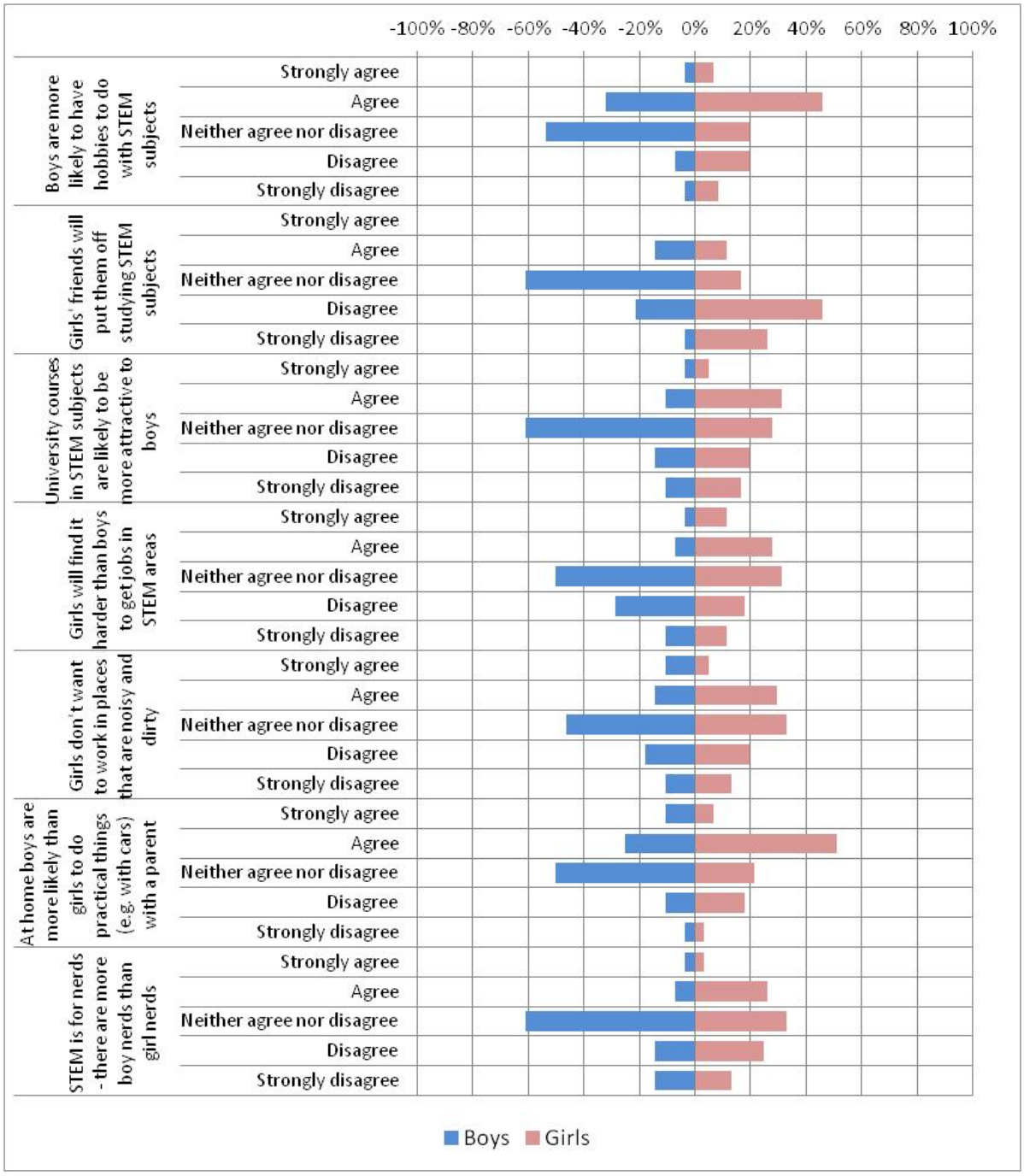

Figure 40. Facilitators and obstacles to the uptake of STEM

		Girls	Boys	
	Effect Size	Mean	Mean	t-test (P value)
My relatives encourage my interest in STEM	-0,09	-0,28	-0,18	0,67
My friends encourage my interest in STEM	-0,33	-0,56	-0,21	0,13
My mother encouraged my interest in STEM	-0,04	-0,26	-0,21	0,85
My father encouraged my interest in STEM	-0,14	-0,20	-0,04	0,54
A character (in a book, TV series, movie, etc...) encouraged my interest in STEM	-0,43	-0,61	-0,11	0,06
More boys than girls take courses in Science, Technology, Engineering and Mathematics. Here are…	-0,56	-0,77	-0,18	0,01
Girls are not as interested as boys in STEM subjects	0,17	-0,08	-0,25	0,47
Girls enjoy studying other subjects more	0,32	0,39	0,07	0,18
STEM subjects are more 'masculine' than other subjects	0,10	-0,15	-0,25	0,66
STEM subjects are taught better to boys	-0,68	-0,70	-0,04	0,01
Girls have less natural ability in STEM subjects than boys	-0,41	-0,52	-0,07	0,07
Boys want to take courses in subjects where there are obvious links to their careers	0,02	0,41	0,39	0,92
Most girls are better at other things (like languages) and they take the subjects they are best at	0,51	0,64	0,18	0,03
Girls want to take subjects where they can be creative	0,18	0,41	0,21	0,42
Girls' parents don't want them to study STEM subjects	-0,91	-0,98	-0,21	0,00
Girls' parents encourage them to take other subjects	-0,60	-0,70	-0,11	0,01
Girls' parents don't want them to have careers in STEM	-0,71	-0,95	-0,25	0,00
Careers in STEM are not family friendly	-0,36	-0,66	-0,29	0,13
Careers in STEM are not in line with the traditional role of women	-0,07	-0,23	-0,14	0,75
Workplaces in engineering etc are not very woman friendly	-0,11	-0,31	-0,21	0,65
Teachers are more likely to encourage boys to take STEM subjects	-0,25	-0,39	-0,11	0,26
Teachers are more likely to encourage girls to take other subjects	-0,58	-0,67	-0,07	0,01
Teachers are more likely to discourage girls from taking STEM subjects	-0,90	-0,97	-0,11	0,00
Teachers are more likely to discourage boys from taking other subjects	-0,79	-0,87	-0,18	0,00
Boys are more likely to have hobbies to do with STEM subjects	-0,02	0,23	0,25	0,92
Girls' friends will put them off studying STEM subjects	-0,84	-0,87	-0,14	0,00
University courses in STEM subjects are likely to be more attractive to boys	0,06	-0,11	-0,18	0,78
Girls will find it harder than boys to get jobs in STEM areas	0,42	0,10	-0,36	0,05
Girls don't want to work in places that are noisy and dirty	-0,03	-0,07	-0,04	0,91
At home boys are more likely than girls to do practical things (e.g. with cars) with a parent	0,11	0,39	0,29	0,62
STEM is for nerds - there are more boy nerds than girl nerds	0,10	-0,18	-0,29	0,64

Figure 41. Facilitators and obstacles to the uptake of STEM

		All Stem (S)	All Non Stem (NS)	
	Effect Size	Mean	Mean	t-test (P value)
My relatives encourage my interest in STEM	0,61	0,04	-0,62	0,00
My friends encourage my interest in STEM	0,43	-0,26	-0,69	0,05
My mother encouraged my interest in STEM	0,37	-0,06	-0,49	0,08
My father encouraged my interest in STEM	0,45	0,08	-0,44	0,03
A character (in a book, TV series, movie, etc...) encouraged my interest in STEM	0,02	-0,44	-0,46	0,93
More boys than girls take courses in Science, Technology, Engineering and Mathematics. Here are…	-0,20	-0,68	-0,46	0,36
Girls are not as interested as boys in STEM subjects	-0,53	-0,36	0,15	0,02
Girls enjoy studying other subjects more	0,20	0,38	0,18	0,35
STEM subjects are more 'masculine' than other subjects	-0,22	-0,28	-0,05	0,29
STEM subjects are taught better to boys	-0,15	-0,56	-0,41	0,50
Girls have less natural ability in STEM subjects than boys	-0,20	-0,48	-0,26	0,35
Boys want to take courses in subjects where there are obvious links to their careers	0,33	0,52	0,26	0,13
Most girls are better at other things (like languages) and they take the subjects they are best at	0,11	0,54	0,44	0,60
Girls want to take subjects where they can be creative	0,20	0,44	0,23	0,36
Girls' parents don't want them to study STEM subjects	-0,14	-0,80	-0,67	0,50
Girls' parents encourage them to take other subjects	0,08	-0,48	-0,56	0,70
Girls' parents don't want them to have careers in STEM	-0,33	-0,88	-0,54	0,13
Careers in STEM are not family friendly	-0,40	-0,72	-0,31	0,07
Careers in STEM are not in line with the traditional role of women	-0,37	-0,40	0,05	0,08
Workplaces in engineering etc are not very woman friendly	0,10	-0,24	-0,33	0,63
Teachers are more likely to encourage boys to take STEM subjects	0,24	-0,18	-0,46	0,26
Teachers are more likely to encourage girls to take other subjects	0,13	-0,42	-0,56	0,53
Teachers are more likely to discourage girls from taking STEM subjects	0,08	-0,66	-0,74	0,71
Teachers are more likely to discourage boys from taking other subjects	0,17	-0,58	-0,74	0,42
Boys are more likely to have hobbies to do with STEM subjects	0,10	0,28	0,18	0,64
Girls' friends will put them off studying STEM subjects	-0,15	-0,70	-0,56	0,50
University courses in STEM subjects are likely to be more attractive to boys	-0,01	-0,14	-0,13	0,96
Girls will find it harder than boys to get jobs in STEM areas	0,13	0,02	-0,13	0,54
Girls don't want to work in places that are noisy and dirty	-0,05	-0,08	-0,03	0,82
At home boys are more likely than girls to do practical things (e.g. with cars) with a parent	-0,24	0,26	0,49	0,28
STEM is for nerds - there are more boy nerds than girl nerds	-0,28	-0,34	-0,05	0,19

Figure 42. Facilitators and obstacles to the uptake of STEM

		Girls STEM (SG)	Girls Non STEM (NSG)	
	Effect Size	Mean	Mean	t-test (P value)
My relatives encourage my interest in STEM	0,46	0,03	-0,53	0,06
My friends encourage my interest in STEM	0,11	-0,42	-0,53	0,67
My mother encouraged my interest in STEM	0,24	-0,06	-0,37	0,33
My father encouraged my interest in STEM	0,21	-0,03	-0,30	0,38
A character (in a book, TV series, movie, etc...) encouraged my interest in STEM	-0,10	-0,58	-0,47	0,71
More boys than girls take courses in Science, Technology, Engineering and Mathematics. Here are…	-0,15	-0,81	-0,63	0,54
Girls are not as interested as boys in STEM subjects	-0,58	-0,36	0,23	0,03
Girls enjoy studying other subjects more	0,17	0,47	0,30	0,51
STEM subjects are more 'masculine' than other subjects	-0,17	-0,22	-0,03	0,48
STEM subjects are taught better to boys	-0,26	-0,75	-0,50	0,32
Girls have less natural ability in STEM subjects than boys	-0,27	-0,61	-0,30	0,28
Boys want to take courses in subjects where there are obvious links to their careers	0,23	0,53	0,33	0,35
Most girls are better at other things (like languages) and they take the subjects they are best at	0,21	0,72	0,53	0,41
Girls want to take subjects where they can be creative	0,31	0,56	0,23	0,21
Girls' parents don't want them to study STEM subjects	-0,50	-1,08	-0,67	0,05
Girls' parents encourage them to take other subjects	-0,21	-0,72	-0,50	0,39
Girls' parents don't want them to have careers in STEM	-0,36	-1,08	-0,73	0,17
Careers in STEM are not family friendly	-0,15	-0,75	-0,60	0,56
Careers in STEM are not in line with the traditional role of women	-0,29	-0,36	0,00	0,24
Workplaces in engineering etc are not very woman friendly	0,33	-0,17	-0,47	0,18
Teachers are more likely to encourage boys to take STEM subjects	0,49	-0,11	-0,70	0,05
Teachers are more likely to encourage girls to take other subjects	0,16	-0,53	-0,70	0,53
Teachers are more likely to discourage girls from taking STEM subjects	0,07	-0,86	-0,93	0,78
Teachers are more likely to discourage boys from taking other subjects	0,17	-0,72	-0,90	0,48
Boys are more likely to have hobbies to do with STEM subjects	0,13	0,28	0,13	0,60
Girls' friends will put them off studying STEM subjects	-0,23	-0,92	-0,70	0,37
University courses in STEM subjects are likely to be more attractive to boys	0,02	-0,11	-0,13	0,94
Girls will find it harder than boys to get jobs in STEM areas	0,12	0,14	0,00	0,64
Girls don't want to work in places that are noisy and dirty	0,26	0,00	-0,30	0,30
At home boys are more likely than girls to do practical things (e.g. with cars) with a parent	-0,16	0,28	0,43	0,53
STEM is for nerds - there are more boy nerds than girl nerds	-0,05	-0,25	-0,20	0,85

Figure 43. Facilitators and obstacles to the uptake of STEM

6.1.4 Main results: pupils

Summing up pupils results, one can see two interesting aspects of the target group: Firstly, that more girls than boys were participating and secondly that most fathers were engineers in this sample. Both aspects may have had a particular impact on study outcomes. In the pupils target group, very few pupils received help with homework. This was reported by around 80 per cent of the boys for all subjects and 50 to 70 per cent of the girls. If they received help then they received it rather from friends than from their parents. Regarding wishes for their future job, girls preferred to enjoy their work and to work with people significant more than boys. Both, girls and boys received most career advice from their parents (over 60%) but boys more from their fathers and girls more from their mothers. This stresses the crucial role of parents for career decisions.

6.2 Parents questionnaires

6.2.1 Description of the sample and the methodology

Figure 44 shows the sex of the parents who took part in the survey. Invitations to participate were made through schools where pupils were participating, by mailing lists, and also through other contacts with parents with children of the right age. There were much larger numbers of mothers than fathers who responded to the invitations to participate through schools. Figure 45 shows the ages of all the children the parents had: each parent had at least one child in the target range of 14 - 18, but often there were also younger siblings (and in other cases, siblings over the age of 18 who do not appear).

The nature of the sample and of the context is such that we will report on the views of all parents as a single group – it would not be possible to attempt to make comparisons between fathers and mothers for example, or between groups based on the sex of the child since often a parent had children of both genders.

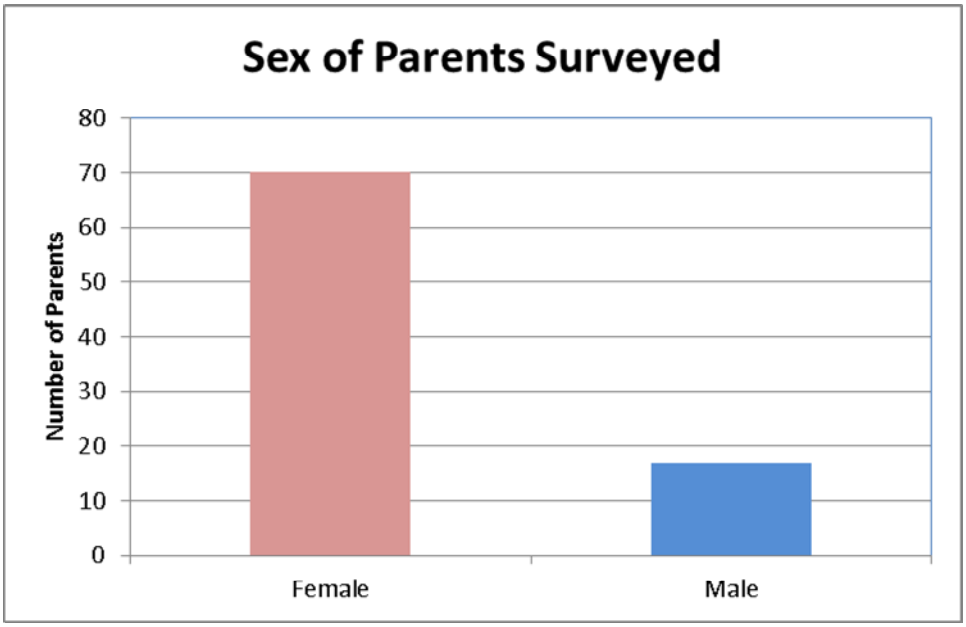

Figure 44. Parents' sex distribution

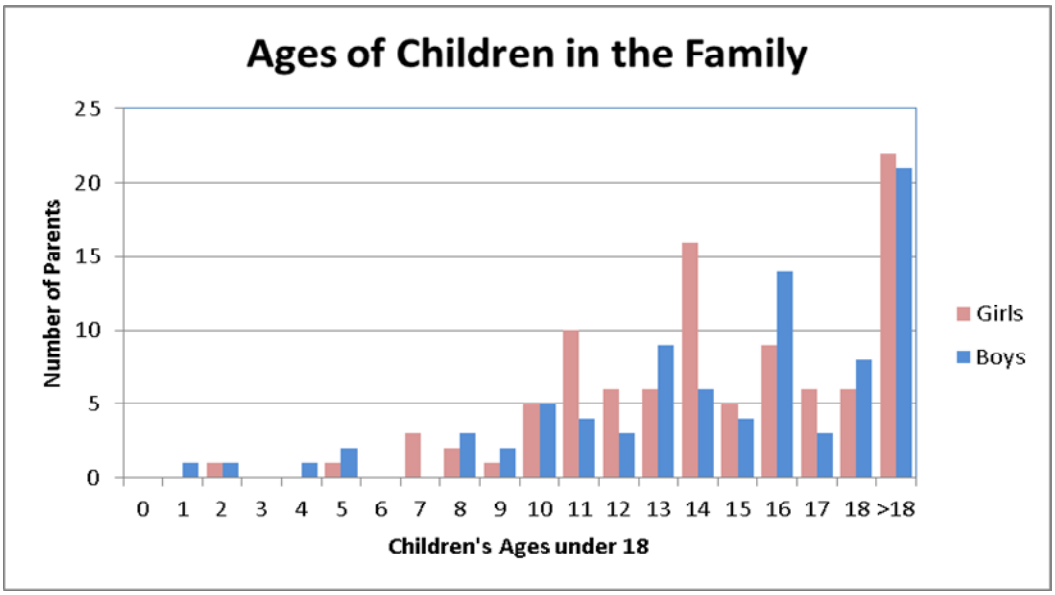

Figure 45. Children's age distribution

6.2.2 Study results

In the following, the main results of the study will be presented which relate to the three main research levels: Individual, STEM in general, and consequences of a STEM career.

6.2.2.1 Individual

- Educational biography

University attendance in Germany has changed substantially over the last thirty years. In this study, the proportion is nearly 60% (see Figure 46) what means that particularly parents with university background were interested in taking part in the study. One indicator therefore is that the main jobs of the fathers are engineers (see Figure 47), but also the proportion of engineers within mothers is quite high (see Figure 48).

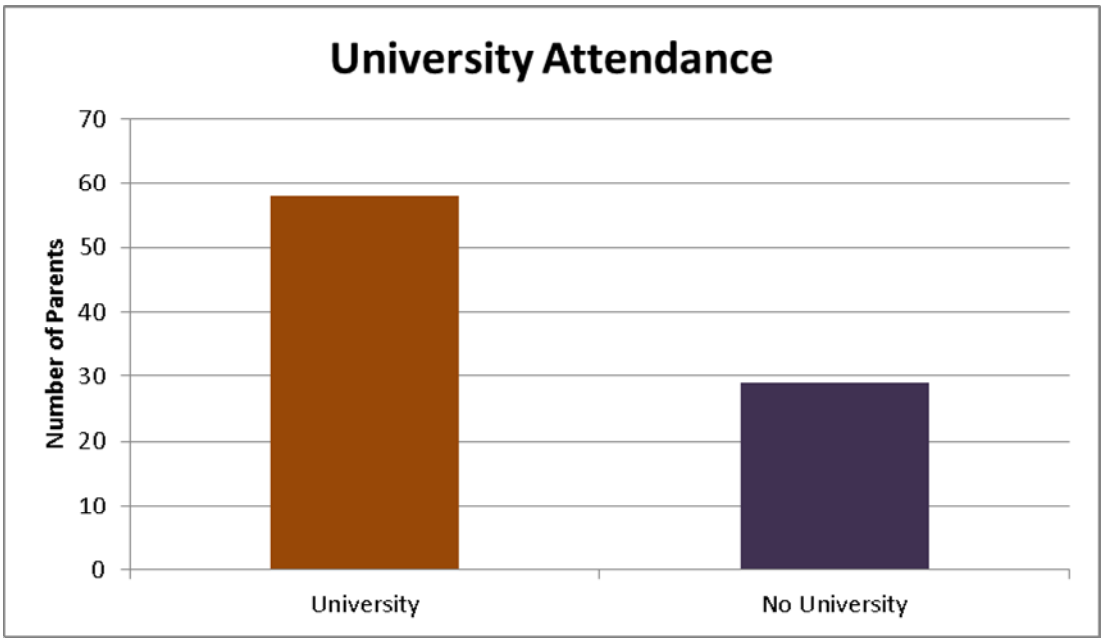

Figure 46. Parents' university status

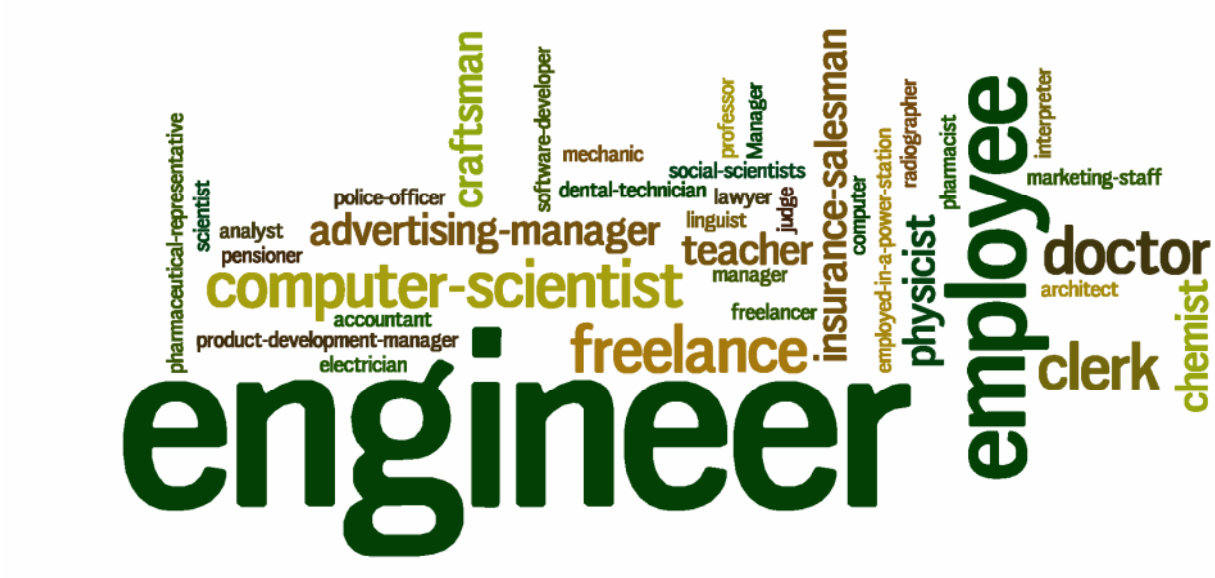

Figure 47. Fathers' profession

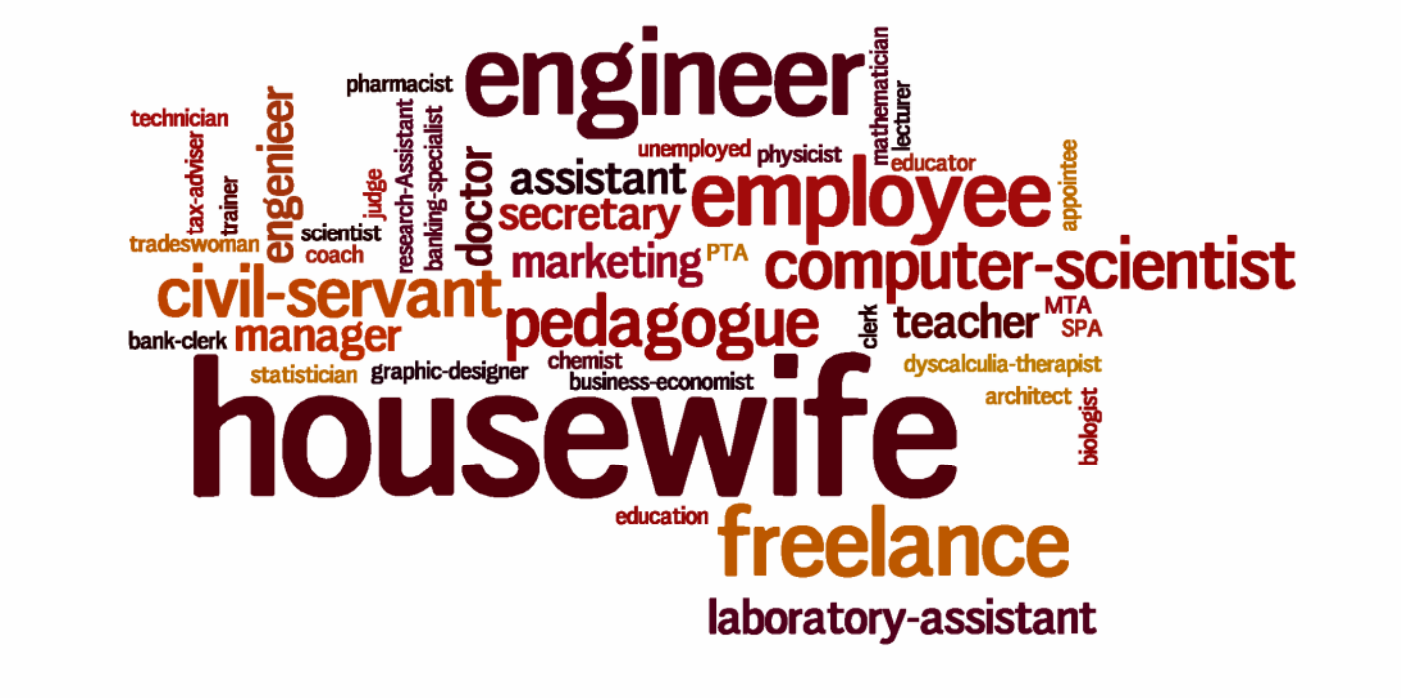

Figure 48. Mothers' professions

Figure 49 and Figure 50 show that mothers and fathers reported very similar patterns of behaviour of engaging with both boys and girls in doing practical activities, with over 70% of boys and girls being involved.

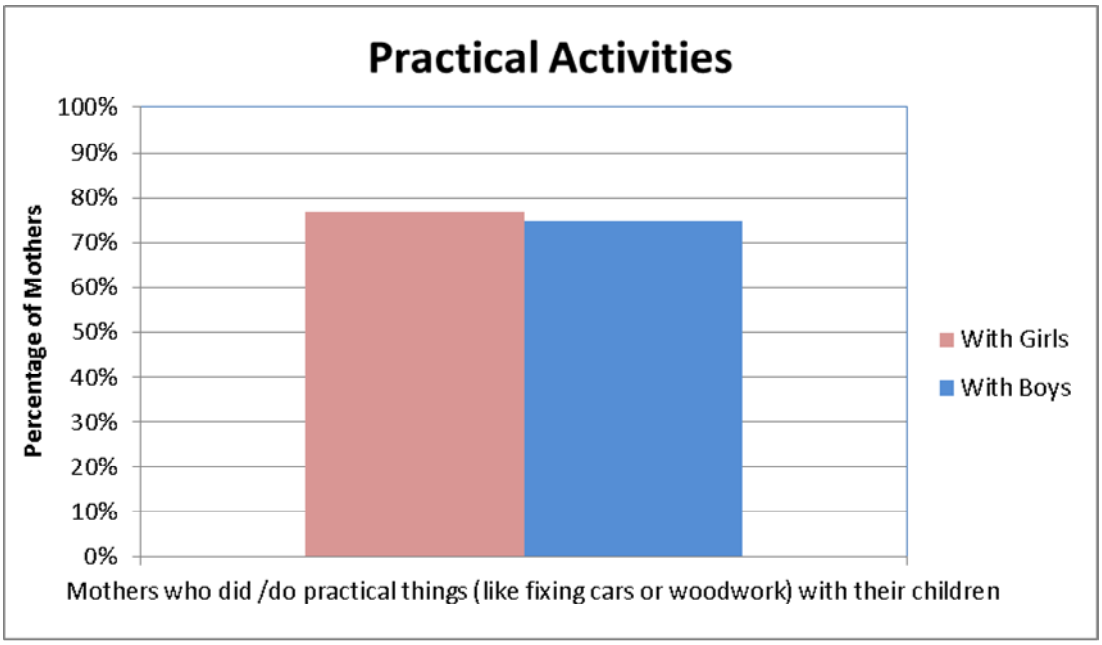

Figure 49. Whether mothers engaged in practical activities with boys and girls

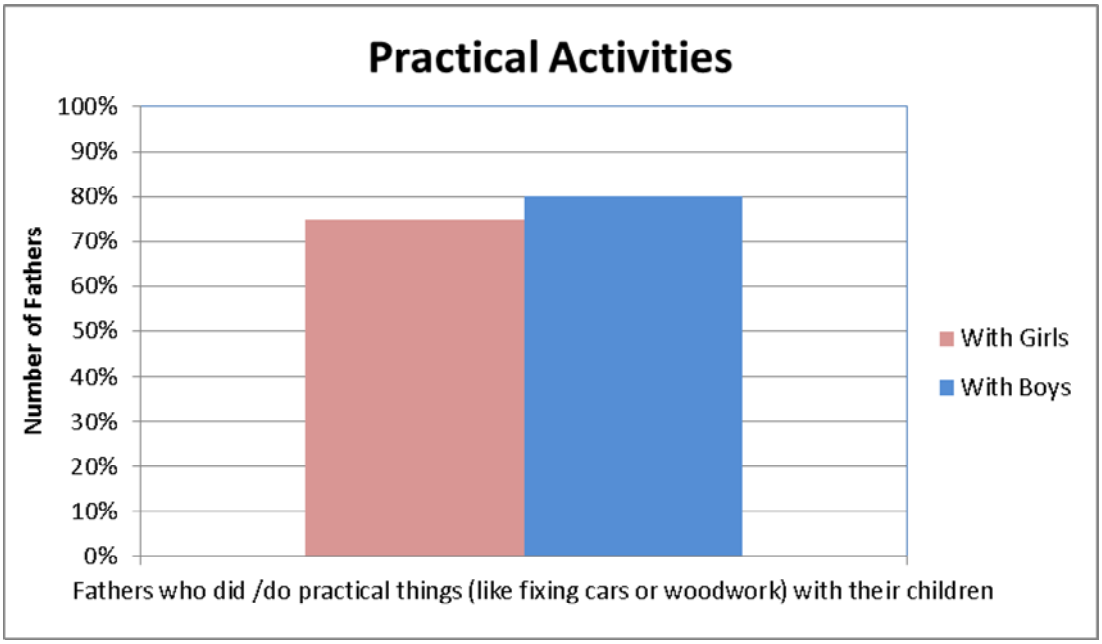

Figure 50. Whether fathers engaged in practical activities with boys and girls

Caution needs to be exercised in interpreting the parents' responses on helping with homework: Figure 51 shows a very different story to that told by pupils, who reported figures down in the 10% - 25% range for parents' helping with different subjects. This may be due to parents answering yes if they currently help but also if they helped in the last couple of years, where pupils might only acknowledge it if the help is current. There are some gender differences to be seen in subjects with fathers helping more with maths and science and less with other subjects.

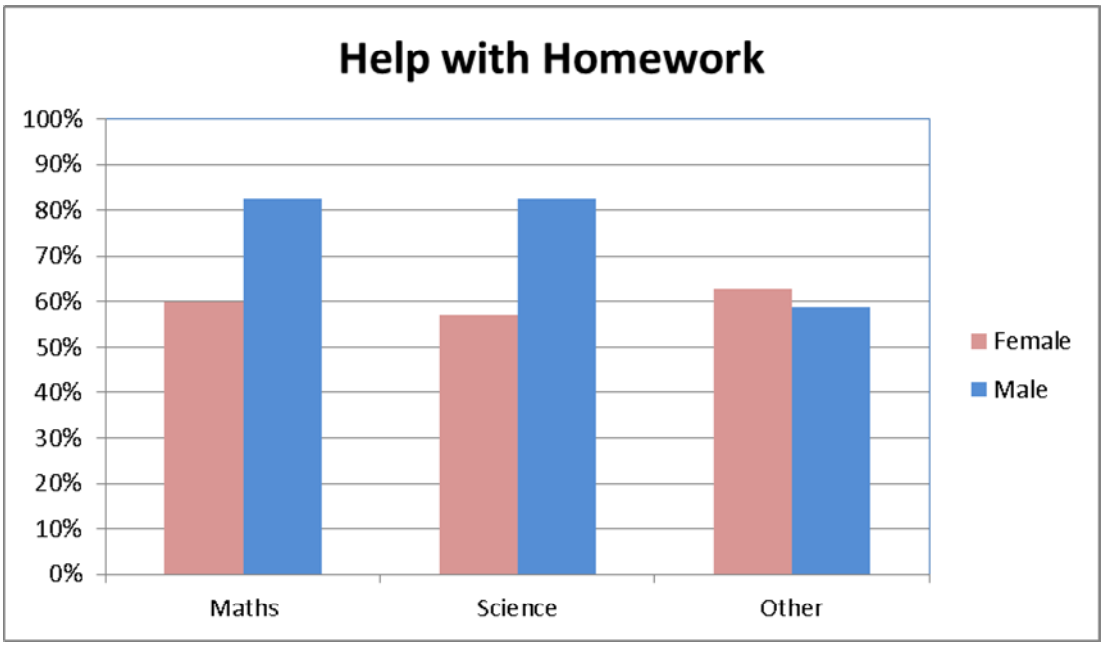

Figure 51. How parents help with homework in different subjects

Figure 52 below shows the sources of advice that parents remember seeking when considering their own career. The role of fathers and mothers was as prominent as in the corresponding responses for pupils; where the role of technologies such as the internet has substantially changed habits of information gathering.

Mothers were cited more often as sources by parents. Yet, reflecting that the parent sample has a high percentage of women, on can guess that the mechanism is the same for pupils and their parents: Girls mainly orient on their mothers while boys focus mainly on their fathers.

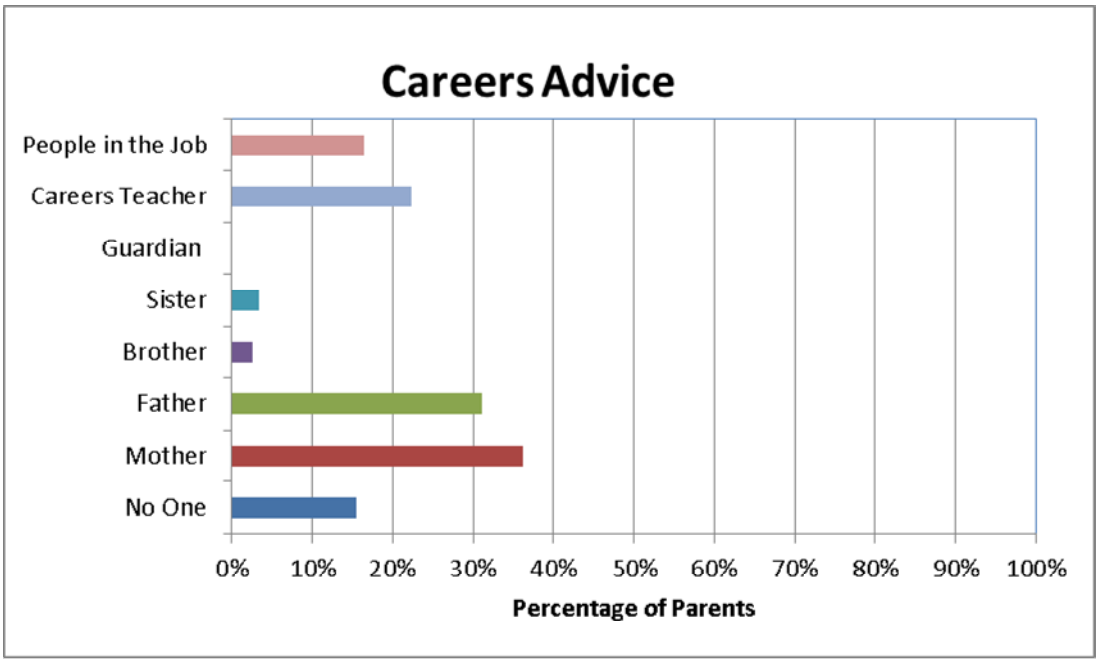

Figure 52. Sources of advice for parents when they were young

6.2.2.2 STEM

- Motivation

The block of items shown in Figure 53 sought to identify parents' perceptions of the value of careers in STEM in a very general sense. It is evident that few of these items provoked any very strong response from parents, which reflects a similar broad perception to that of pupils. Generally there seems to be a moderately positive view of STEM careers as offering prestige and good prospects, an interesting work environment and to contribute to the development of society though that environment may be pressured and competitive.

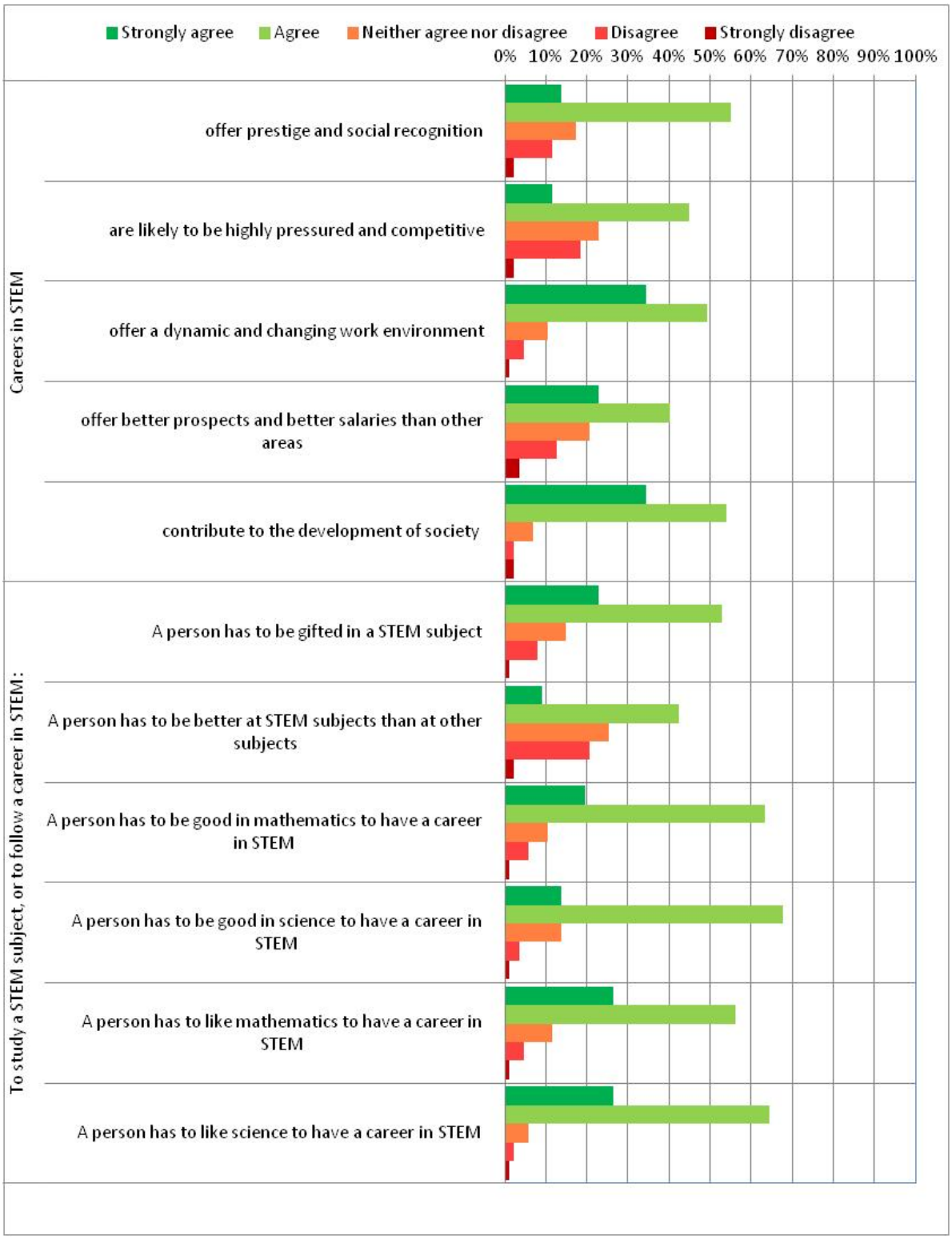

Figure 53. Parents' view of the general value of careers in STEM

- Abilities

The block of questions shown in Figure 53 tried to get at parents' perceptions of the abilities and attitudes needed in relation to STEM and careers in STEM. Parents moderately agreed overall in respect of feeling that a person had to be gifted in STEM, or better at STEM than other subjects but were moderately in agreement with the propositions that a person needed to be good at maths and at science, and to like maths and science to have a career in STEM.

The next block of statements, shown in Figure 54, were seeking to draw out parents' perceptions of STEM careers from a more personal standpoint than the statements reported on earlier in this section.

There are four statements which provoked fairly strong responses from parents: the two strongest were in disagreeing that women in STEM have to be like men and to have a successful career in STEM you need to think and act like a man. This is similar to the responses from pupils, where both boys and girls also disagreed with both these statements, though the girls disagreed more strongly in both cases. The other two were not quite so strong, but parents disagreed that friends wouldn't be working in STEM, so young people wouldn't either and parents agreed that family factors are an important influence on choice of study and career.

Again, these are consistent with the pupil responses, where girls disagreed more strongly than boys with the first statement (about the influence of friends) and girls agreed more strongly than boys with the second (about the influence of family).

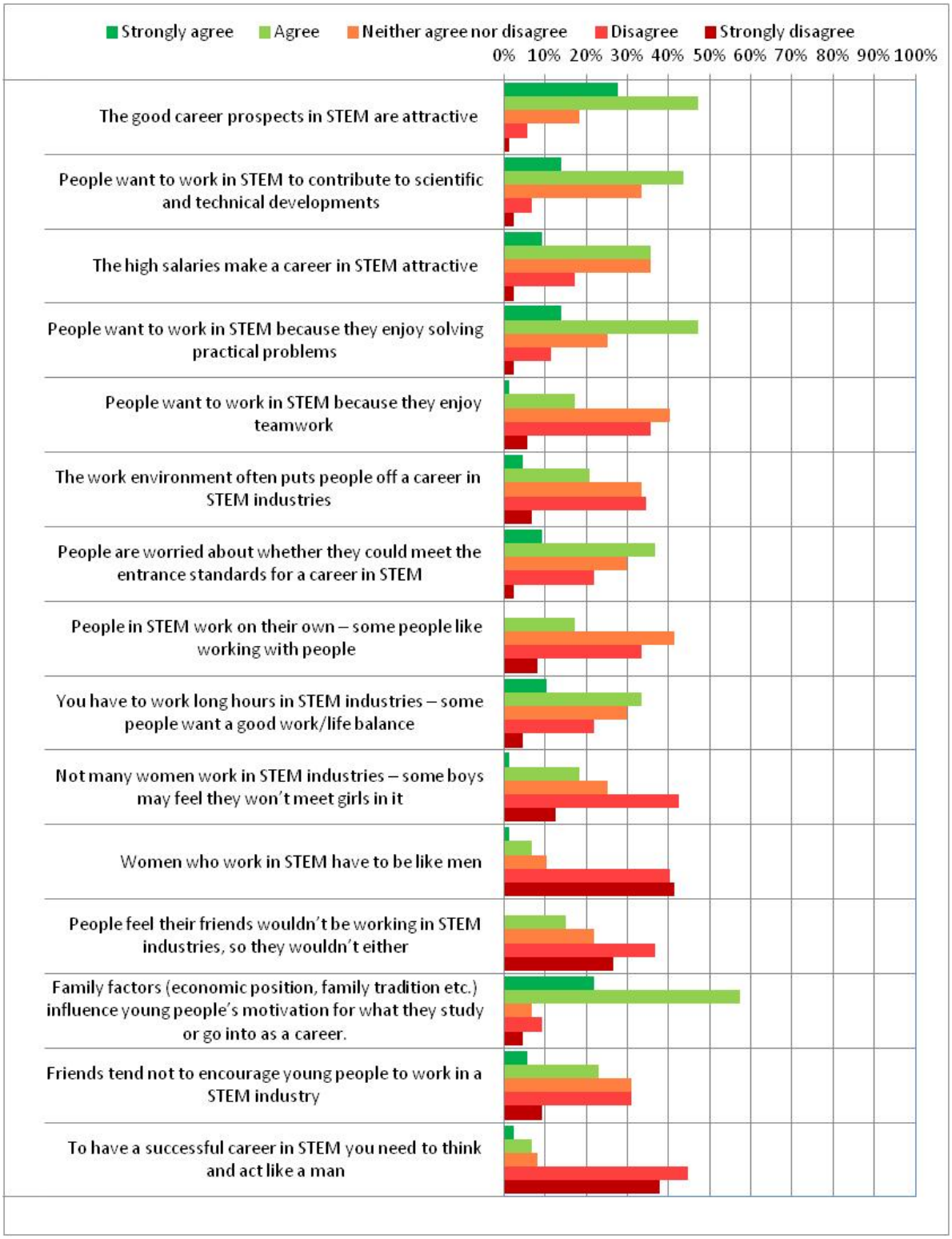

Figure 54. Parents' view of the value of careers in STEM to an individual

- Socio-cultural influences

This large block of statements was designed to identify attitudes to a range of socio-cultural influences, defined in a very broad sense. Figure 55 and Figure 56 show that, on the whole, parents tended to disagree with propositions that girls were not as good as boys at STEM or that parents, or teachers, somehow discouraged girls to take up STEM, either explicitly or implicitly and tended to agree that girls were not as interested in STEM as boys and enjoyed other subjects more than STEM.

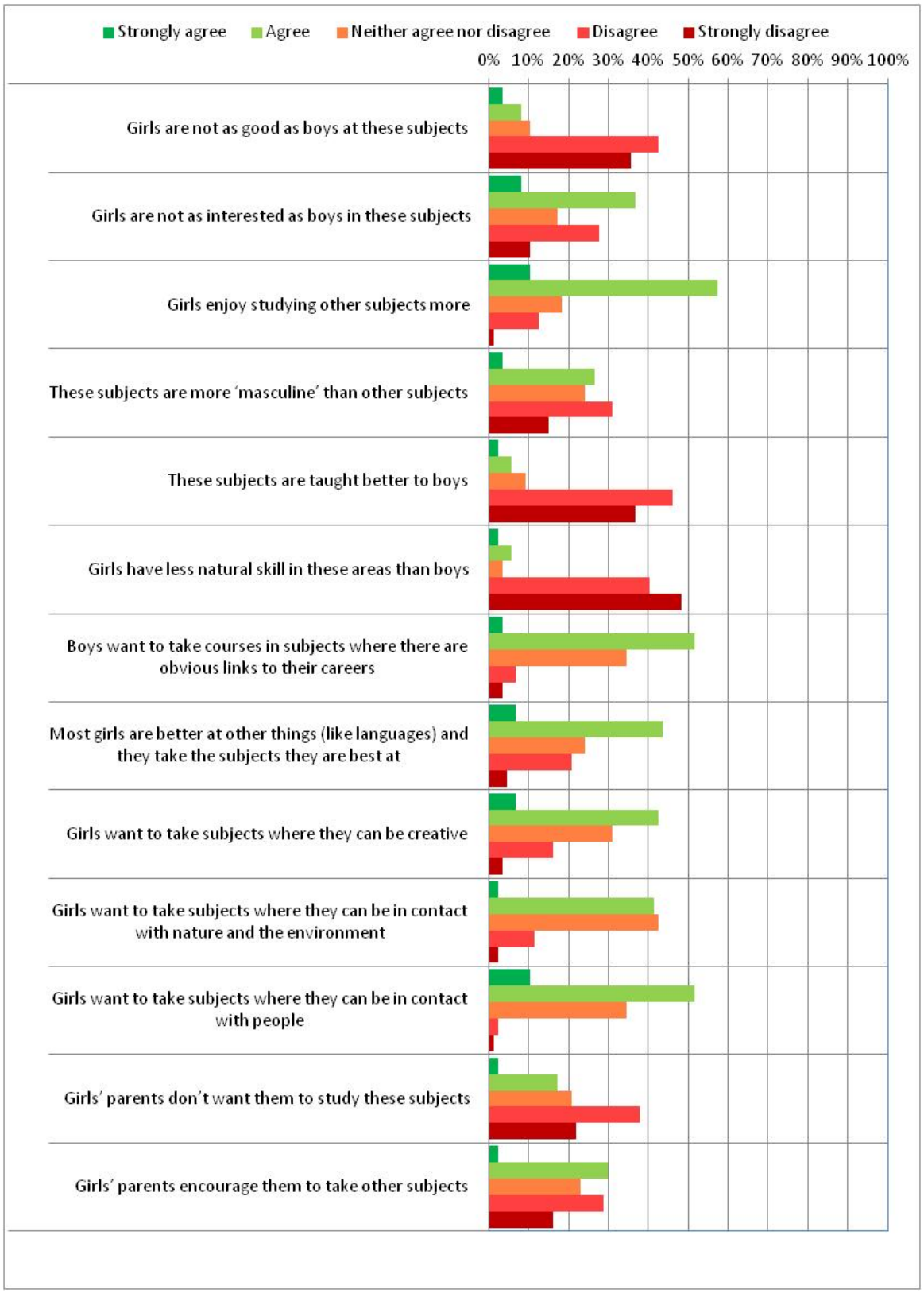

Figure 55. Parent perception of a range of socio-cultural influences

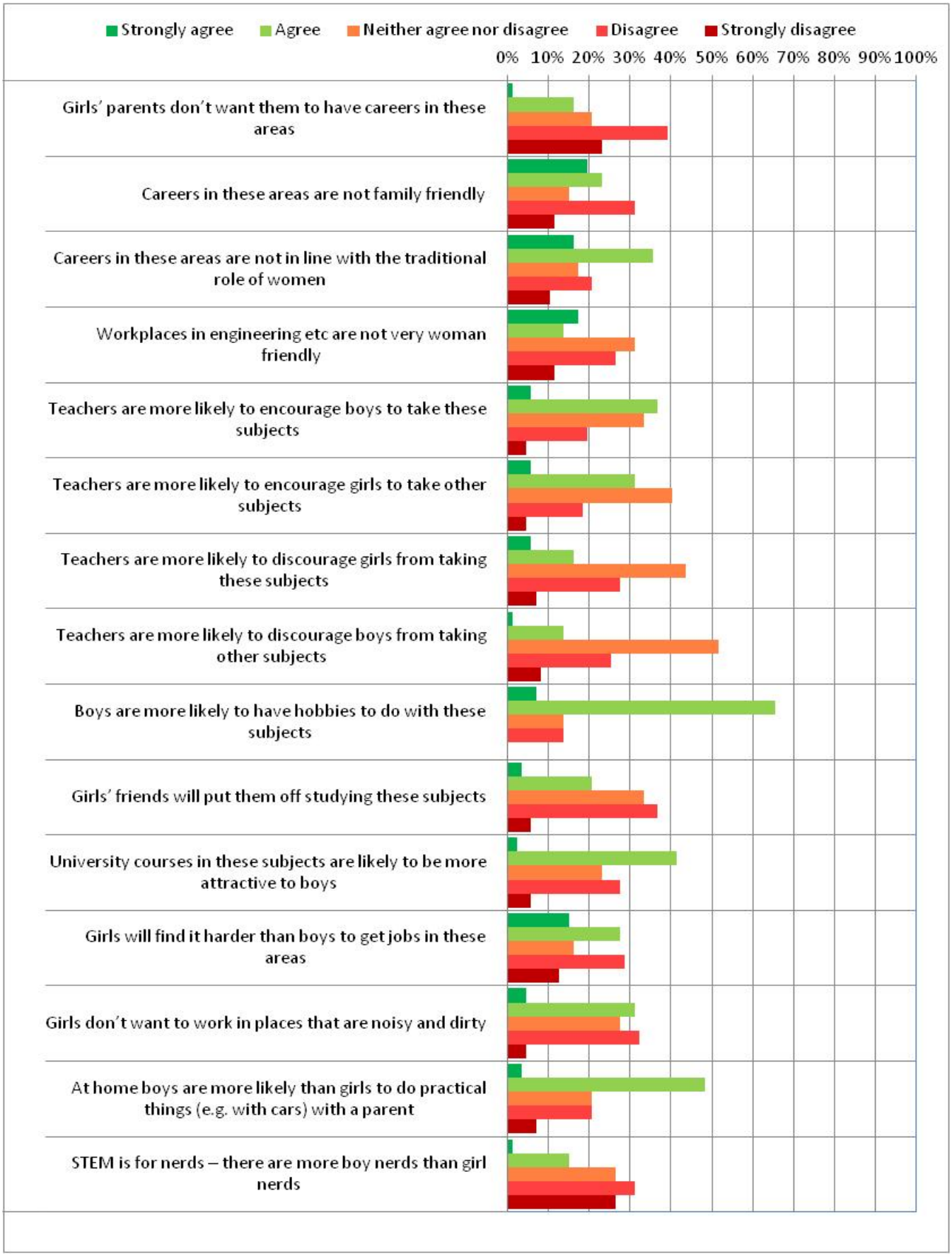

Figure 56. Parent perception of a range of socio-cultural influences

6.2.3 Main results: parents

Also in the parents' sample, much more women than men took part. Thereby it is noteworthy, that around 60% of them had a university degree. While most of the fathers were engineers, housewife was mothers' dominant profession. Yet, the majority of mothers were in professions and many of them also in the STEM field. Even though, much more fathers than mothers helped their children with math and science homework while for other subjects help was nearly distributed evenly. Parents stressed the importance of abilities and motivation for STEM careers and also the influence of family factors. Furthermore, parents agreed that boys are more likely to have hobbies in the context of STEM subjects and are also more likely to do practical things.

6.3 Teachers questionnaires

Figure 57 shows the sex of the teachers who took part in the survey. Invitations to participate were made through schools where pupils were participating, by mailing lists, and also through other contacts with teachers.

Unfortunately, the sample achieved is far to be enough for a quantitative analysis. The nature of the sample is such that we couldn´t report on the views of all teachers as a single group and to a lesser degree it would not be possible to attempt to make comparisons between female and male teachers for example, or others features.

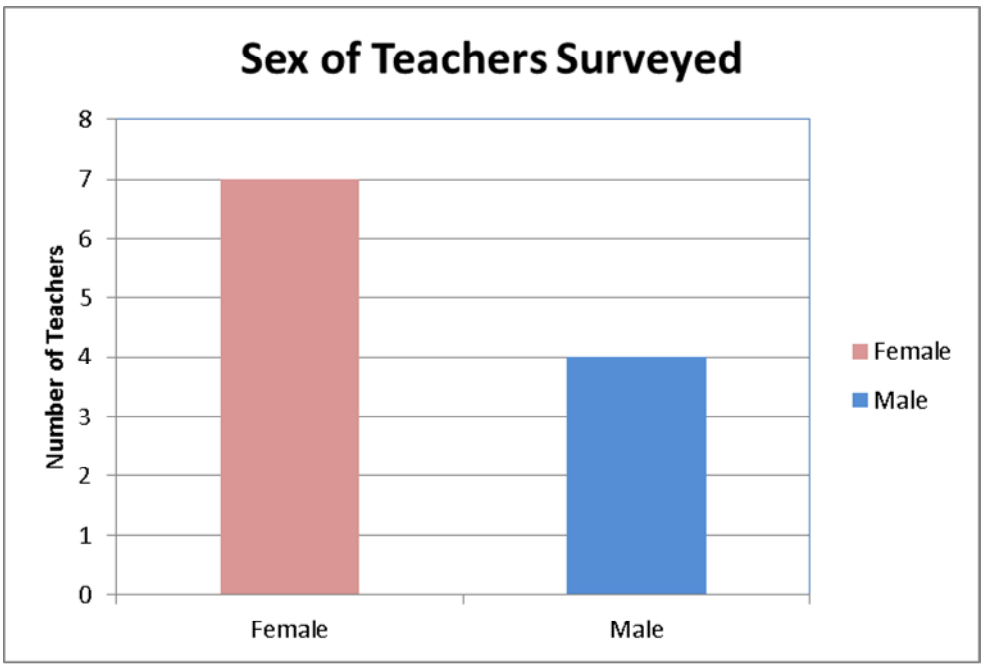

Figure 57. Teachers' sex distribution

6.4 Students questionnaires

6.4.1 Description of the sample and the methodology

Figure 58 shows the number of female students that took part in the survey. Invitations to participate were made through schools where pupils were participating, by mailing lists, by associations, and also through others. Even if intended only for female students, also few male students completed the online survey.

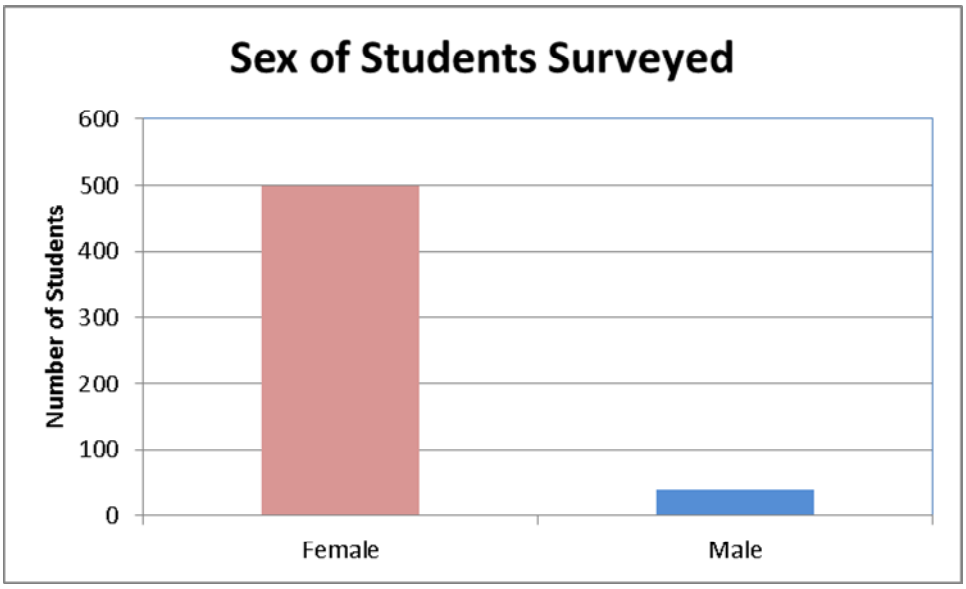

Figure 58. Students' sex distribution

In the following, the main results of the study will be presented which relate to the three main research levels: Individual, STEM in general, and consequences of a STEM career.

6.4.2 Study results

6.4.2.1 Individual

- Educational biography

Figure 59 shows the age of first interest in the subject area that the students are currently studying; half of the respondents affirmed to have chosen their future studies when we were between 15 and 18 years old. Yet, the figure also shows that career choice starts early and gets more and more important till the age of 18. This is an important data to decide when it is necessary and more effective to inform, support and guide pupils in their career choices. And a good sign to policy makers for introduce strategies and actions for promoting STEM and a gender equity in this area.

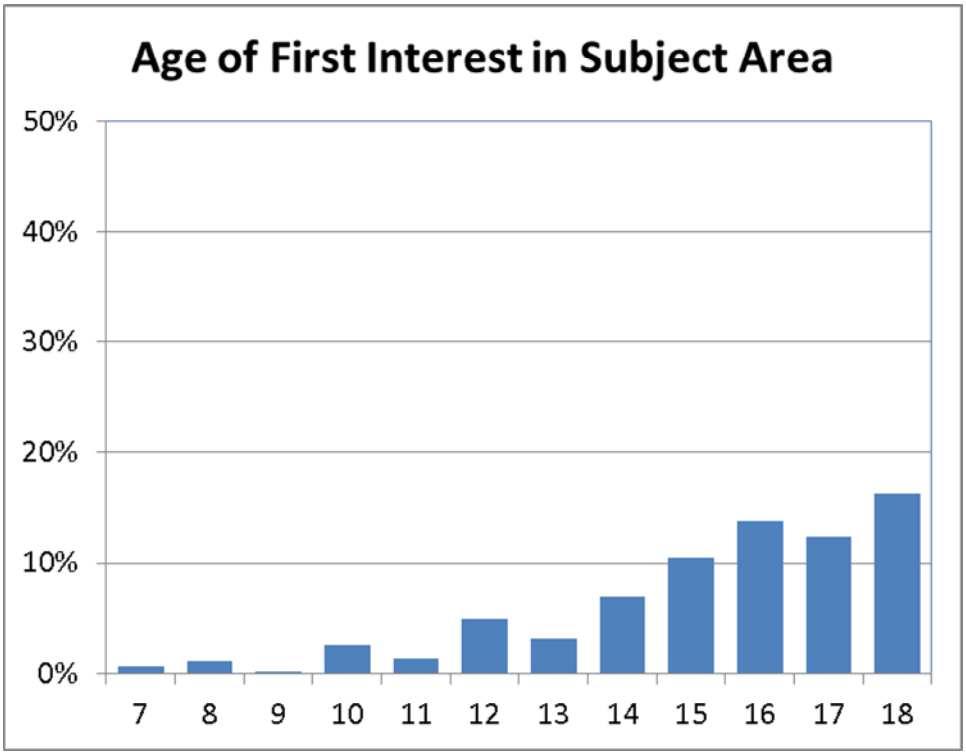

Figure 59- Students' age of first interest

Looking at the students' family background, one can see that most students had parents with higher educational degrees and also most fathers had STEM-backgrounds, with a very high percentage of engineers (see Figure 60). Compared to pupils' mothers, the percentage of students' mothers that were working was much higher (see Figure 61). These relatively high educational backgrounds allowed parents to support their children during their homework. Thus, and in contrast to the pupils, female students mainly received homework support from the family with the fathers in maths and science as well as the mothers in other subjects. Furthermore, fewer students stated they did not receive any help for their homework compared to pupils (see Figure 62).

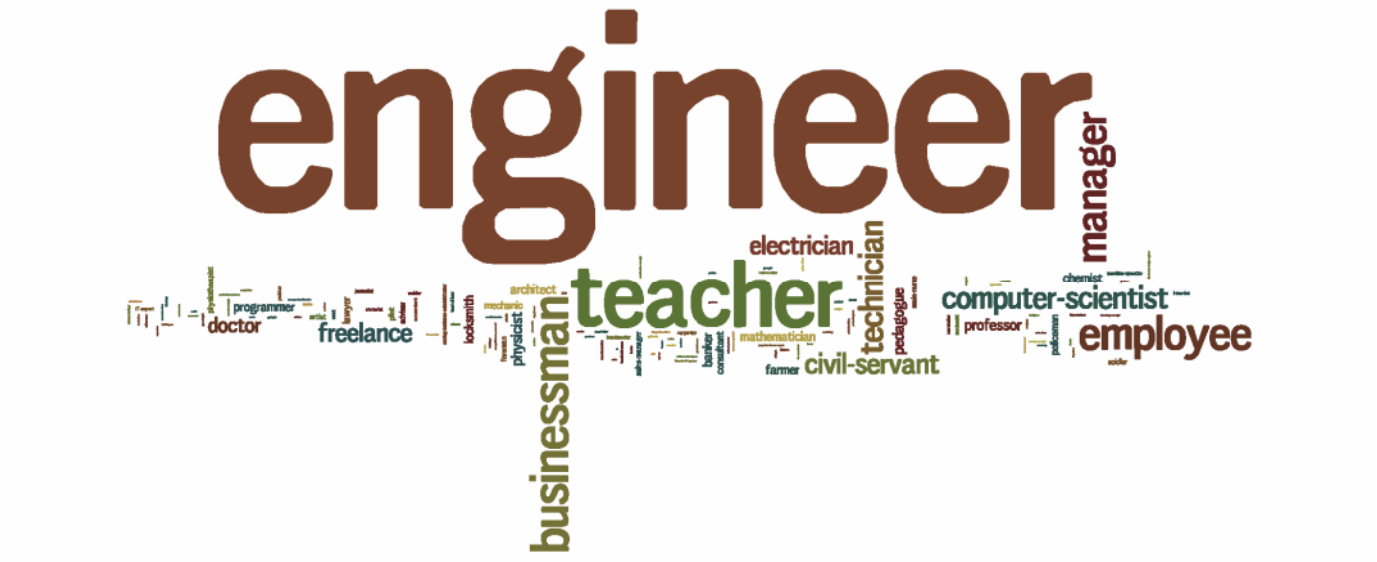

Figure 60. Students' fathers professions

Figure 61. Students' mothers professions

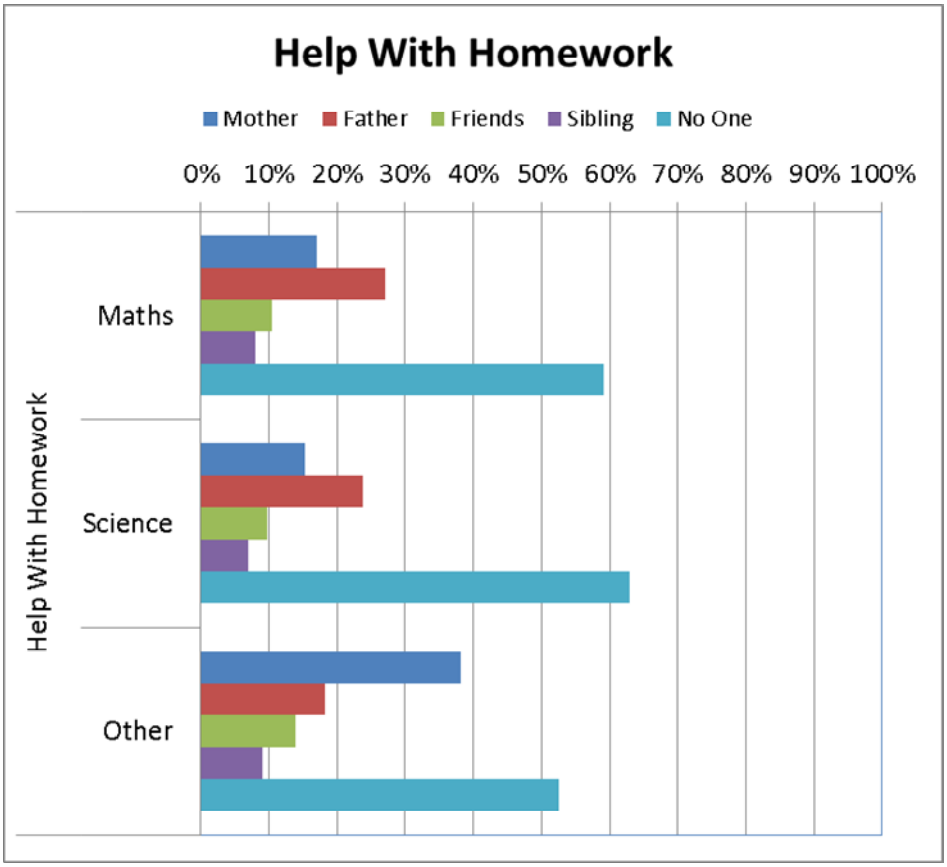

Figure 62. Help with homework in the different subjects

- Personal values and influences

Figure 63 shows that for STEM female students enjoying their work and the 'work-life balance' are two important items in terms of identifying personal values and influences. Over two thirds of this group strongly agreed with these statements. In second importance, 'I enjoy solving practical problems', 'I want to have a successful career', 'I like working with people', a contribution to the development of the society, and 'I like to try new things' are frequently mentioned.

- Factors for career choice

Regarding factors for career choice, the Figures 63 and 64 give interestung insights. Over 70% of the female students choose STEM studies because they wanted to have a job they're good at and one that is intellectually challenging. Furthermore, they want a job with a practical value, that improves peoples' lives and only ranked 5th a lot of money.

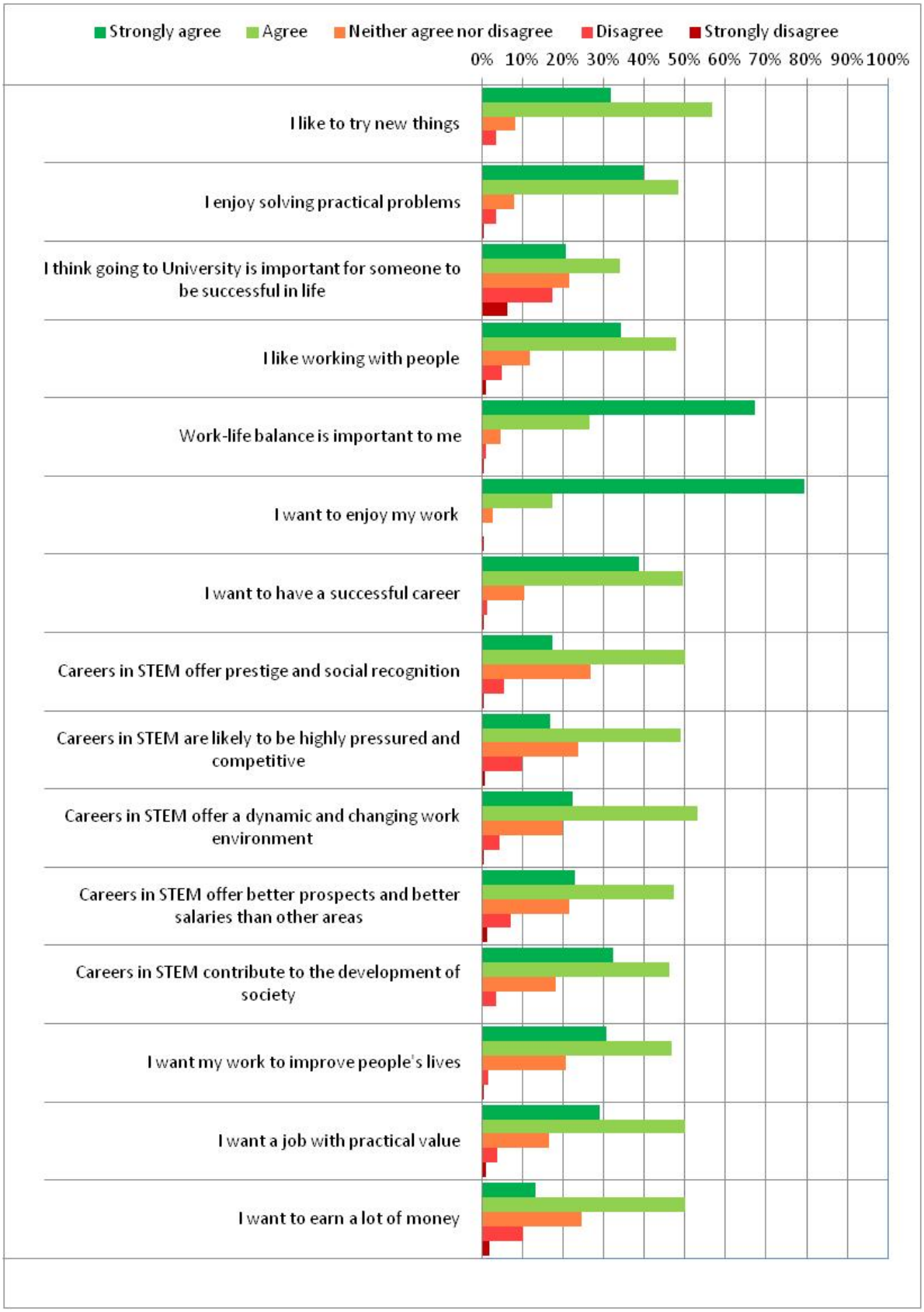

Figure 63. Items relating to personal values and influences

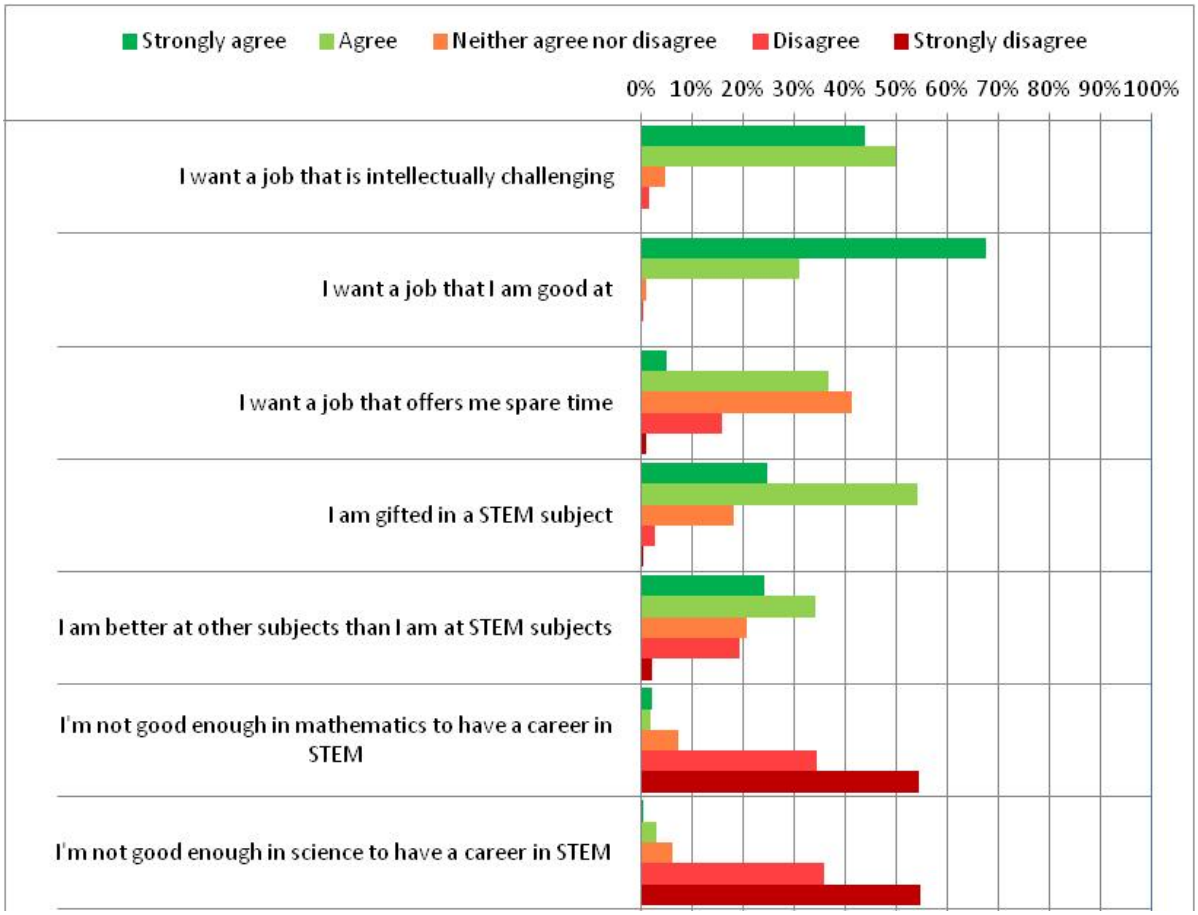

Figure 64. Items relating to personal values and influences

Figure 65 - 67 show the responses on careers advice, information or activities; respondents could tick all that applied in these questions. Over 70% of the female students took advice from someone of their family, with mothers and then fathers being the most common. According to figure 65, people on the job were named by about 40% of the students and specific career teachers by about 25%. The internet with varous websites is now a major source of information with about 80 per cent of the students citing it. Personal contacts and other sources show relevance for about 30 per cent (see Figure 66).

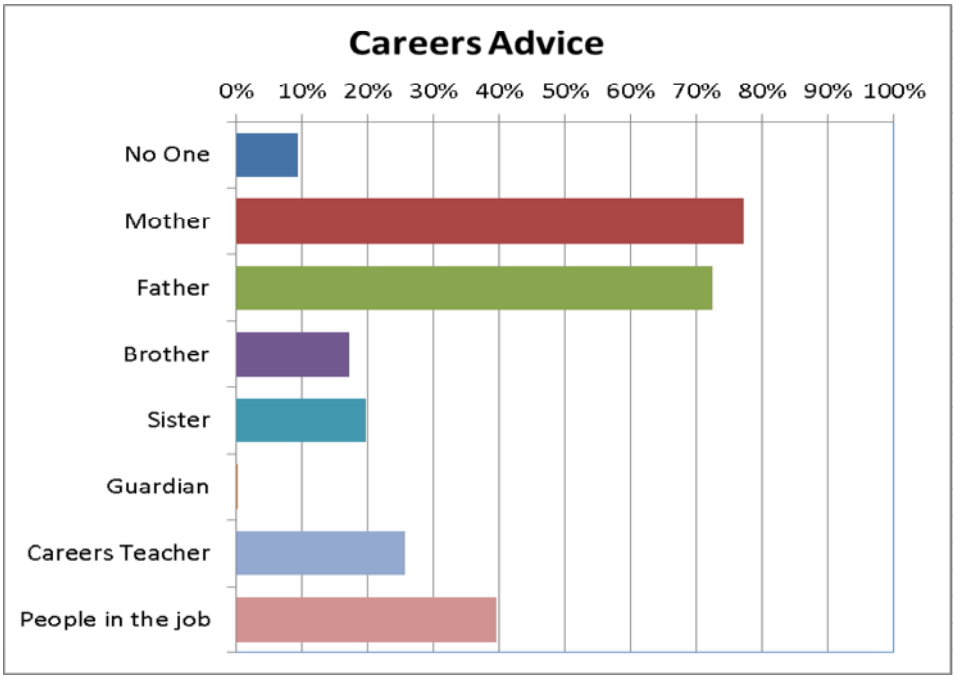

Figure 65. Responses about sources of careers advice

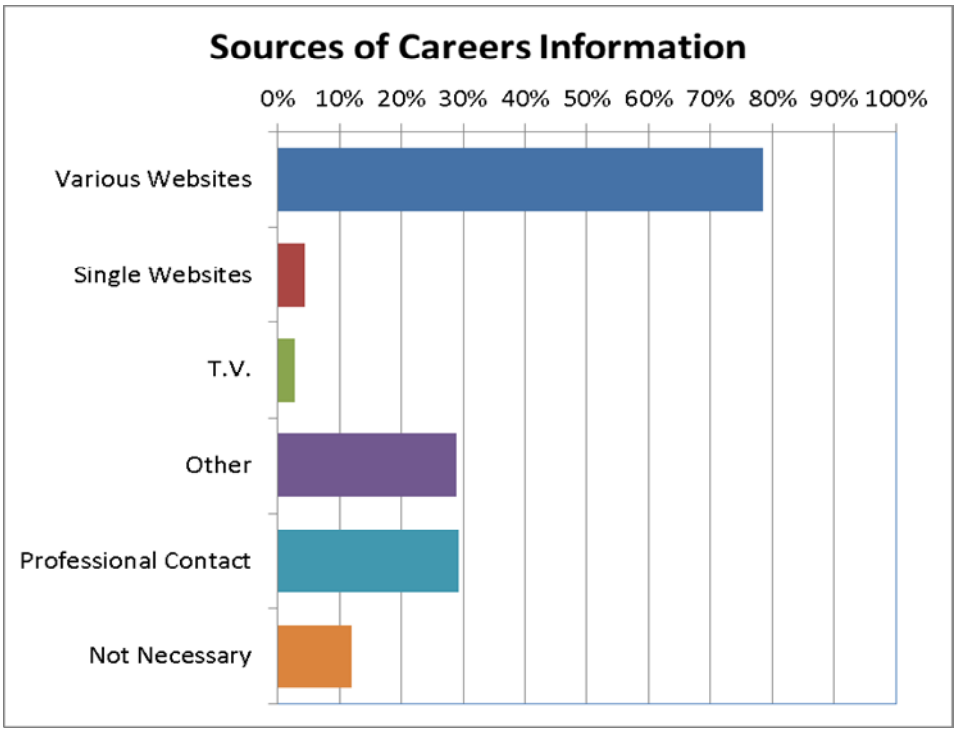

Figure 66. Responses about sources of careers information

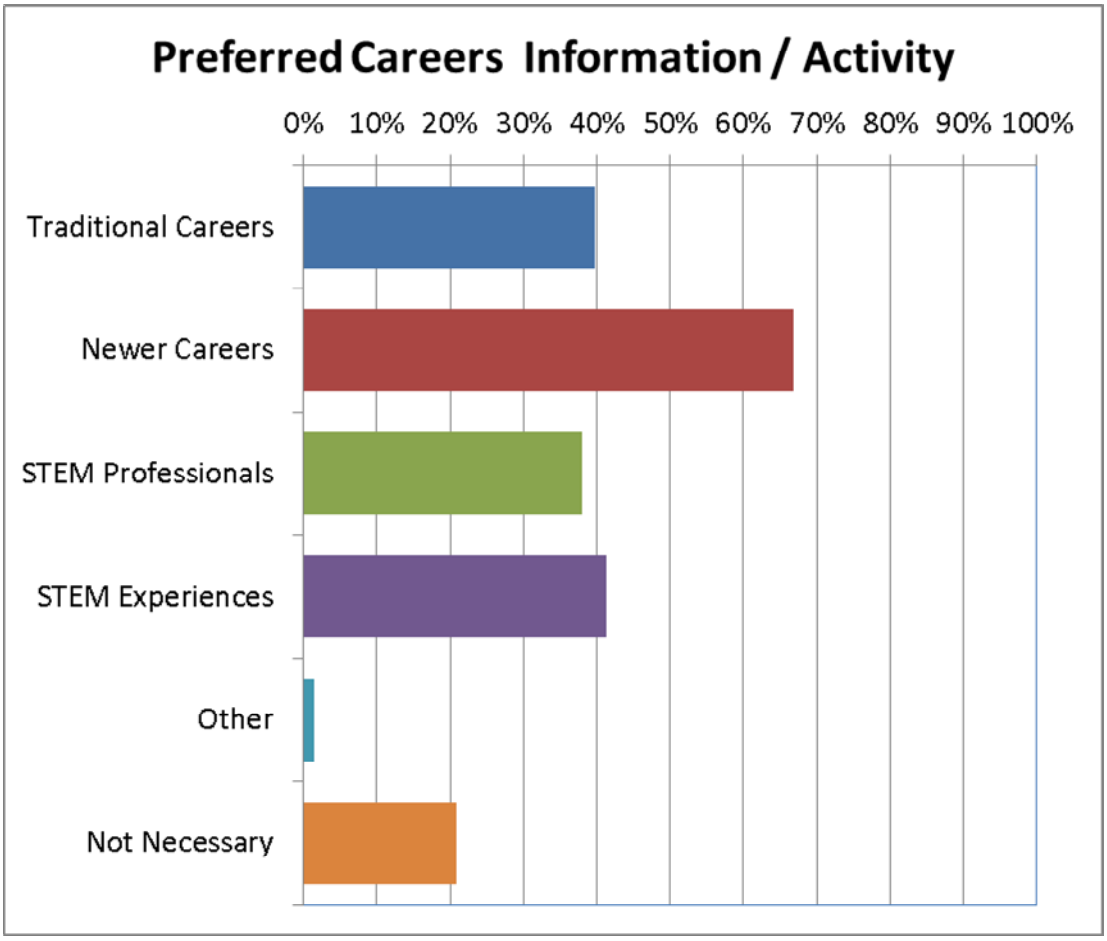

Figure 67. Responses about preferences in careers information / activities

There does seem to be an appreciation that the world of work is changing and that newer careers need to be explored alongside the more traditional options (see Figure 67). In fact, more students listed newer careers than listed traditional careers but this might be partially explained by some pupils feeling they already had good information on traditional careers they might be interested in. The information that could be provided by STEM professionals or through STEM experiences is very important for students, much more than for pupils; this might be explained by the proximity of them for accessing into the labor market.

6.4.2.2 STEM

The figures 68 - 72 give several insights into the perception of STEM by STEM students.

- Motivation

The items sought to identify perceptions of the value of careers in STEM in a very general sense. It is evident that few of these items provoked any strong response from students. Generally there seems to be a moderately positive view of STEM careers as offering prestige, social recognition and to contribute to the development of society though that environment may be pressured and competitive.

The items that sought to identify career aspirations that students have. The strongest support was for the good career opportunities, with the practical value and the high salaries were also supported.

The statements that were seeking to draw out students' perceptions of STEM careers from a more personal standpoint than the statements reported on earlier in this section.

- Abilities

The questions that tried to get at STEM female students' perceptions of their abilities and attitudes in relation to STEM and careers in STEM. In general, students felt they were gifted in a STEM subject, but not in a strong way. The common answer is that they like and are good in mathematics and science, what it is coherent that they are currently studying careers where these courses are central. Even when they feel capable and self-confident now, they recognized at the begening to have difficult according to the high pressure of these courses.

- Socio-cultural influences

Several questions were designed to identify attitudes to a range of socio-cultural influences, defined in a very broad sense. Many responses were neutral; however the modal response for the majority of these statements was a strong rejection, especially those relevant to consider STEM as a more masculine environment.

In terms of family attitudes in terms of people encouraging STEM participation, students often recorded to have szrong support by their mothers or fathers. In their experiences also friends, secondary teachers and event a character motivated their interest in STEM.

In relation with ability or attitude towards STEM students strongly identifying with a position of equality, so the responses to 'girls have less natural ability in STEM subjects than boys', 'girls are not as good as boys at STEM subjects' and 'girls are not as interested as boys at STEM subjects' are all 'strongly disagree', with in general recording more than 40% of all responses as 'strongly disagree'.

A similar story emerges for the statements relating to the perceptions of teacher attitudes and parental attitudes; in general students disagree strongly with suggestions that there is a difference in the experiences of boys and girls in these areas.

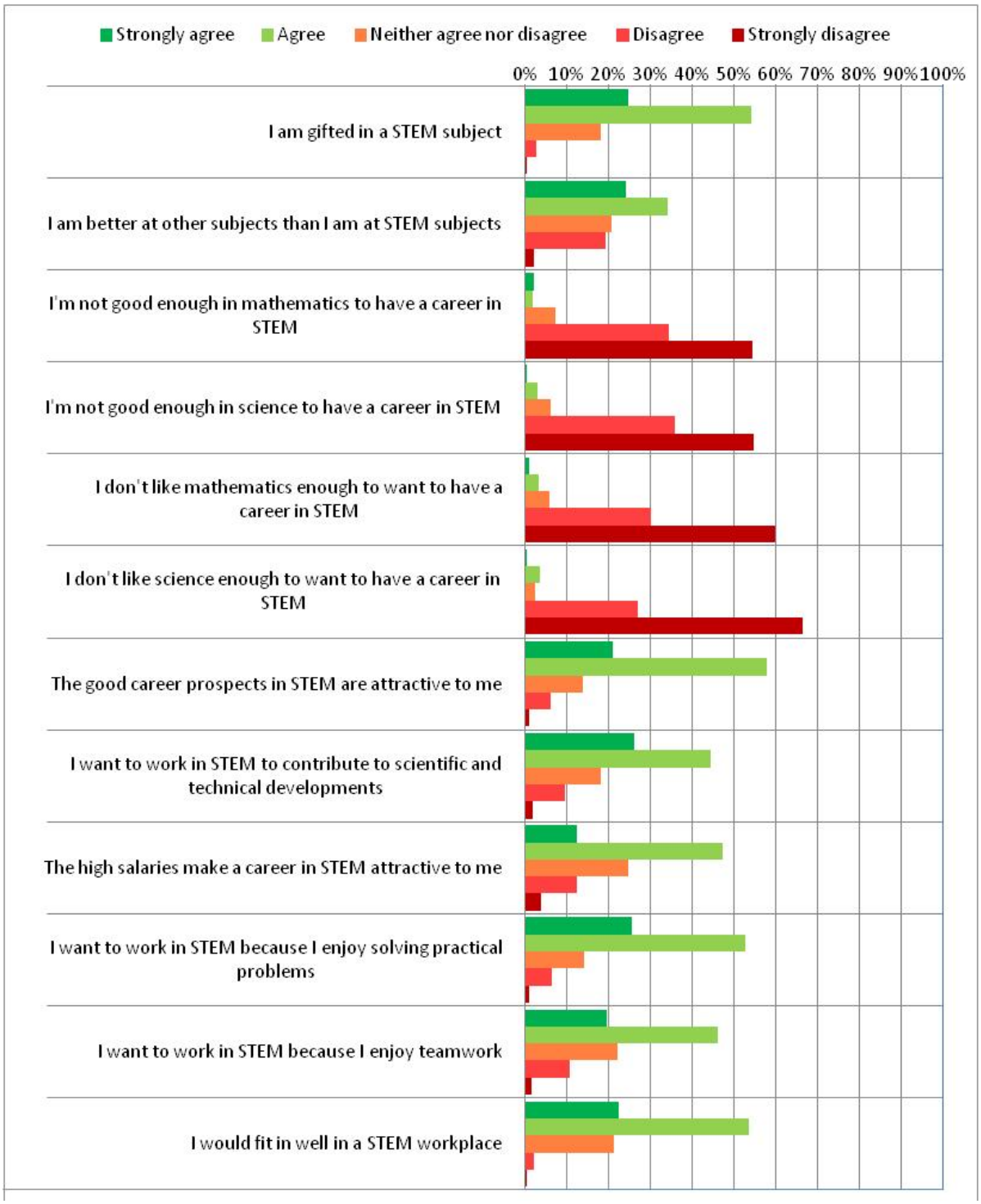

Figure 68. Responses to a range of influences and views on STEM

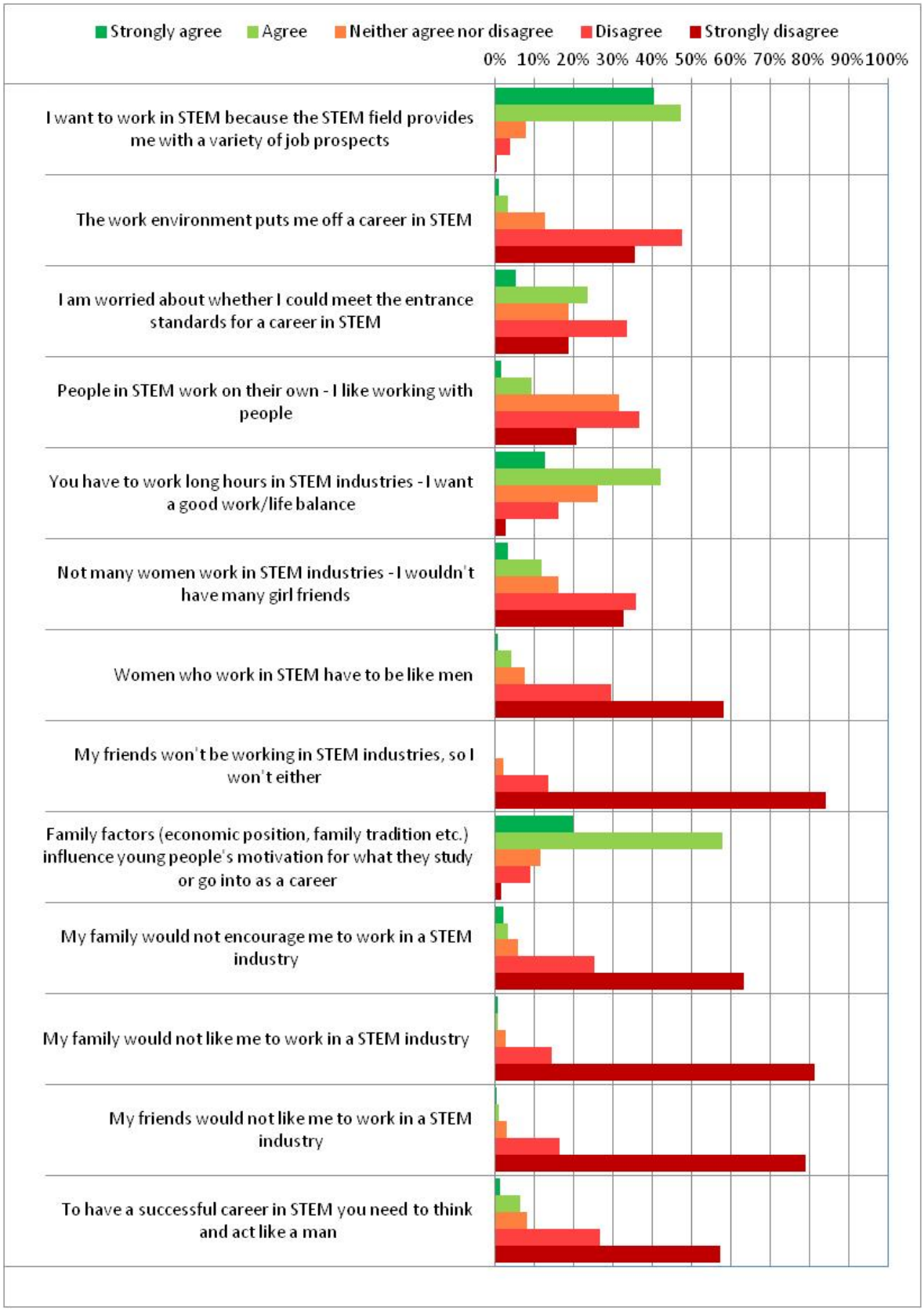

Figure 69. Responses to a range of influences and views on STEM

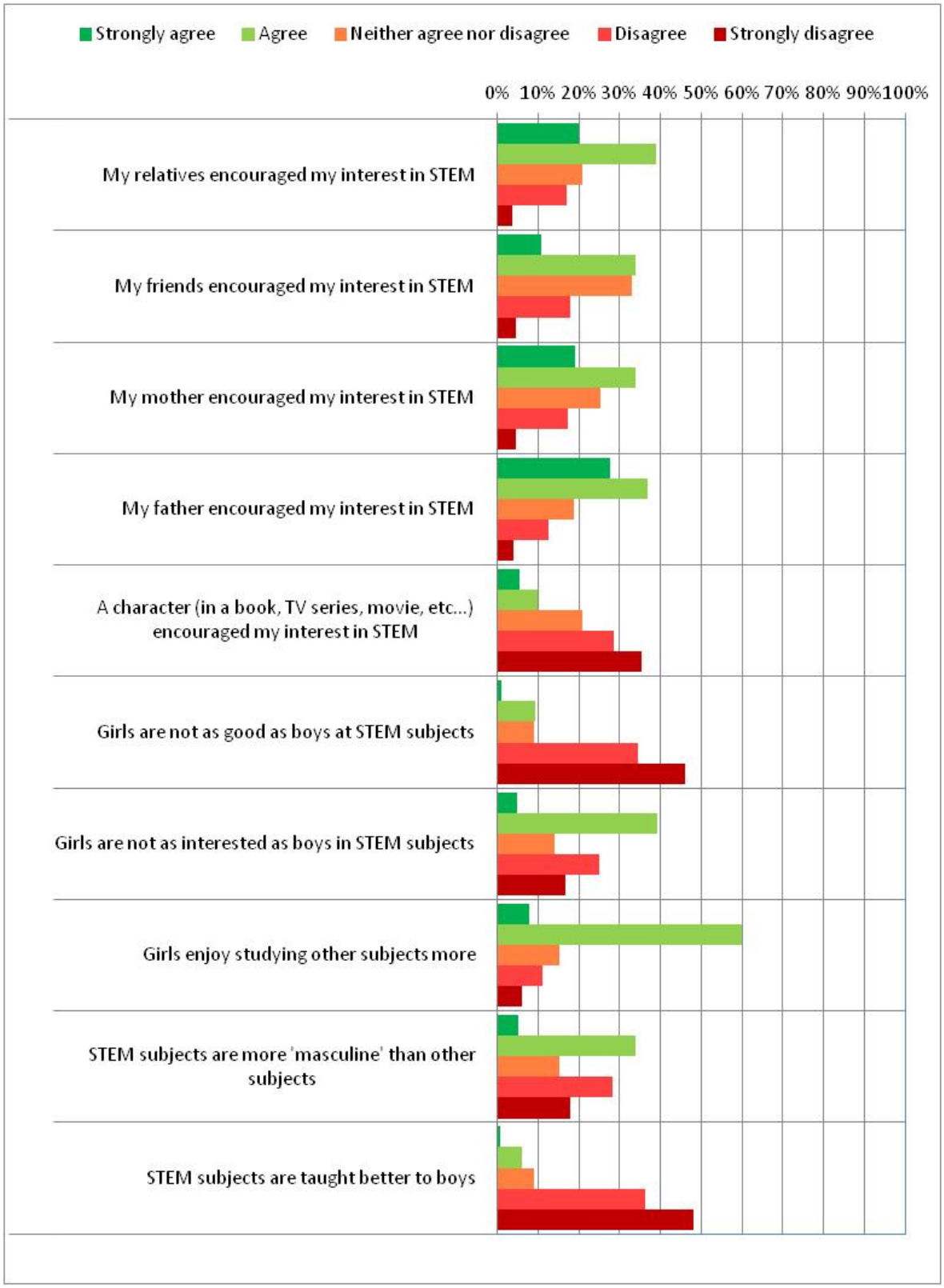

Figure 70. Responses to a range of influences and views on STEM

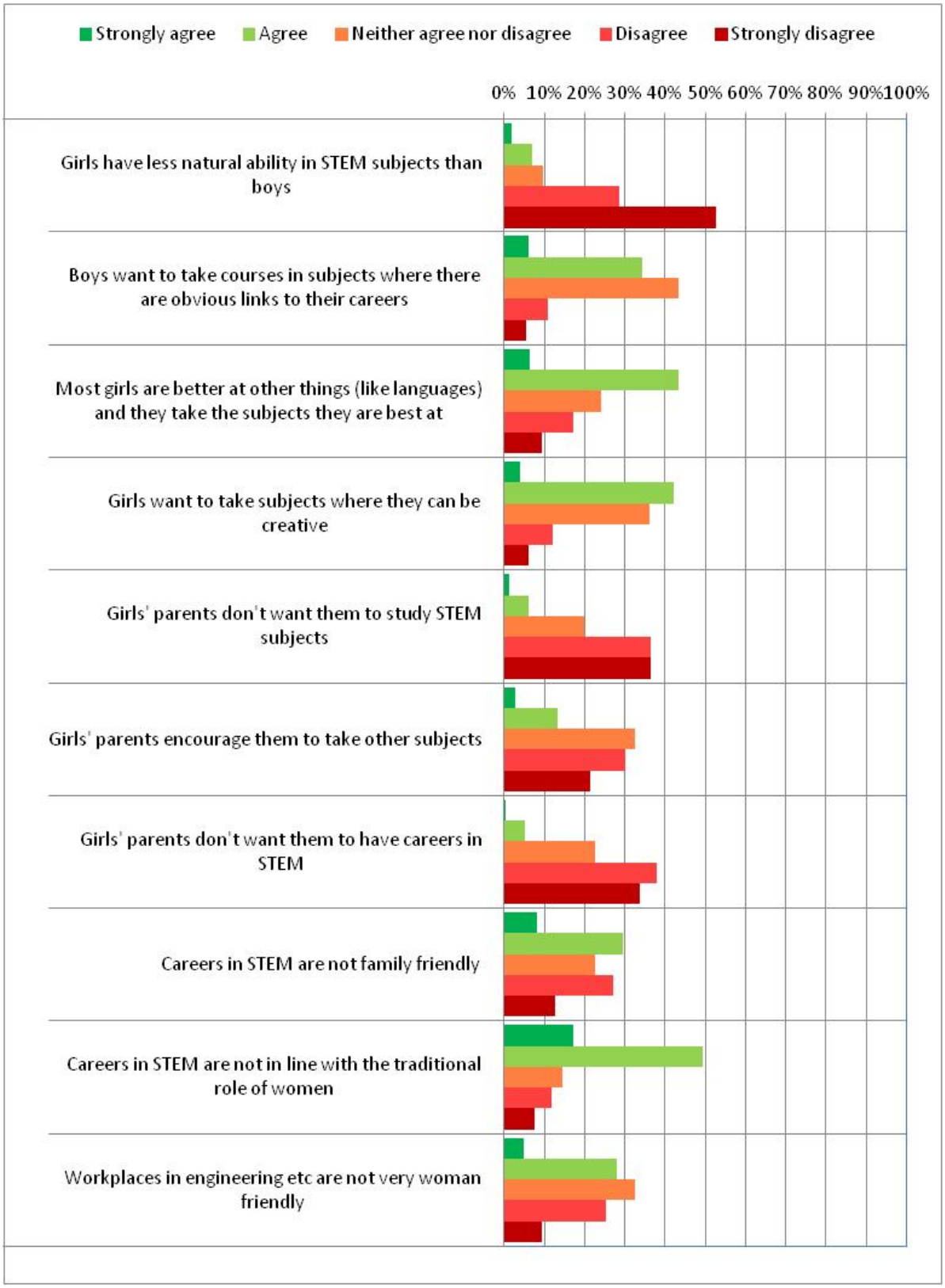

Figure 71. Responses to a range of influences and views on STEM

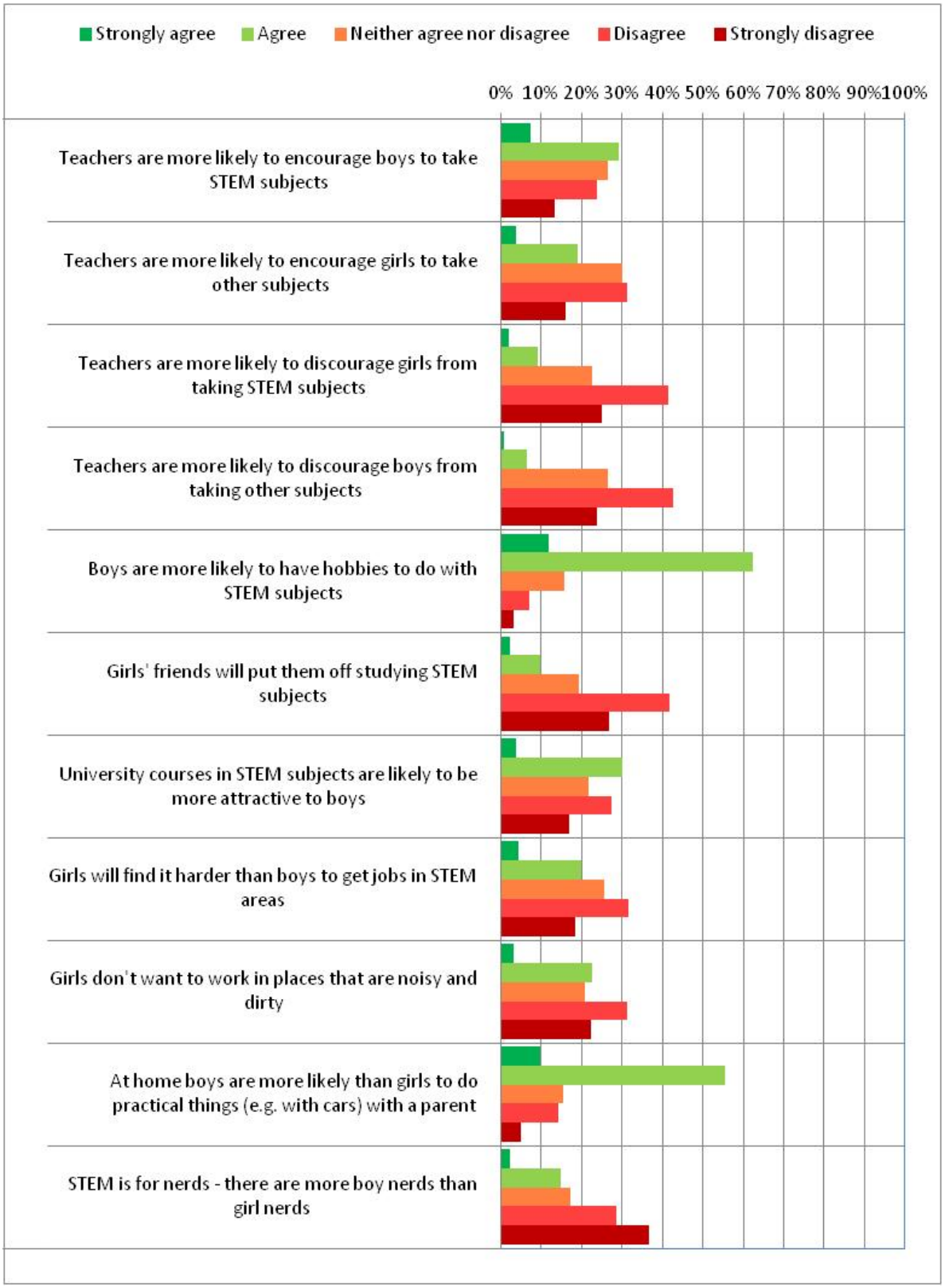

Figure 72. Responses to a range of influences and views on STEM

6.4.2.3 Consequences of a STEM career

Figure 73 shows the proportions of students who responded 'yes' to the questions which related to potential obstacles or facilitators for engagement with STEM. Many of the experiences reported the role of teacher and the importance of school events - such students' fairs or halls - for encouraging their interesting in STEM and increased. What it seems to be insufficient is a direct career advice.

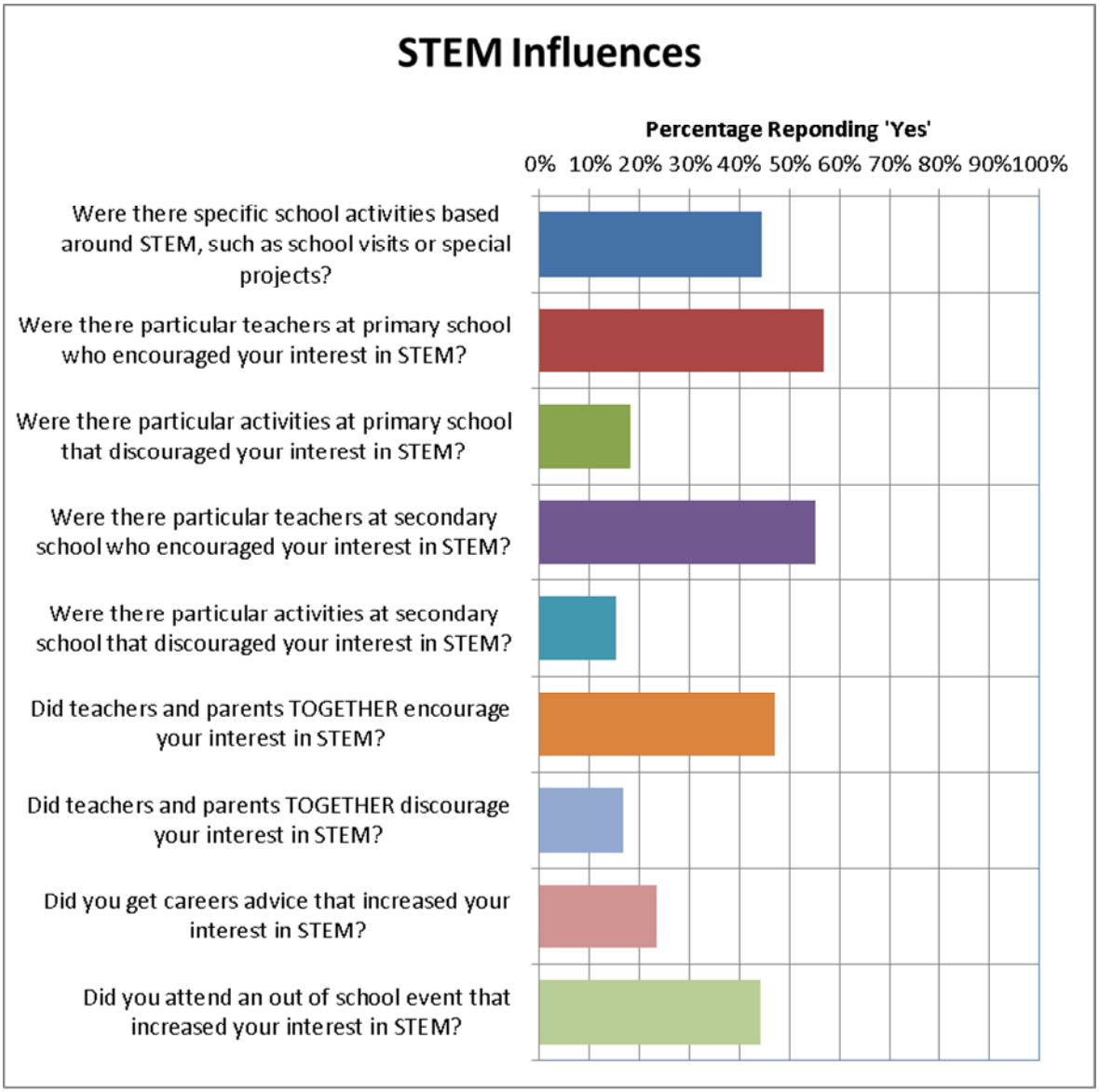

Figure 73. Facilitators and obstacles to the uptake of STEM

Many of the statements reported on earlier in this section can be looked in terms of acting as obstacles or facilitators for engagement with STEM, and we will try to identify the strongest messages here.

- Obstacles to STEM

There were rather few negative stereotypes about STEM (STEM was not seen as boring; not seen as being just for boys; STEM people are not seen to be 'odd').

- Facilitators for STEM

In the interviews, it was evident that work experience was the single most important factor in helping pupils decide on a university course or career path, whether in STEM or not, but that level of perception is not available with the nature of the items in the questionnaire. Other themes from the interviews however were reinforced by the questionnaire responses: STEM is seen to help the development of society, and careers in STEM are seen to be prestigious and offer a dynamic environment which can be challenging. Students' responses indicate that the encouragement of their family and teachers greatly facilitates them to choose a STEM career.

6.4.3 Main results and discussion

Regarding students questionnaires, one could see a big interest of nearly 500 participants. Thereby, a very interesting finding was that most fathers were engineers themselves. Over 70 per cent of them want to enjoy their work, to work in a job that they are good at and emphasize the importance of work-life balance. Very many of them got career advice from their parents and various websites. Students seem to hold the most positive views about STEM and women working and studying in STEM fields. As they are girls who have already chosen STEM as a career, their responses in a way reaffirm the assumption that self-confidence and encouragement from the socio-cultural environment are interconnected and facilitate girls to choose a STEM career. In the qualitative studies, however, students expressed concerns that they will meet difficulties in the future, when it comes to employment, because of their status as women and also because of the economic crisis. They also reported more obstacles in university when it comes to professors compared to secondary teachers who were overall described as being supportive.

6.5 Summary

Summing up pupils results, one can see two interesting aspects of the target groups of the studies: Firstly, that more females than males were participating and secondly that most fathers of students and also pupils were engineers. Both aspects may have had a particular impact on study outcomes. On the one hand it may be, that persons from the STEM context were more interested to participate in this study than persons from other contexts. Yet, this may be a particular advantage for getting insights into STEM career pathways. A maior source of career advice was the Internet and the parents and many report hight parental support for STEM careers. Regarding wishes for their future job, female pupils preferred to enjoy their work and to work with people significant more than boys. This is reflected by the questionnaires of STEM-students: over 70 per cent of them want to enjoy their work, to work in a job that they are good at and emphasize the importance of work-life balance.

7. Implications

In the following, consequences for family, educational institutes and for stakeholders of politics and industry will be exposed. This aims at developing new implications for promoting more equality regarding a career choice in STEM.

7.1 Consequences for the family (parents)

With regard to implications for family, the tendency could be established that parents of lower socio-economic background prefer that their children work as soon as possible. With respect to this, more financial support measures like scholarships or grants for gifted pupils in STEM should be offered by the government or STEM-related companies to encourage more young people of lower socio-economic family background to take a STEM-related study into account.

In general, most of parents support their children following STEM-related career or study subjects because they think that jobs in STEM offer a high salary and job prospects. This attraction of girls and boys for STEM studies may be a consequence of family influences and sometimes as consequence of positive role models in the family (e.g. parents as STEM-teachers or STEM-professionals). A lot of the female students were getting in touch with STEM and "sciences"-oriented toys or special mathematics tasks in early childhood. Thus, it is essential for children to get the opportunity to explore elementary STEM-related activities and toys at home that parents provided their children. This built the basis for an interest for STEM-subjects in school and finally also for a career pathway. Based on these findings it is important that parents support the early development of their children's interest for STEM.

With respect to information about STEM-studies and job, only few parents know about new specializations and careers opportunities or current associations to useful careers. Some of the parents criticized that the schools did not provide enough information for pupils about career opportunities in particular in STEM. However, most of the pupils' parents reported that they discuss the future career pathways or wishes with their children under the scope if the future plans fit to the person or not. The collaboration between schools and parents regarding information regarding new career pathways (in STEM) is necessary but the involvement of parents at public school is of rather low with respect to information about career pathways.

7.2 Consequences for educational institutions (teachers/schools/universities)

Schools as educational institutions could play an important role regarding the career decision and the interest development in STEM of pupils in two respects: First, as educational institution, information about new STEM-studies or opportunities could be offered for pupils. Therefore, it is appropriate for schools to collaborate more with (local) universities to provide more information about current study subjects in STEM and to let pupils get in touch with students of these subjects which aim at sharing their study experiences with pupils. Second, it is a good habit that STEM-teachers have impact on the interest of pupils by making the STEM-lessons of more practical use for pupils and by encouraging them to choose STEM by sharing experiences during their own STEM study. In addition, the some interviewees perceive the low self-confidence of girls in STEM-classes, so that it is subject to teachers to enhance the self-confidence of girls in STEM-classes. To sum up, a stronger involvement of schools and teachers regarding the career choice process

and of the arousing the interest for STEM of pupils is still crucial and should be implement in concrete practices and action plans by educational institutions.

Regarding the situation of female STEM-students at universities, the following consequences could be revealed: Some students perceived a high pressure concerning the drop-out-rate in STEM, they missed social contacts sometimes, and they observed still a lack of acceptance for females in STEM and a lack of female role models/ contact persons e.g. female professors. It is a crucial practice to implement measures against these obstacles in STEM by building networks for women in STEM-related studies and female tutors at university in STEM as contact persons for question concerning the study contents, requirements, and career pathways after university graduation.

7.3 Consequences for society (policy makers/industry/etc.)

In schools there seems to be a lack of information regarding careers and future professional options intended to reduce classic gender associations. Most of the pupils do not have an idea about STEM job profiles or what does a study in STEM mean exactly. Therefore, it is necessary to give more information about current STEM-job profiles to pupils by different companies.

Most of the interviewees, still perceived stereotypes against women in STEM fields (at school, at university, and at work): for women it is difficult to achieve higher positions or jobs, such as managers or directors, or they receive less remuneration. Most of the interviewees are concerned that a STEM professional has to be flexible regarding working hours, he or she has to handle prejudges against women in these fields. In addition, he or she might have problems to combine family and work in STEM which is clearly more an obstacle that refers to women in STEM. For that reason, it is crucial to continue with policies that encourage gender equity at occupational and labour levels.

While some interviewed parents and teachers say that the situation has changed, they recognize that some stereotypes still remain at the career level but the share of women in STEM studies increased a lot in the last years. According to the findings of this study it is essential to reveal the urgent needs for industries, enterprises, and professional associations in order to develop information about possibilities and jobs specializations to young people in order to facilitate more women in STEM.

References

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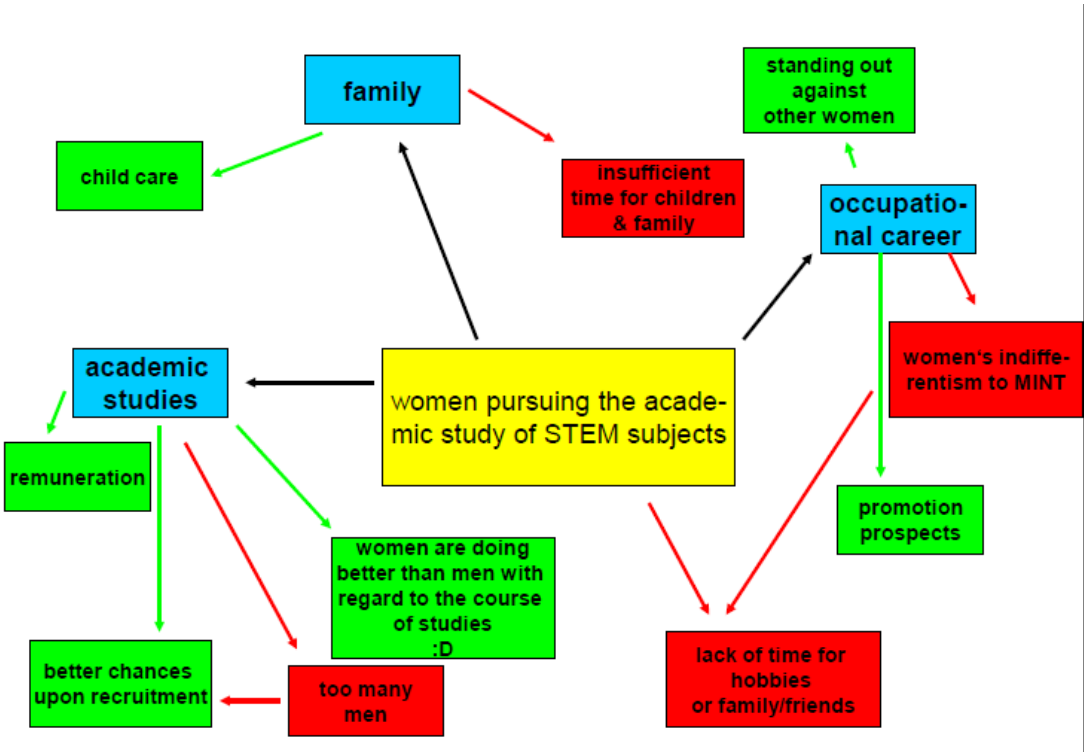
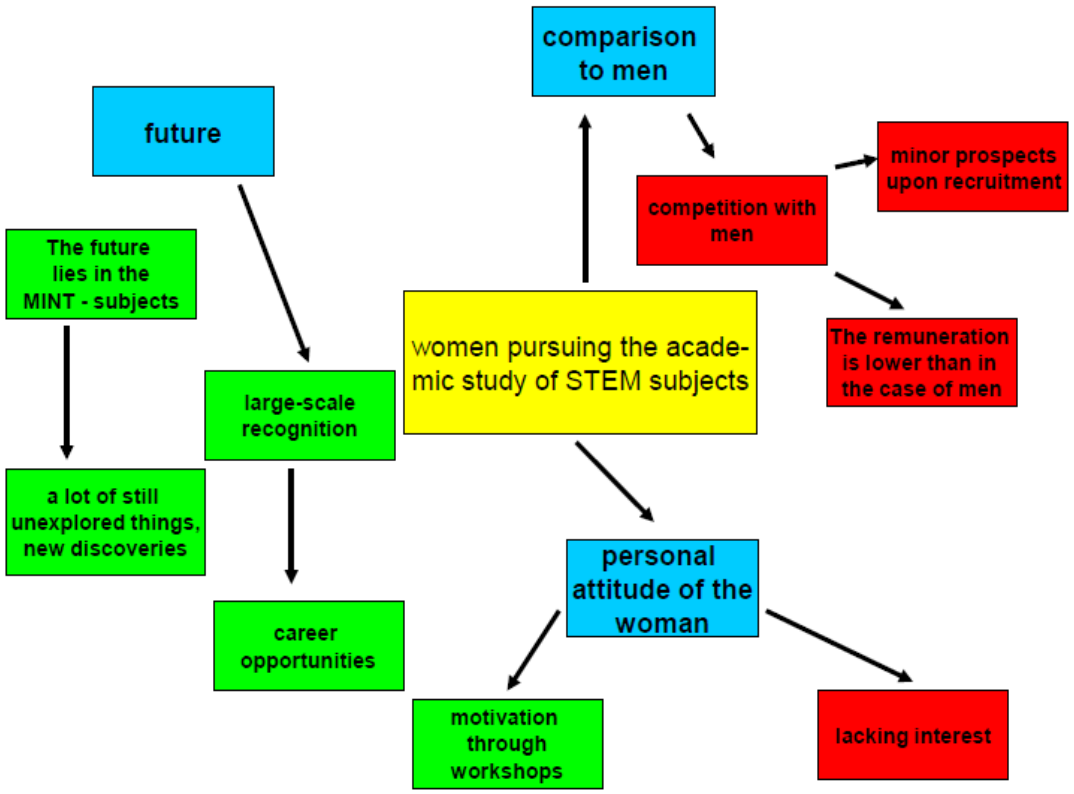
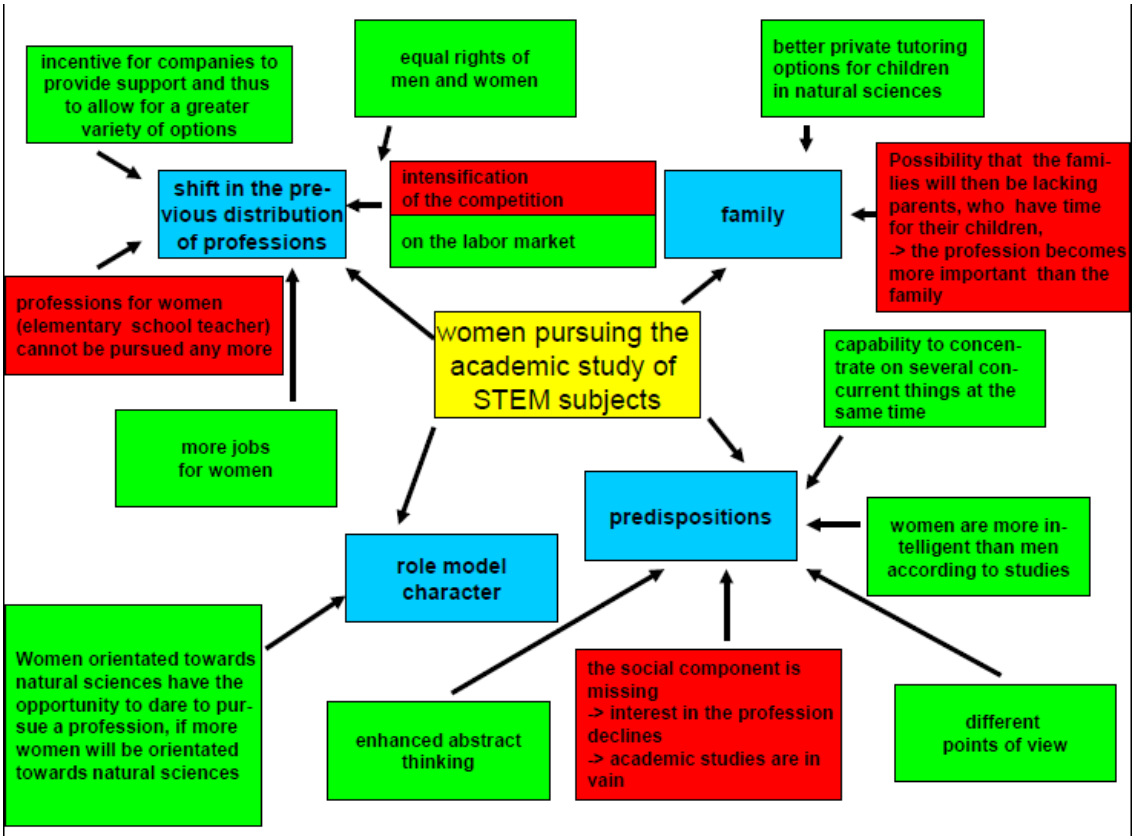
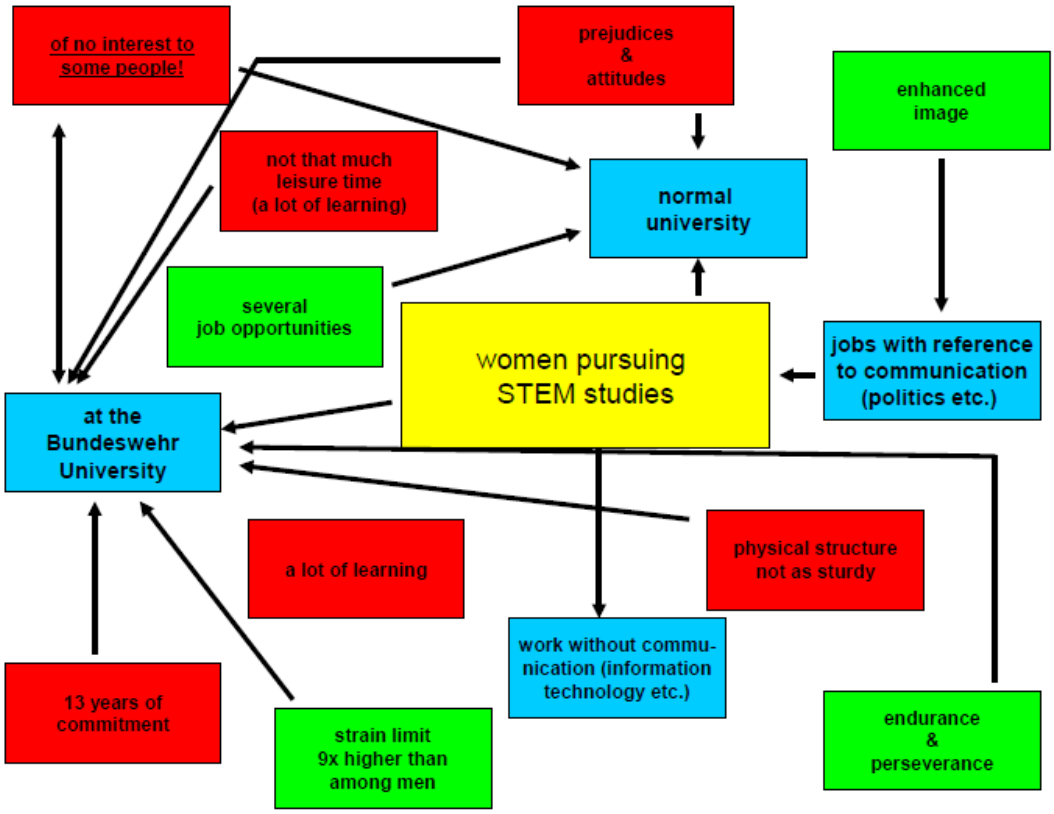
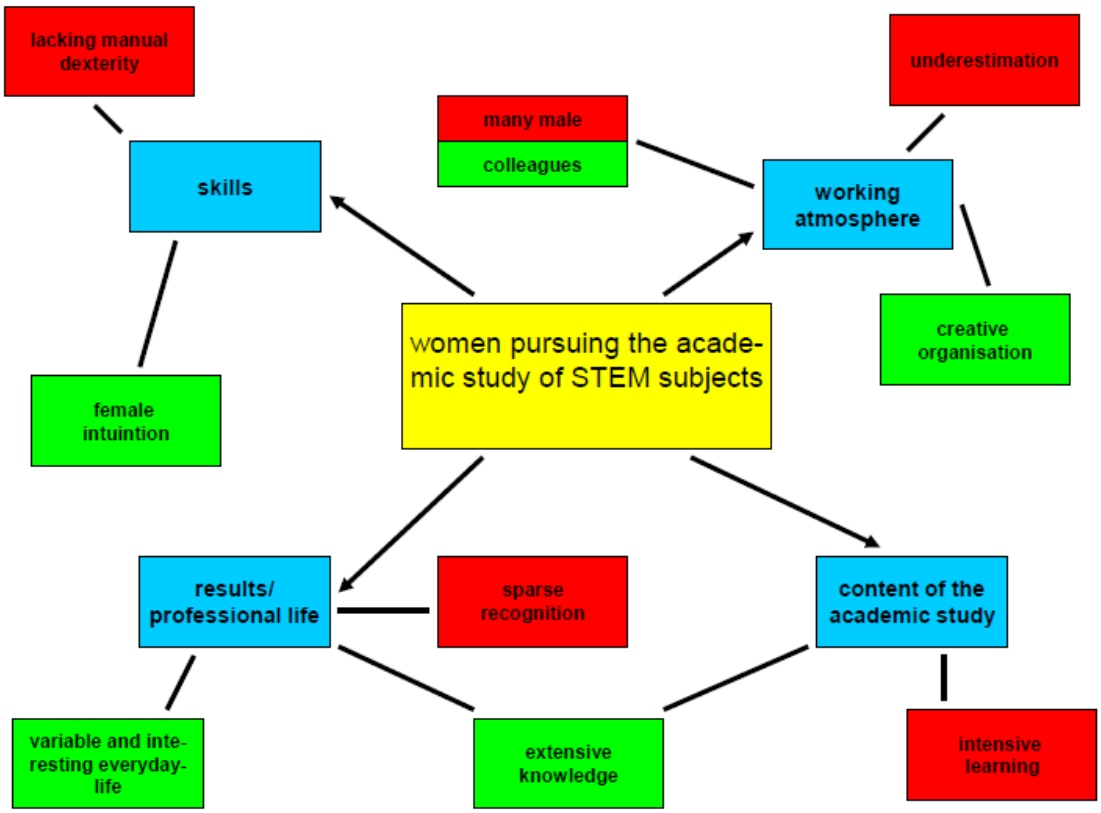
Annex A – Focus groups results (Concept Maps)

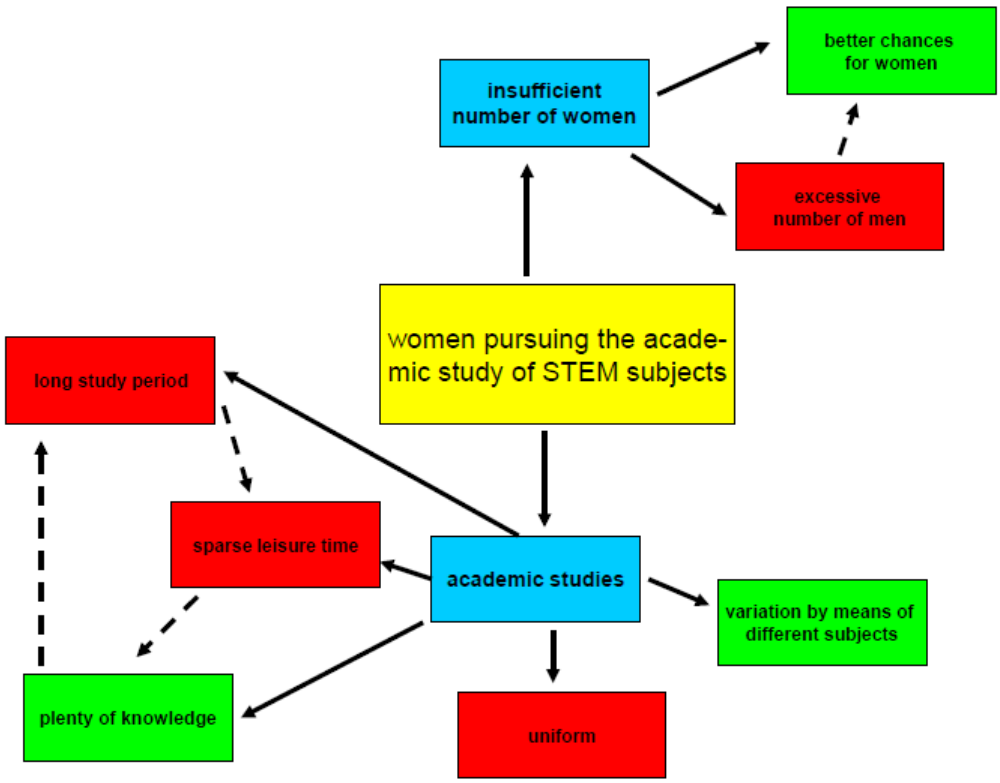


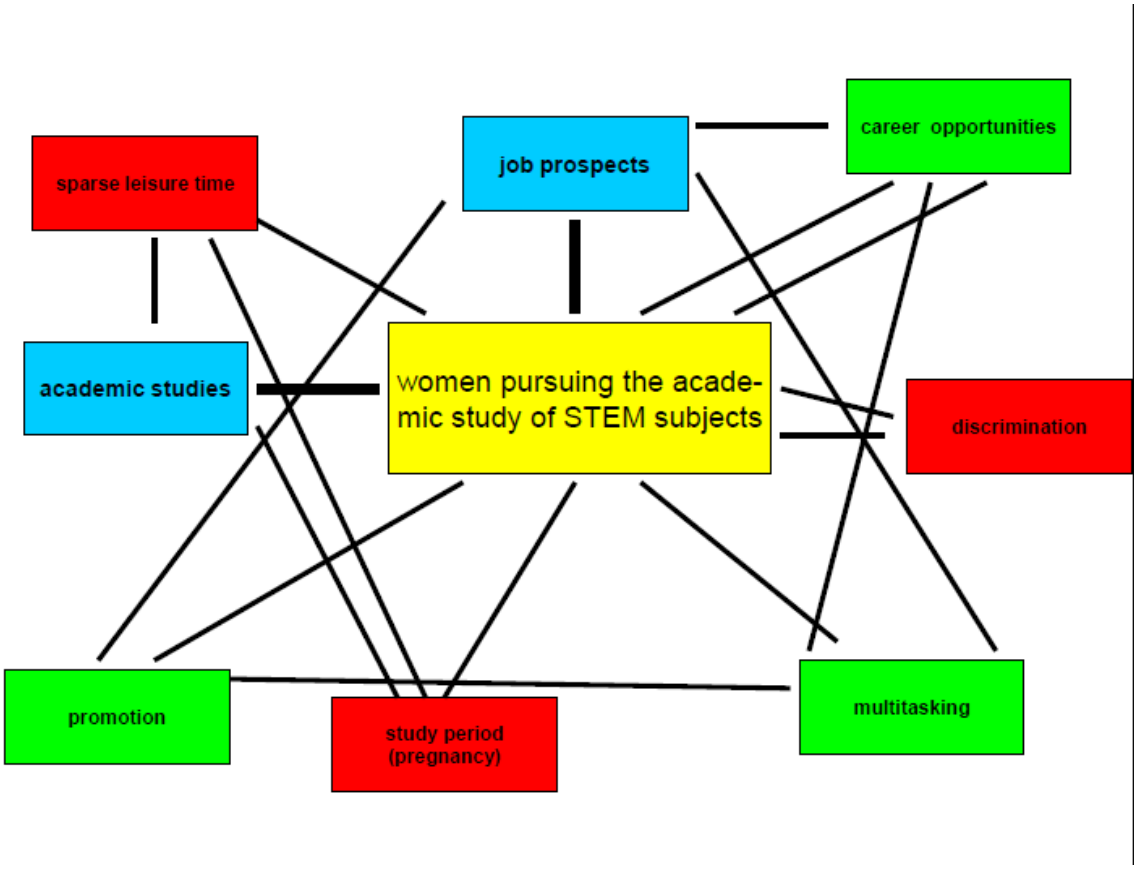


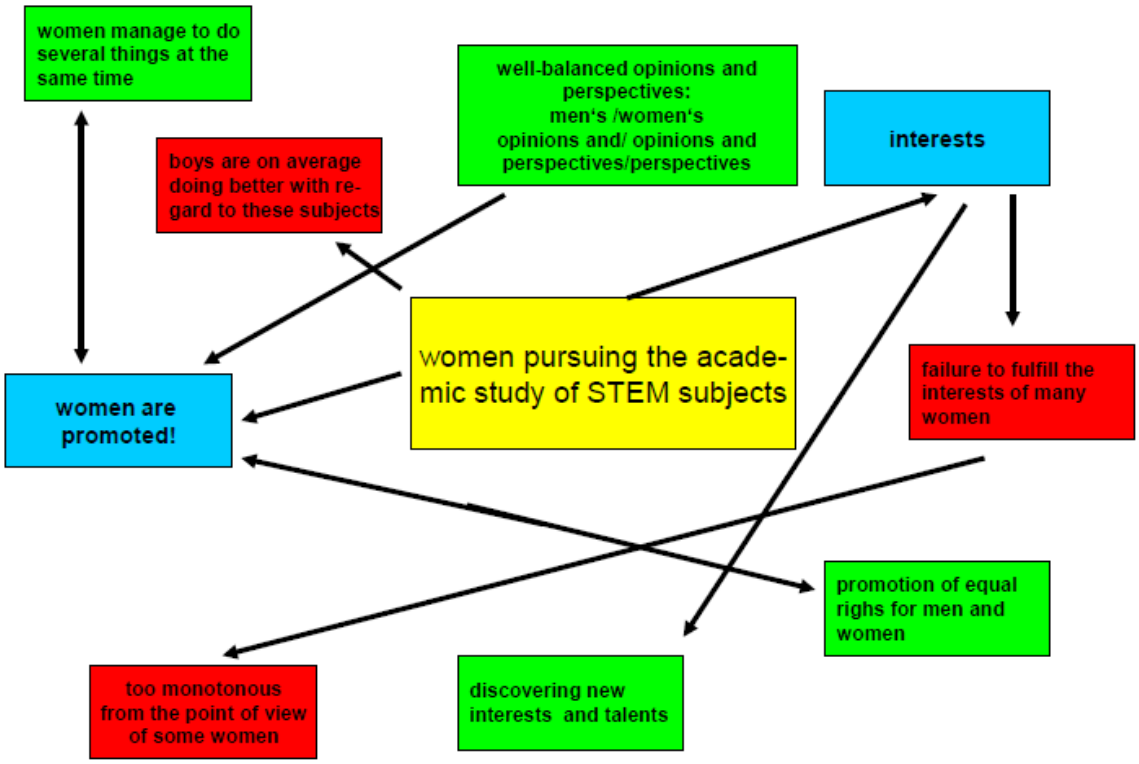

incentive for companies to provide support and thus to allow for a greater variety of options
equal rights of men and women
better private tutoring options for children in natural sciences
shift in the previous distribution of professions
intensification of the competition
on the labor market
family
Possibility that the families will then be lacking parents, who have time for their children, -> the profession becomes more important than the family
professions for women (elementary school teacher) cannot be pursued any more
women pursuing the academic study of STEM subjects
capability to concentrate on several concurrent things at the same time
more jobs for women
predispositions
women are more intelligent than men according to studies
role model character
Women orientated towards natural sciences have the opportunity to dare to pursue a profession, if more women will be orientated towards natural sciences
enhanced abstract thinking
the social component is missing -> interest in the profession declines -> academic studies are in vain
different points of view


of no interest to some people!
prejudices & attitudes
enhanced image
not that much leisure time (a lot of learning)
normal university
several job opportunities
women pursuing STEM studies
jobs with reference to communication (politics etc.)
at the Bundeswehr University
physical structure not as sturdy
a lot of learning
work without communication (information technology etc.)
13 years of commitment
strain limit 9x higher than among men
endurance & perseverance


lacking manual dexterity
underestimation
many male colleagues
skills
working atmosphere
women pursuing the academic study of STEM subjects
creative organisation
female intuintion
results/ professional life
sparse recognition
content of the academic study
variable and interesting everyday-life
extensive knowledge
intensive learning


better chances for women
insufficient number of women
excessive number of men
women pursuing the academic study of STEM subjects
long study period
sparse leisure time
academic studies
variation by means of different subjects
plenty of knowledge
uniform


career opportunities
job prospects
sparse leisure time
academic studies
women pursuing the academic study of STEM subjects
discrimination
promotion
study period (pregnancy)
multitasking


women manage to do several things at the same time
well-balanced opinions and perspectives: men's /women's opinions and/ opinions and perspectives/perspectives
interests
boys are on average doing better with regard to these subjects
women pursuing the academic study of STEM subjects
women are promoted!
failure to fulfill the interests of many women
promotion of equal righs for men and women
too monotonous from the point of view of some women
discovering new interests and talents

Annex B - Data of interviewees

Interviewee	Age	Sex	Target group
I 1	26	female	student
I 2	25	female	student
I 3	51	male	parents
I 4	29	female	teacher
I 5	55	male	parents
I 6	28	female	student
I 7	56	female	teacher
I 8	-	male	parents
I 9	18	male	pupil
I 10	-	female	teacher
I 11	-	female	parents
I 12	-	female	teacher
I 13	58	female	parents
I 14	-	female	student
I 15	-	female	parents
I 16	17	female	pupil
I 17	-	female	parents
I 18	-	male	parents
I 19	-	male	parents
I 20	48	female	parents
I 21	-	female	parents
I 22	-	female	pupil
I 23	16	female	pupil
I 24	-	female	parents
I 25	-	female	parents
I 26	-	female	parents
I 27	17	male	pupil
I 28	-	male	teacher
I 29	25	female	student
I 30	24	female	student
I 31	-	female	teacher
I 32	-	female	teacher
I 33	46	male	teacher
I 34	-	female	parents
I 35	25	female	student

I 36	-	female	parents
I 37	-	female	teacher
I 38	-	female	teacher
I 39	-	male	parents
I 40	-	female	pupil
I 41	-	female	teacher
I 42	-	female	teacher
I 43	-	male	teacher
I 44	-	female	parents
I 45	48	female	parents
I 46	15	female	pupil
I 47	-	male	teacher
I 48	-	female	teacher
I 49	18	male	pupil
I 50	-	male	teacher
I 51	17	male	pupil
I 52	-	male	teacher
I 53	26	female	student
I 54	23	female	student
I 55	-	female	teacher
I 56	-	male	teacher
I 57	25	female	student
I 58	48	male	teacher
I 59	-	male	pupil
I 60	17	male	pupil
I 61	17	female	pupil
I 62	-	female	parents
I 63	-	female	parents
I 64	-	female	parents
I 65	16	female	pupil
I 66	-	female	pupil
I 67	-	female	pupil
I 68	-	female	pupil
I 69	-	female	pupil
I 70	-	male	pupil
I 71	-	male	pupil
I 72	-	male	pupil
I 73	-	male	pupil
I 74	-	male	pupil

I 75	-	male	pupil
I 76	-	female	pupil
I 77	-	female	pupil
I 78	-	female	pupil
I 79	-	female	pupil
I 80	-	female	pupil
I 81	-	male	pupil
I 82	-	female	parents
I 83	21	female	student