Research Project

Obstacles females encounter while pursuing STEM studies

supervisor Ralph Meulenbroeks, Qudsia Basit, 4244494, FI-MSECRP30, student Science Education & Communication aan UU

Identifying why so few pre-university female students who choose science subjects pursue scientific studies

Abstract

Females are underrepresented in STEM majors and careers. The Netherlands lags behind other European countries when it comes to female students opting for the STEM field. Measures have been taken to reduce the gender gap and make STEM less male-dominated. Subsequently, the percentage of female secondary school students choosing science or technology subjects has increased, however the percentage increase of female students opting for STEM remains small. This study investigates the reasons why so few female students with science or technology subjects in secondary school pursue STEM studies. Non-anonymous questionnaires were conducted to examine whether fifth and sixth year pre-university students have considered STEM. Semi-structured interviews were conducted with both male and female students separately. The groups were further divided into students that did consider STEM and students that did not and finally divided into the highest and lowest achieving students.

The analysis of the obtained data showed that there was indeed a large gender gap for all students scoring lower than an average of 8, with less female students choosing STEM. In interviews, the main factors that female students attributed to influence their choices to pursue or not pursue the STEM field were: stereotypes about the study, about the people that belong there and the lack of information on what can be achieved as a STEM professional. Female students scoring relatively low on STEM subjects extended stereotyping to include low interest and low capability. As such, appropriate advice can be construed for secondary schools in the Netherlands to create gender awareness and decrease this gender gap.

Keywords: gender differences, science, motivation, interest, performance, stereotypes, STEM

Section I Introduction

The research in most developed countries around the world show that females are underrepresented in science, technology, engineering, and mathematics (STEM) majors and careers (Brownstein & Saul, 2016). Gender differences in participation can be hypothesized to originate from different causes. Ceci et al. (2009) reviewed which factors contribute to the underrepresentation of females among STEM faculty members. They found that females with a talent for mathematics opted for a field of study that was not mathematical in character, more so often than their male counterparts. Furthermore, they show that such preferences are apparent throughout adolescence (Ceci et al., 2009).

For the situation in European countries Eurostat published the following information on "International Girls in ICT Day" 2017 about the rate of female students in Information and Communication Technologies (ICT) in the EU; in 2015, about 1.4 million people studied ICT and were in the minority; the average rate of female students in ICT was 17 percent of all students; the lowest rate was in the Netherlands, at 6 percent, and the highest rate was in Bulgaria, at 34 percent. Thus, the Netherlands lags behind other countries when it comes to female students opting for STEM studies.

In the present study, we focus on the situation in the Netherlands, which is -as has been demonstrated above- even more skewed than in other countries. The gender gap in education in the Netherlands is bigger than in most other countries. In "Een verkenning van sekseverschillen in het onderwijs: De Staat van het Onderwijs - Onderwijsverslag over schooljaar 2016/2017" it shows that in the Netherlands, stereotypical male and female studies and jobs still exist. For example, 80% of health sector employees are female, whereas in the technical, ICT and logistics sector this number varies between 12% and 14%. Dutch higher education has the lowest percentage (14 - 23%) of female graduates in science studies in the EU (20 - 29%).

There has been a lot of research conducted to identify the reasons behind the gender gap in STEM. In previous studies the possible factors causing the gender gap were: early experience, self efficacy, performance, attitudes towards STEM, stereotypes of the field, negative stereotypes of women's abilities, role models, discrimination, peer support, and variability in the representation of females across STEM fields, which will be discussed later in this research project.

Several measures haven been taken by the Dutch VHTO (Women in Higher Technical Education), an organisation with expertise in gender diversity in STEM. VHTO aims to decrease the gender gap in science and technical subjects in secondary school and in students choosing to study STEM in higher education and therefore increase the enrolment of female students in science. These measures include changing stereotypes, creating gender awareness, addressing the stereotype, informing female students of STEM, showing opportunities and possibilities available as a STEM professional, changing the fixed mindset, and instilling self-confidence within science subjects through trainings, workshops, and hosting events with female STEM professionals.

These efforts have not been without success. In the Netherlands, students in secondary school have to choose between the cultural, economical, scientific or technical subject cluster. The percentage of female students choosing a science subject cluster rose from 30 to 34, and the percentage of female students opting for the technology subject cluster rose from 9 to 26 from

2018 to 2019. In total, the numbers increased by 21 percent (from 39 to 60 percent), which means that now more than half of all the female students chose a science or technology subject cluster (Booij et al., 2015). However, these positive results are not reflected in the total number of female students in STEM tertiary education and STEM-related jobs in the Netherlands. Apparently, the improved participation of female students in STEM-related subjects in secondary education does not carry over to later career and study choices, and the numbers still remain very low (Booij, Jansen & van Schaik, 2015). There is a relative dearth of research addressing this discrepancy (Jansen et al., 2013; Booij, Jansen, Joukes & van Schaik., 2011).

Efforts to make the STEM field less typically male-dominated are expected to be beneficial for the global economy. This is due to the high demand for scientists (AAUW Issues: Science, Technology, Engineering, and Mathematics (STEM) Education, 2021), and especially true concerning the high demand for STEM scientists (Soper, 2014). By examining the reasons why female students remain direly underrepresented in STEM studies we can aim to discover solutions for this predicament and thereby increase the enrolment of female students in STEM studies. In doing so, one may increase the number of STEM scientists by diversifying the field. Diversifying the field will lead to a change in the stereotypical perception of scientists to help solve this problem further. The high demand for scientists may thus be fulfilled and, females as a group can also benefit; career options for female students will be broadened and mixed-gendered teams will be able to create product designs for all genders (Cheryan et al., 2015).

The aim of this research is to decipher why so few female students who choose science or technology subjects in secondary school pursue a scientific study after secondary school. This will help to identify the reasons for the underrepresentation of the enrolment of female students in STEM studies, as the majority of unused potential seems to be amongst female students (Stoet & Geary, 2018). Thus, we want to find out why female students do not continue in the field of science, in order to show the barriers that may be stopping female students. Gender differences, motivation, interest in science, performance in science education, feeling compatible with qualities for science education, and the stereotypical view of scientists and science studies shall be part of this project. This will all contribute to the main goal of this research, which is as follows:

What are the determining factors on the basis of which female pre-university secondary school students with a science or technology subject cluster choose to pursue or not pursue a STEM study?

I. What does the international literature say about the gender gap in STEM studies?
II. What is the difference between male and female students in terms of science or technology subject cluster choice and STEM study preference in the Netherlands?
III. What do students report on their reasons for considering, or not considering, pursuing a STEM study?

Section II Theoretical background

An important body of research is available on the causes behind the low female participation in STEM studies. This research takes into account the male and female genders, but does not accommodate the gender "other". One of the dominant themes in the literature is that the stereotypical role models that are found a lot in the media: movies, cartoons, tv shows, advertisements and on websites. Research shows that the media plays a big factor in propagating the stereotypes of science students. Media mostly depicts them as socially unskilled males, who are singularly obsessed with technology (Cheryan et al., 2015). High school students report that their ideas about scientists are influenced by the media more than by any other source (Tan et al., 2017). In the media, jobs in computer science or engineering are often depicted as geeky or just for males (Pau et al., 2011; Mercier et al., 2006; Rommes et al., 2007). Brief exposures to television (Weisbuch et al., 2009) or reading a stereotypical article can influence the attitude of students and their interest in majoring in computer science.

Several studies show that the classroom environment is also a contributing factor in stereotyping the dominant culture of computer science and engineering students. Objects and environments within the classroom provide cues and information which depict computer science and engineering as more compatible with characteristics associated with males. This results in female students being less likely to choose these majors, because of the feeling that they do not fit in or belong (Cheryan et al., 2009; Barbercheck, 2008). In contradiction, studies show that non-stereotypical classrooms caused the expectations of female students about their performance in science and engineering to increase, and the general classroom atmosphere has an influence on female participants' opinions of the STEM field, as well as on their own levels of confidence Cheryan et al., 2011a).

This variety of factors, such as media, classroom environment, narrow characterisations of people in the field, all play a role for female secondary school students. Therefore, to effectively change the perception and stereotype that people have of science it is crucial to keep in mind that all these factors influence the perception of female students of science, or scientists and could very well be the reason for the gender gap in STEM field majors. Socio-cultural analysis of variability in gender representation takes into account both microlevel and macrolevel cultural factors of STEM, as seen in figure 1 (Cheryan et al., 2017). The factors of figure 1 which will be discussed below are in the following order: role models, stereotypes of the field and the people in the field, negative stereotypes of women, women's abilities and performance, self-efficacy and attitudes.

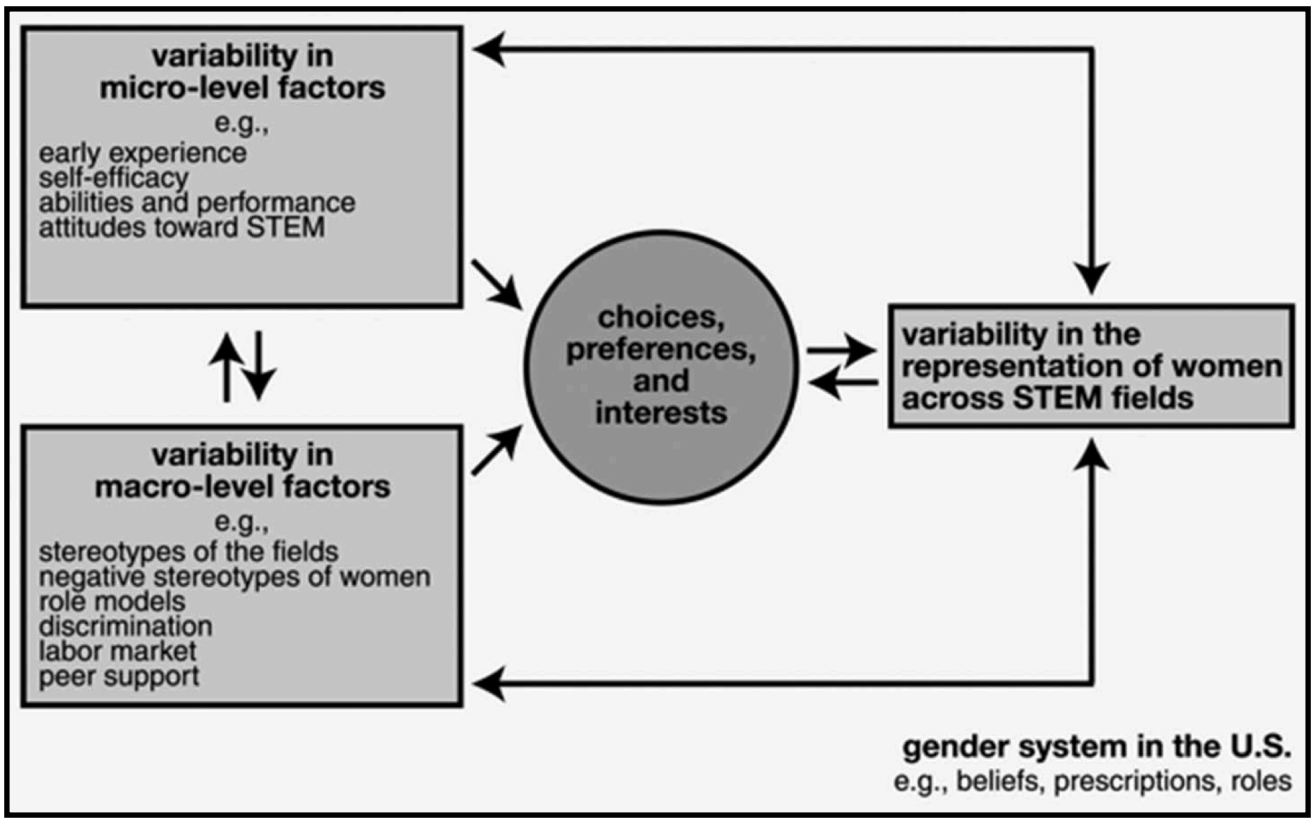

Figure 1. Social-cultural analysis of variability in gender representation in the U.S (cheryan et al., 2017).

Role models

Findings of some important factors of the model in figure 1 will be showed, starting with the effect that role models have on students. A study showed that female role models have an affect on the success beliefs of female students (Master, Cheryan & Meltzoff, 2014). This research suggests that female teachers are particularly helpful for female students when compared with male teachers, when there are negative stereotypes about female students and the STEM field involved.

In another experiment on STEM field stereotypes (Cheryan et al., 2011), U.S. non-computer science majors interacted with one of four confederates (two white females and males) in order to get to know each other. Results showed that females were affected by the stereotype (see table 1) and felt less capable to choose the major. The same experiment was conducted with virtual confederates, but this time for males and females to see if the stereotype would also affect males. The interaction between the participant and confederate in both experiments was less then two minutes.

After interaction with a member of a field, even if for short time, the encounter shaped a student's beliefs about their potential in the field. Females felt less capable to undergo the science study after their interaction with stereotypical science role models. However, the stereotype did not affect the males' belief of how well they would succeed within the major.

Consequently, it can be seen that female role models will not increase the participation of female students if these female role models fit the science-student stereotype. In fact, male role models were effective in inspiring females to enter STEM fields, as long as they did not fit this

stereotype. as This experiment highlighted that stereotypes have a stronger influence on students than the actual gender of the role model (Cheryan et al., 2011).

Name	Jennifer/David (stereotype)	Jennifer/David (non-stereotype)
What year of school are you in?	Junior	Junior
Wat are you majoring?	Computer Science	Computer Science
Where are you from?	Seattle	Seattle
What are your hobbies?	Playing videogames, watching anime and programming	Playing sports, hanging out with friends and listening to music
What is your favourite movie?	Star Wars	American Beauty
What is your favourite tv show?	Mystery Science Theater 3000	The Office
What is you favourite magazine?	Electronic Gaming Monthly	Rolling Stone

Table 1. Question and answers of the experiment (cheryan et al., 2011).

Thus, the current stereotypes of people in STEM are stronger factors in causing the gender gap than a lack of female role models. This is because they are seen as masculine, and therefore incompatible with the stereotypical female gender role. When one person believes themselves to be similar to another, they begin to adopt the same interests and goals as that person, based solely on how the other person acts (Selfhout, Denissen, Branje, & Meeus, 2009). Therefore, to increase effectiveness it is important to choose role models that are similar to students in goals, values, attitudes and hobbies, rather than merely examining the gender of the role model (Drury et al., 2011).

Stereotypes

The risk of confirming negative stereotypes about one's group, is known as stereotype threat. The research (Master et al., 2014) examined how the interaction of stereotype threat cues and teacher gender affected concerns of male and female students about negative stereotypes. The results showed that if their teacher was male, and after having read the stereotype threat paragraph, female students were more concerned about negative stereotypes than male students; female students were less concerned when their teacher was female. Thus, female teachers are valuable in negating negative stereotypes about female students in the STEM field. They serve as role models, as "identity safety" and as a signal to female students that they ought not to be stereotyped based on gender. When negative stereotypes are noticeable, male teachers must be careful to minimise the effects of such stereotypes by encouraging female students to choose these career paths, more so than female teachers (Master et al., 2014). Female role models can be beneficial over male role models when it comes to performance (Marx & Roman, 2002; Marx, Stapel & Mueller 2005; McIntyre, Paulson & Lord, 2003) and more positive attitudes (Lockwood, 2006; Stout et al., 2011). Competent female teachers show that female students can overcome these stereotypes and succeed in STEM (Lockwood, 2006). Female teachers can also signal to female students that their teacher will be less likely to have negative stereotypes about them (Wout et al., 2009).

One study in particular addressed the importance of stereotyping as a part of macrofactors in the model of figure 1 (Cheryan, Master & Meltzoff, 2015). Three experiments were conducted. The first experiment involved two groups of females: one who read articles about how computer scientists fit the current stereotypes, and the other about how they do not. Females who read the non-stereotypical article were significantly more interested in majoring in computer science than females who read the stereotypical article.

In the second experiment, six actors said they were junior computer science majors and three of them fit the stereotype in appearance and preference (see table 1), whilst three of them did not. They interacted with the students and results showed that females who talked to the non-stereotypical students were significantly more interested in majoring in computer science than females who talked to the stereotypical students. Whether or not the actor was male or female did not have an impact on their interest. An important thing to note here is that talking to the stereotypical computer science major did not affect the male students. It did, however, affect females as they felt less similar to the stereotypical student.

The third experiment consisted of one stereotypical classroom and one non-stereotypical classroom. Females in the non-stereotypical room showed significantly greater interest in majoring in computer science than females in the stereotypical room. The environment of the classroom did not affect males' interest in computer science. Females in the stereotypical classroom expected to perform worse than males, but in the non-stereotypical classroom, females' expectation increased and they were expected to do equally as well as males. Females were less likely to associate themselves with the stereotypical objects than males. The more masculine they found the environment, the less interest they expressed (Cheryan, Master & Meltzoff, 2015).

In the model of figure 1, the stereotype of STEM studies causes the underrepresentation of females mediated by their preferences and interests. The opposite is also true and can be seen in the underrepresentation of males in the humanities. To examine how this stereotype affects the underrepresentation of males in humanities, two experiments were held. In society, males can be seen to benefit from a higher status than females, when in the workplace (Fiske et al., 2016). This benefits and protects them when they find themselves in a female-dominated field. In fact, it can give them privileges in those domains. The study showed that females were less interested in computer science and felt less similar to computer science majors than males did. Males were also less interested in English and felt less similar to English majors than females did. Males and females who saw themselves most similar to the majors, were the ones most who expressed most interest in it. Thus, feeling similar to the people in the field has a big effect and we can conclude that it is not merely about the gender of the students in the field, but gender difference is mediated by perceived similarity (Cheryan & Plaut, 2010). However, females feeling dissimilar to STEM fields is more problematic than males feeling dissimilar to female-dominated fields, since male-dominated fields have greater pay and status (Cheryan & Plaut, 2010).

There are three examples to be found of universities that changed the stereotypes on their courses and garnered very positive results. Firstly, the enrolment of females in Harvard's difficult introductory computer science course dramatically increased to its zenith proportion due to the male computer science professor who defied computer science stereotypes (Malan, 2009). Furthermore, two computer science departments, Carnegie Mellon and Harvey

Mudd, both changed cultural stereotypes and reduced the gender gap (Hafner, 2010). They achieved this by using diverse role models, showing students a wide range of computer science applications, and changing their introductory course so that it was not simply for "geeky-know-it-alls". The intervention to change the stereotype increased the participation of female students for majoring in computer science from below 10 percent, to 40 percent in 5 years.

Negative stereotypes of women

When it comes to abilities many people believe that for some specific fields, innate talent of high intelligence is required in order to be successful (Leslie et al., 2015). Moreover, females are often negatively stereotyped on this dimension. This creates obstacles for females who hold such beliefs to enter these fields. A study in US high-profile public and private research universities with 1820 participants showed that the more demanding or selective a field of study, the less females that participate, as males are viewed as more suited to do high level work than females (Leslie et al., 2015). The greater the belief that raw talent or giftedness is needed for a certain field, the less females there are to be found in that field. The cause of this is the notion that females are less suited for a high level of scholarly work (Leslie et al., 2015). The fields that value raw talent over dedication rated themselves as less welcoming to females. Therefore, these beliefs on field-specific ability can create obstacles for females to enter them by making them feel less well-suited than males, and disciplines that hold such a belief include STEM fields (Leslie et al., 2015).

Women's abilities and performance

A large body of research (Wierenga & Crone, 2019) shows that there is no innate gender difference in ability for STEM subjects. There are no noteworthy differences between male and female students in cognitive skills, intelligence, working memory, planning and non-cognitive skills. As gender differences in achievement and skills related to STEM fluctuate in time and between countries, environmental factors appear to have an effect on it (Driessen & Van Langen, 2011b). Furthermore, within-gender variation in achievement in STEM subjects is bigger than the between-gender variation (Wierenga & Crone, 2019). All this evidence points to the idea that female students do have the capabilities to pursue STEM studies, but choose not to. It turns out that differences in the enrolment of STEM studies for female students can be explained by the ideas that people have about gender (Wierenga & Crone, 2019).

Self-efficacy

When the matter of entering the field arises, we can see that females enter STEM at lower rates than males would be expected, due to their abilities in the fields. There are no differences in abilities of males and females when it comes to math performance (Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Schmader, Johns, & Forbes, 2008). However, female students still remain less likely to choose STEM professions than males (Ceci & Williams, 2010). Data shows that having female role models for the recruitment of females into STEM fields, is not as effective as female role models are for retention (Lockwood, 2006). To recruit more female students into STEM fields, it is important to ensure they identify themselves more with the field, have feelings of belonging there and increase their self-efficacy (Drury, Siy & Cheryan, 2011). Females performed better with a female role model as a professor than they did with a male role model; taking a calculus course with a female professor increased the

self-concept and attitude of females towards math. Female role models thus help female students who are underperforming and misidentifying with the field (Stout et al., 2011).

Attitudes

The extent to which a person's own perceived traits and attributes overlap with academic prototypes are related to an improved attitude towards the field (Cheryan, Master & Meltzoff, 2015). A research conducted in a German high school showed more positive attitudes towards a field if students perceived an overlap between themselves and the prototype of a a typical student who excels within that field (Cheryan & Plaut, 2010). Furthermore, interviews with female students on their attitudes toward computer science showed that feeling dissimilar to computer scientists, even on attributes that were completely separate from computer science skills or abilities, were related to lower interest in the field. Such perceptions or stereotypes of the STEM field may be inaccurate, but nevertheless have influence on students and their choices (Cheryan et al., 2010).

Gender gap along the achievement distribution

A recent study showed that the gender gap in STEM studies is different along the achievement distribution (Cimpian, Kim & McDermott, 2020). This is not given in the model of figure 1, but will be taken into account for this research project. The study showed that one way to find out how gender relates to choosing STEM studies is to look at how well male and female students perform at STEM studies. A study with 5960 high school students, college students and majors looked separately at high-achieving, average-achieving and low-achieving students, by following them for seven years. They found out that gender imbalance is different throughout the achievement distribution and, thus requires different interventions (Cimpian, Kim & McDermott, 2020).

Something is welcoming low-achieving males and repelling low-and-average achieving females. When ranking students from lowest to highest achieving, the results showed that the lowest achieving 1 percent of males were majoring in PECS at the same rate as females at the 80th percentile of STEM achievement. Furthermore, the gender gap at the bottom of the achievement distribution is much bigger than the gender gap at the top of the achievement distribution. When it came to persistence in study, males and females persisted at equal rates for high-achievers, but males persisted more for the low-achievers. Looking at students that did not intend to major in a STEM study, we find that more males than females ended up joining the study in all points of the achievement distribution. Furthermore, males scoring below the 1st percentile were at least as likely to join as females scoring above the 99th percentile of the non-intenders.

Previous studies that focussed on the gender gap among STEM students show some obstacles for females to enter these fields. However, this explains the gender gap and the influence the gender gap has among the high-achievers, yet it does not explain or help the gender gap among low achievers. Intervention that may work for high-achieving females is not likely to work for low-achieving females. So it is important to change the way we evaluate gender equality and focus more on the achievement distribution for better and more specific interventions. Otherwise, the current interventions will only affect high achievers and not change much about the gender gap, as the biggest gap is among average-and low achievers. Somehow, male-dominating fields deter females while they are welcoming for lower achieving males. Furthermore, having high-achieving females as roles-model will still send signals to average or

low-achieving females that they do not belong. This results in having less qualified males over more qualified females (Cimpian, Kim & McDermott, 2020).

We can conclude that many factors strongly affect the outcomes of female students in STEM: negative stereotypes about their ability and stereotypes about the field and kind of people who belong in STEM. Gender gaps in attitudes towards STEM, performances in STEM and self-efficacy are different, but related aspects of motivation. Thus, female students do not feel similar to STEM students, nor do they feel as though they fit in or that they can be successful in the field.

Remaining factors mentioned in figure 1 of the model include; early experience and peer support. However, these factors will not be contributing towards the study as the main focus entails the stereotypical views female students have of STEM during their secondary school years.

Therefore, in this research project, the hypothesis is that female students will report feeling less capable, less well-suited and less interested than male students in the STEM field. It will not match their career aspirations. The lower we go on the achievement distribution, the larger this gender gap will be.

Section III Methods

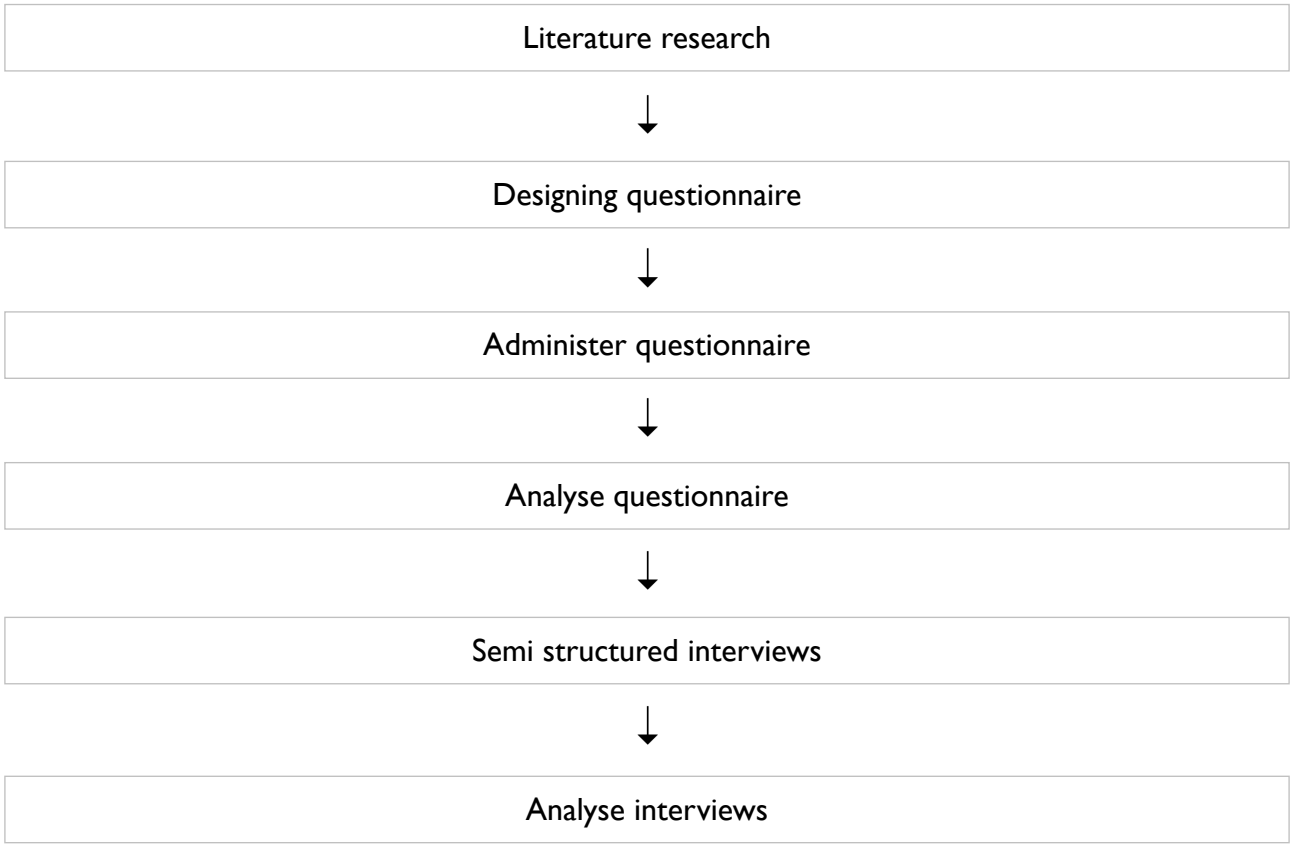

Figure 3. Procedure of the research

The first part of this research project is about what relevant literature states about the percentage of the enrolment of female students into STEM studies and subject clusters, what is already known about the obstacles female students have to overcome choosing a STEM study, or what might be holding them back from even considering it. These results have been summarised in the theoretical background. The second sub-question was addressed by a questionnaire and the third sub-questions by interviews.

The questionnaire is taken from students at the school RSG Slingerbos, in Harderwijk. However, some studies have a selection procedure with a deadline of the 15th January. Students in the sixth year of pre-university education have a few months after the commencement of their sixth and last year of secondary school before they must apply for the further studies they wish to pursue. As such, most students start looking for a potential study in their fifth year of pre-university education. Therefore, the questionnaire and interviews were conducted with students in the fifth and sixth year of pre-university. Since the aim of the research project is to find out why female secondary school students who are interested in science subjects do not pursue a STEM study, the questionnaire was conducted from students that already had a science or technology subject cluster. All students with a science or technology subject cluster filled out the questionnaire. In total, 123 students took part in the questionnaire, of which 76 were female students and 47 male students (figure 4).

The questionnaire was used to determine whether students considered choosing a STEM study by looking to see if it was within their top three list. The questionnaire posed the

following questions: **(1) What are the top three fields of studies that you want to choose? and (2) What is important to you when you think about choosing a certain study.** The fraction of female students with a science or technology subject cluster that considered choosing STEM were compared with the fraction of male students with a science or technology subject cluster that considered choosing STEM. This was to examine if there was a difference. The questionnaire was not anonymous and students were informed of how their data would be used in writing at the beginning of the questionnaire, therefore ensuring informed consent was obtained. Based on the answers of the questionnaire, they were divided into eight different groups for the semi-structured interviews. As seen in figure 4, the students were divided into male and female students, then further divided into students that had considered choosing STEM, and those who had not. The results for the most frequently used reasons not to pursue a STEM study were analysed from both male and female students, to see if there were differences. Recent literature revealed that the gender gap was different along the achievement distribution, and as such, these groups were then divided into low- and high-achieving students. Chemistry and mathematics are the two subjects that are obligated when students choose a science or technology subject cluster. Therefore, the participants in each group were ordered from low to high-achieving, based on their fourth year average maths and chemistry grade. However, due to the lockdown of the COVID-19 pandemic, the focus group sizes were incomplete and the interviews with the male students were shorter than the interviews with the female students.

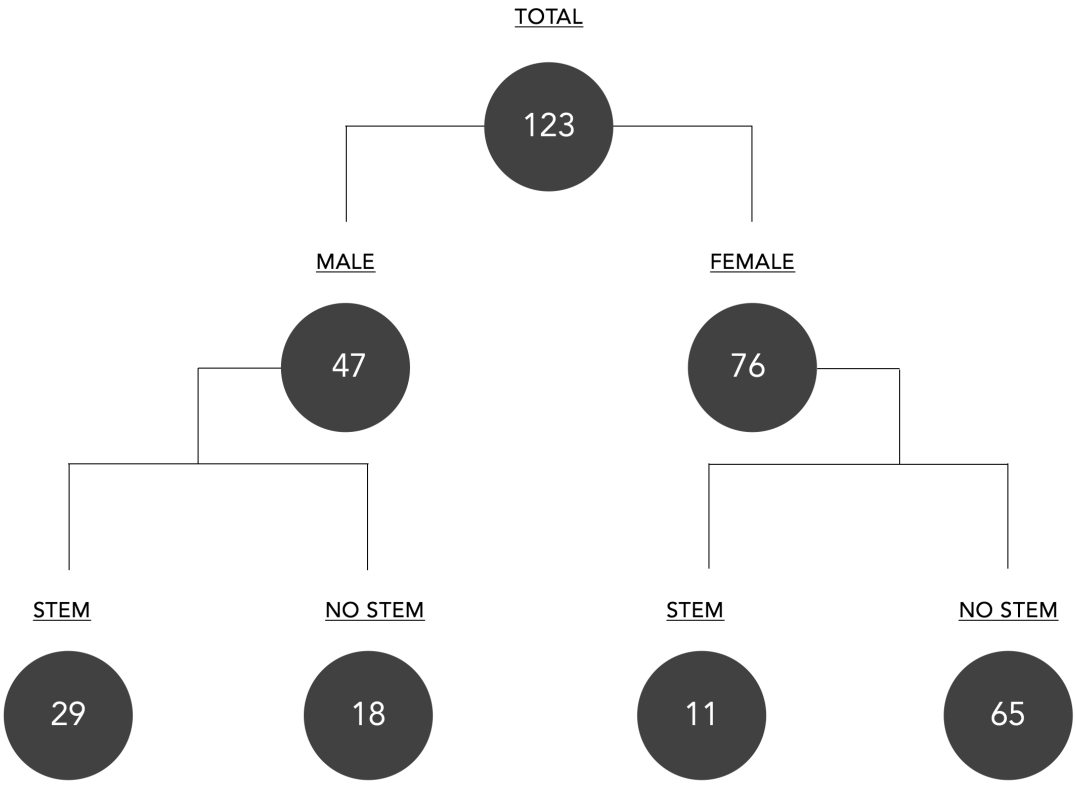

Figure 4. Number of participants of the questionnaire in each group.

In terms of our main research aim, the most interesting group were the female students who had chosen science or technology subject clusters, but had not considered a STEM study. For the sake of completeness, however, semi-structured interviews were held to garner more information about the reasons or obstacles any group in figure 5 faced with regards to STEM studies. The interviews also provided a means for face-to-face discussions which could reveal the reasoning behind thought patterns better than questionnaires did or bring new avenues of thought to light. During the interviews, the focus was on examining the socio-cultural reasons or influences behind their reasons for not considering a STEM study. First, interviews were held with female students that had not considered a STEM study. These interviews focussed on the reasons for considering, or not considering, STEM. The interview protocol can be found in appendix 1. The interviews were recorded and transcribed with the consent of the students that took part. Based on the transcription, open coding was performed on the quotes. The coding scheme will be given in the results section. All codes were subjected to second coding with a resulting Cohen's Kappa of 94%, indicating near-perfect agreement.

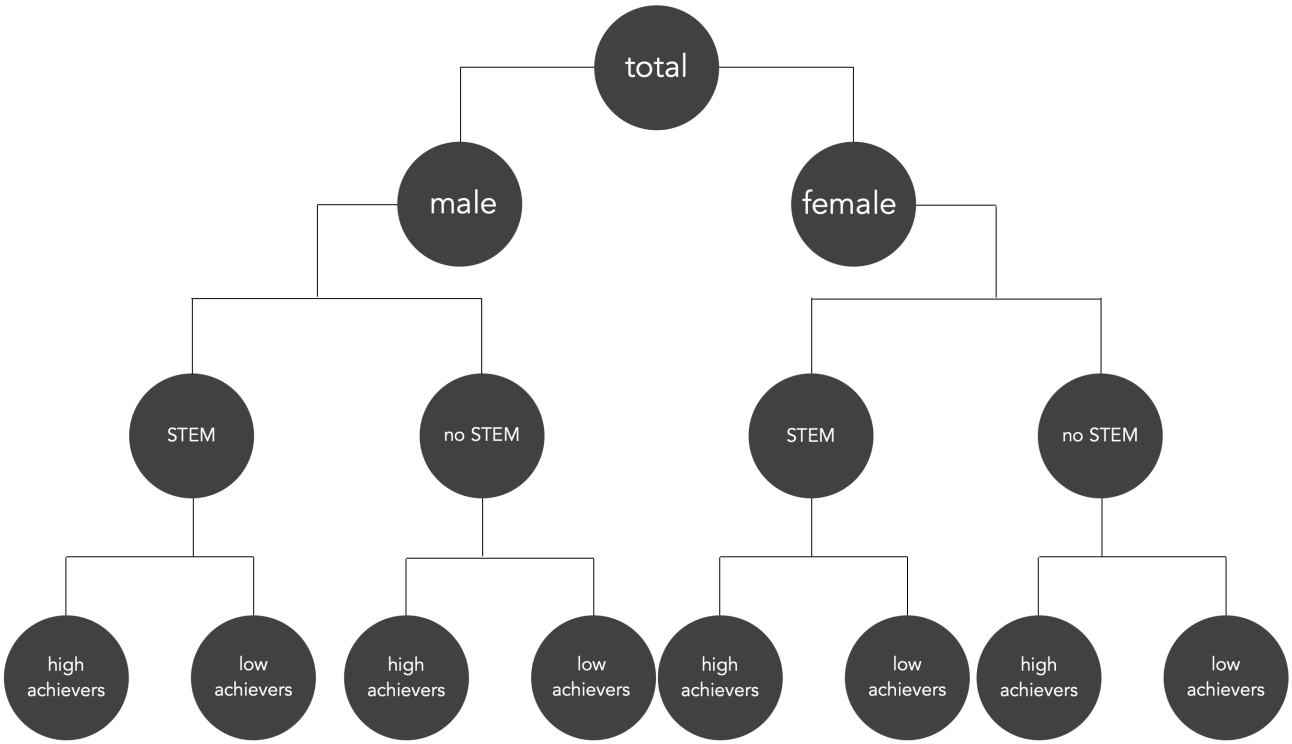

Figure 5. Division of the participants of the questionnaire in each group.

Section IV Results

A. Findings of the questionnaire

In answering subquestion 2, the results of the questionnaire are given in figures 5 to 15.

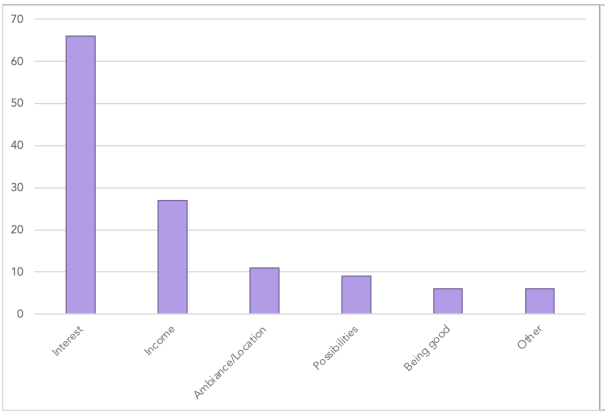

Figure 6. Reasons behind choosing a study to pursue for female students after secondary school.

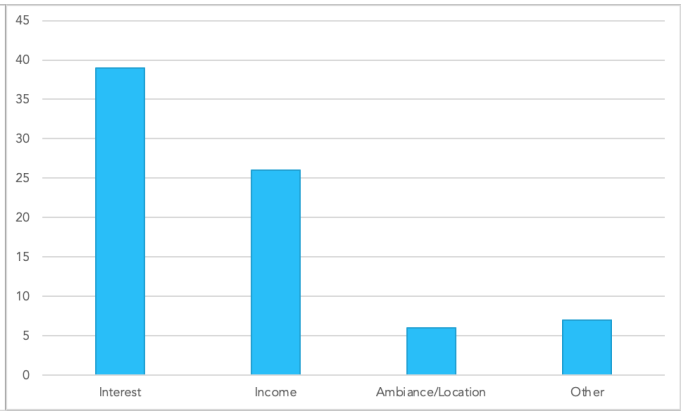

Figure 7. Reasons behind choosing a study to pursue for male students after secondary school.

Reasons for choosing a study

The results from the question asking the main reasons behind choosing a study were mainly similar: male and female students valued interest (intrinsic motivation), income (extrinsic motivation) and the location of the university. However, female students also valued a broad range of possibilities and wanted to be good at what they do.

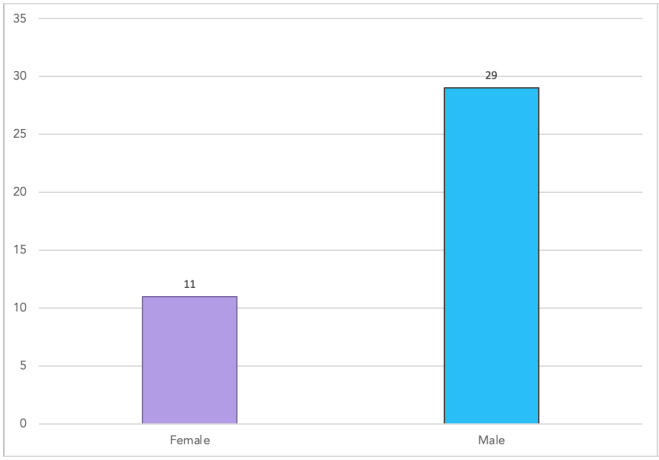

Figure 8. Absolute numbers of female and male students with STEM in their top three fields.

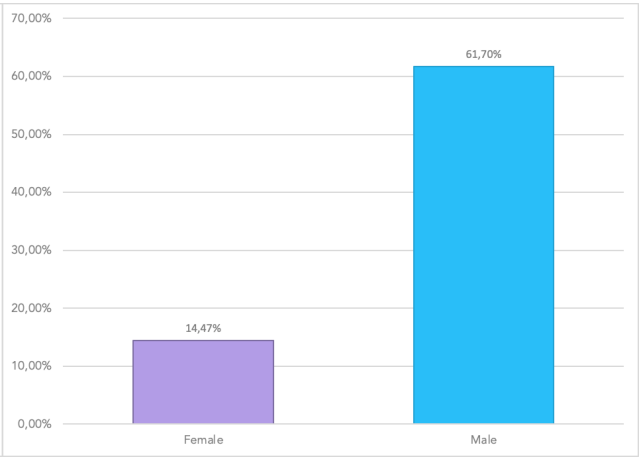

Figure 9. Relative numbers of female and male students with STEM in their top three fields.

Top three studies mentioned

All students that filled out the questionnaire gave the top three fields that they were considering to pursue from a total of ten fields. Focussing on the STEM studies, the results of the questionnaire in figure 8 and 9 show that 11 of the 76 female students have the STEM field in their top three, which is 14.5%. This percentage is much lower than the percentage of male students of 61.7%, where 29 out of 47 male students had STEM in their top three. Even though female students took part in the questionnaire 1.6 times more than male students, the absolute numbers of male students considering the STEM field were larger than the female students' absolute numbers.

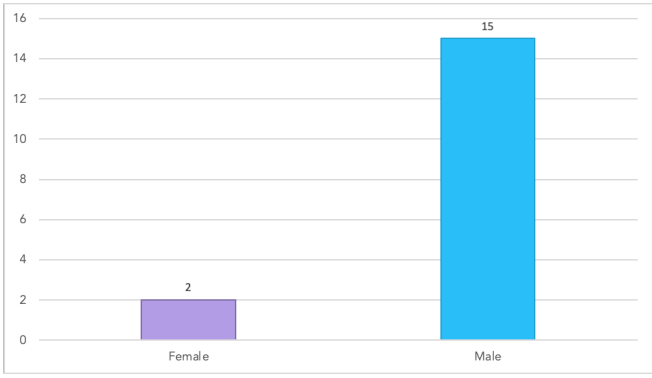

Figure 10. Absolute numbers of female and male students with STEM as their number one choice.

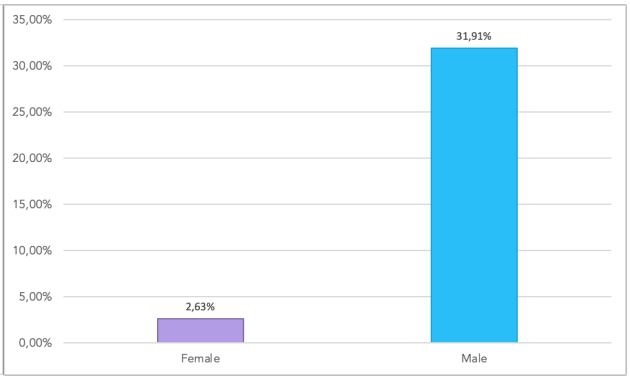

Figure 11. Relative numbers of female and male students with STEM as their number one choice.

Examining closer, the students who do want to pursue a STEM study, we find in figure 10 and 11 that 2 out of 76 female students, and 15 out of 47 male students, put the STEM field as their number one choice. In relative numbers, this is 2.6% of female students and 31.9% of male students who actually think to pursue a STEM study. Again, the absolute number of male students were higher, despite the fact that the total number of female students taking the questionnaire was 1.6 times higher. Thus, all figures 9, 9, 10 and 11 show the low interest of female students for STEM studies.

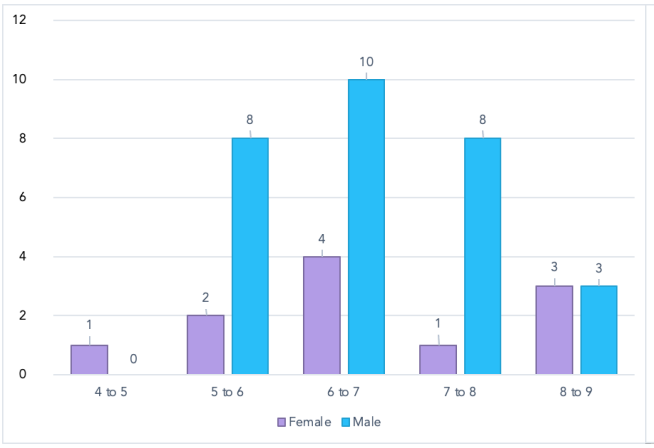

Figure 12. Absolute numbers of female and male students per average grade with STEM in their top three fields.

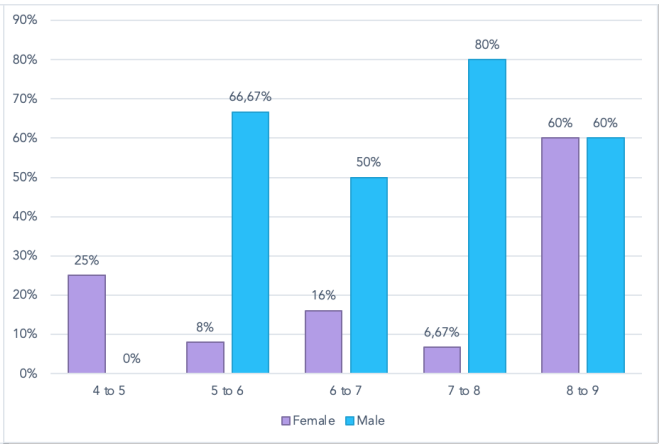

Figure 13. Relative numbers of female and male students per average grade with STEM in their top three fields.

STEM study choice related to performance

Averages were taken from the students' grades in the subjects of mathematics and chemistry. These averages ranged from four to nine. Both genders were divided into five groups, according to their average end score. The groups were made out of students with an average score from 4 to 5, 5 to 6, 6 to 7, 7 to 8 and 8 to 9. For each gender and group on this achievement distribution, the number of students considering STEM were examined.

Results STEM study choice along the achievement distribution

If we compare the number of male and female students choosing STEM across the achievement distribution, we see in figures 12 and 13 that the absolute and relative numbers of the highest achieving students considering the STEM field were equal. The

lowest achieving group with an average score of 4 to 5 contained just four female students. One female student out of the four considered STEM, which caused the relative number to be high, at 25%. However, we can see that for students achieving an average of 5 to 8, the absolute number of male students was higher than the absolute number of female students. The same goes for the relative numbers. We find the biggest gap in students that achieved an average from 7 to 8. Only 6.7% of the female students in this group considered STEM, whereas 80% of male students did. This led to a maximum gap of 73.3% between male and female students. It is noteworthy that both male and female students with an average from 8 to 9 had the same numbers and no gap at all, whilst the gender gap of students scoring lower than 8 was big. Female students with scores lower than 8 did not consider STEM as much as male students scoring lower than 8. Thus, it is clear from the questionnaire results that achievement does have an influence on a girl's motivation to consider the STEM field.

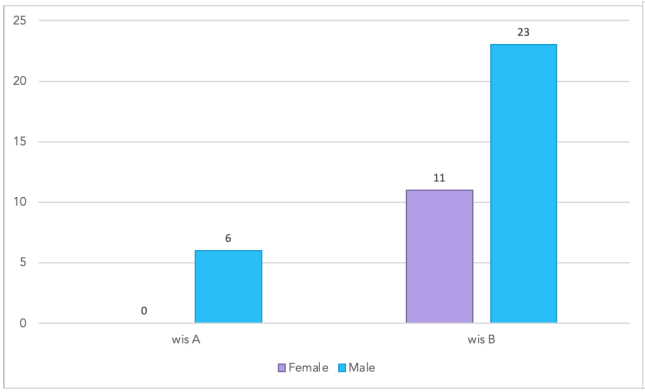

Figure 14. Absolute number of female and male students with STEM in their top three with maths A or B.

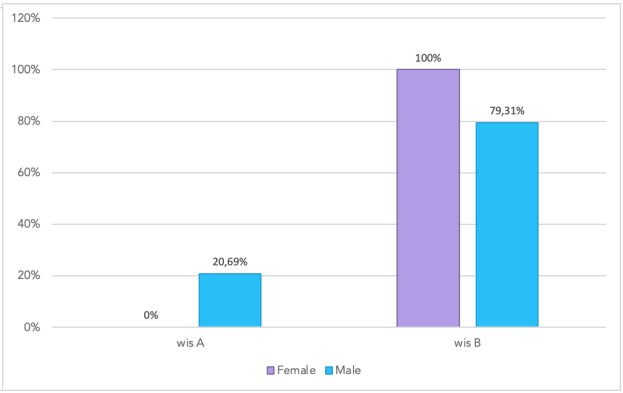

Figure 15. Relative number of female and male students with STEM in their top three with maths A or B.

Math choice for male and female students

Students chose either maths A or B at school. Maths A focuses more on statistics and applied analysis, and maths B has more theoretical problems with graphs and formula's[1]. As can be seen above, the ratio of the male students choosing STEM with a maths A is 1:4, whereas none of the female students with maths A chose a STEM field. From figures 6 and 7, we can conclude that female students want to be good at what they do. This could mean that female students with maths A did not choose STEM because they believed they were not good enough and required some form of approval to pursue it further.

[1] https://www.wismon.nl/news/wat-is-het-verschil-tussen-wiskunde-a-en-b

B. Findings of the interviews

The open coding of the interviews led to the determination of six categories. Each category has been given a name, an explanation with an example quote in table 2.

Category	Name	Explanation	Example Quote
1: WHP	**Working with people or helping people**	Quotes indicating that students find it important to work with people or help people. These quotes often refer to a preference for medical or life science study.	I just think it's more fun to have a job where you can actually mean something for people and that you can help them with something.
2: FO	**Future options with a STEM study**	Quotes relating to the perceived (job) options students have after completing their degree.	You have a vision about the future and it is hard when you do a STEM study to know where you will end up. Of course there are a lot of institutes and companies, but I think you will still end up in research.
3: SS	**Study Stereotypes**	Quotes indicating stereotypes about the STEM study, such as the content or the environment.	With technical studies in Delft: I would just not want to go to Delft, because I would think that I may not fit in.
4: PS	**People Stereotypes**	Quotes indicating stereotypes about people that choose STEM studies or work in the STEM field.	I see someone who is untended (onverzorgd?) and has glasses. There, you have people that really have a passion for IT and working with computers.
5: CAP	**Capability**	Quotes relating to the way students perceive their own capability to succeed in the STEM field.	Not personally, I am not very creative and you do need that to design new things.
6: IN	**Interest**	Quotes relating interest in the STEM field.	I just that I won't have enough interest in it to really pass it I think.

Table 2. Categories of the quotes found in the interviews.

The results of the coding are given in figures 16 to 19.

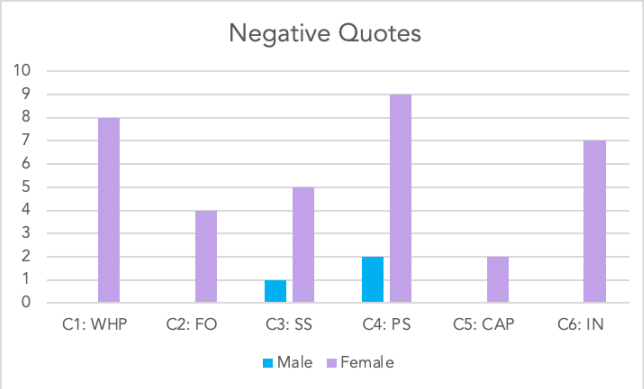

Figure 16. Graph showing the amount of negative quotes about STEM for each category.

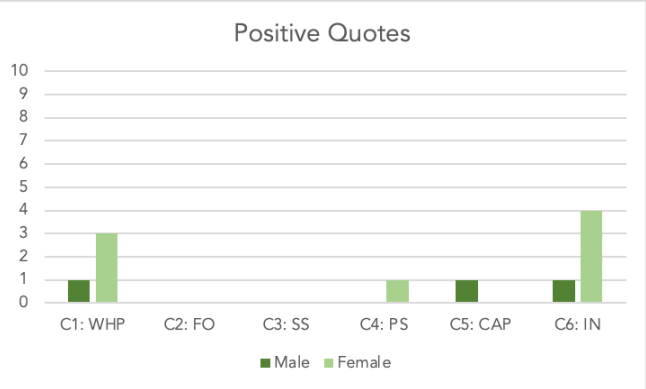

Figure 17. Graph showing the amount of positive quotes about STEM for each category.

It is evident from the figures 16 and 17 that, overall, the female students were responsible for the majority of the quotes. It is noteworthy from figure 16 that the female students had negative quotes on all categories and the male students had no quotes regarding category 1 (working with/helping people), 2 (future options), 5 (capability) and 6 (interest). The male students do mention negative stereotypes about the study and the people in the field, however female students had the most negative quotes about with working with people, the people in the field and interest in the field. The relevant quotes will be mentioned below in the following sections.

Looking at figure 17, we can see that female students do not have any positive quotes about categories 2 (future options), 3 (study stereotypes) and 5 (capability), whilst they mentioned negative quotes on all six categories. Hence, female students had only negative quotes about future options, stereotypes of the field and capability. The female students also had many less positive quotes (8) than negative quotes (33). The categories in where the male students did not have any negative quotes, were also the categories in which the male students did have positive quotes: 1 (working with/helping people), 5 (capability) and 6 (interest), although they had no quote in category 2 (future options). The categories 2 and 3 had no positive quotes at all, for both genders.

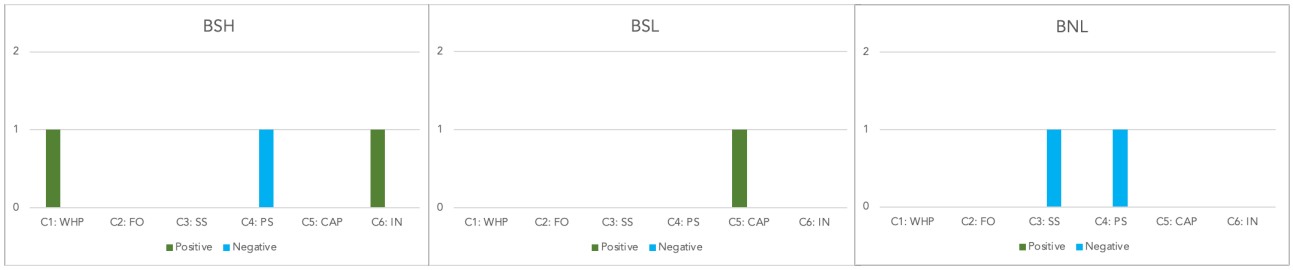

Figure 18. Graphs of the separate groups of male students showing the amount of negative and positive quotes about STEM for each category.

Subcategories of the male students

In figure 18, we see the (very limited) number of quotes uttered by the male students in the three different categories: for the category "male, no STEM, high-achieving" (MNH), no subjects were found. Male students that did consider a STEM study still mentioned negative stereotypes about the people in the field, but did positively associate helping people with the field, and

interest in the field. Male students that did not consider STEM and had low grades in STEM subjects, mentioned negative stereotypes about both the study and people in the field. Neither of the groups of male students have any positive or negative quote about category 5 (capability) and 2 (future options).

Figure 19. Graphs of the separate groups of female students showing the amount of negative and positive quotes about STEM for each category.

Moving to the interview results of the four groups of female students, the bottom graphs show that the female students that did not consider STEM only had negative quotes in almost all the categories. They had a lot of negative quotes, whereas female students that did consider STEM, the top graphs, had both negative and positive quotes and they did not have quotes in all the categories. Some categories are empty and they had less negative quotes overall.

<u>Analysing "female students, no STEM, high-achieving" (FNH) with "female students, no STEM, low-achieving" FNL)</u>

FNH do not have negative quotes in category 5 (capability). Thus, they think they can do it and have a science or technology subject cluster, but still do not choose STEM. This can be caused by the negative image they have of all the other categories, because they do have negative quotes in all the other categories and have the highest amount of negative quotes. The two categories with the most negative quotes for FNH were: category 1 (working with/helping people) such as: "*I just think it's more fun to have a job where you can actually mean something for people and that you can help them with something*", and 3 (study stereotypes). For FNL, these categories were also 1 (working with/helping people), and 6 (interest). Both groups had comments about stereotypes, such as this FNL quote: "*Often, when people are very technical, they always wear the same clothes*", and "*I just immediately think about a man, like with IT I also first think about a man*."

Analysing "female students, no STEM, high-achieving" (FNH) with "female students, STEM, high-achieving" (FSH)

Similar to FNH, FSH also had no comment about category 5 (capability). However, FNH had negative comments about category 2 (future options) and 4 (people stereotypes), such as: "*With technical studies in Delft, I would just not want to go to Delft, because I would think that I may not fit in*", whereas FSH did not. It is also notable that the categories 1 (working with/helping people), 3 (study stereotypes) and 6 (interest) in which FSH had negative comments, also contained positive comments: "*I think of someone in decent clothes, a blouse or a suit. Also a cheerful someone actually. So not the serious side of professional, but a happy person*."

Analysing "female students, no STEM, low-achieving" (FNL) with "female students, STEM, low-achieving" (FSL)

In contrast to FNL, FSL do not have any quotes about categories 2 (future options), 3 (study stereotypes) and 5 (capability). Even though both groups of female students scored low on STEM subjects, FNL had negative quotes about capability and FSL did not. Which is surprising as both performed equally well in STEM subjects. FNL had the most negative quotes in category 1 (working with/helping people) and 6 (interest), such as: "*I have looked at astronomy, because it looked interesting to me, but I couldn't do it and I thought, what can I do with it later anyways*". FSL only have positive quotes in these categories, such as: "*I have looked at IT and thought about industrial design, because I already do subjects like IT and technasium (a Dutch secondary school with a focus on technical studies)*." Whilst having science or technology subjects, FNL had stereotypes about the study and negative quotes regarding future options or possibilities in the STEM field, while FSL did not. The only category where FSL did have negative comments about was category 4 (stereotypes of the people).

Analysing "female students, STEM, low-achieving" (FSL) with "female students, STEM, high-achieving" (FSH)

Like FSL, FSH also had positive quotes in categories 1 (working with/helping people) and 6 (interest), such as: "*Engineering I think, because I do Research and Design and I always liked to design a house*", but they also had negative quotes in these two categories. Both groups did not mention anything about category 2 (future options) and 5 (capability).

FSH shows high interest (6) and negative stereotypes of the field (4), but they are also positive about this. However, they do not have any quote in category 4 (study stereotypes). WhileFSL have the exact opposite: they have negative and positive quotes in stereotypes of the people (4), and do not say anything about the field (3). Both groups mentioned less stereotypes about the field and the people in the field, than the female students that did not consider STEM.

Section VI Conclusion

Revisiting our research questions, we come to the following conclusions:

What does the literature say about the gender gap in STEM studies?

Literature showed that negative stereotypes of female students about their ability, the environment of STEM studies and the kind of people who belong in STEM, affect their performance and interest negatively in STEM. Females do not feel similar to STEM students, nor do they feel like they fit in, or as if they are able to succeed in the field.

What is the difference between male and female students in terms of science or technology subject cluster choice and STEM study preference?

Results of the questionnaire show that for students with a science or technology subject cluster and high average end grades in STEM (8 and higher) there is no gender gap. In this category, male and female students choose STEM equally often. However, for all students scoring lower, there is indeed a big gender gap, with female students choosing STEM much less often.

What do students report on the reasons behind (not) considering to pursue a STEM study?

In the interviews, female students give the main factors influencing their choices to pursue or not pursue the STEM field: stereotypes of the study (e.g. the thought that in the STEM field you do not work with people or you cannot help people), stereotypes of the people that belong there (e.g. the feeling that they do not fit in) and the lack of information on what you can do as a professional in the STEM field (e.g. type of jobs, the opportunities or possibilities in the STEM field or what you can achieve with it). Female students scoring relatively low on STEM subjects, extended stereotyping to also include capability (e.g. the thought that they will not be able to succeed in STEM). This group also mentioned low interest as a factor for not choosing STEM, despite the fact that they have chosen the science or technology subject cluster. The male students only mentioned negative comments about stereotypes of the study and the people in the field.

Section VII Discussion

Limitations

Due to the issue of lockdown, the sample size of the research was limited to students all from one school. Therefore, there may be a bias in the results as this school is a medium-sized school in a rural area and is not an average urban school. There is also a difference in sizes from interviews with male students compared to interviews with female students. There were not enough males as there were females and for one group of males there were no males at all. Furthermore, this research does not include the gender: "other".

Future study

A detailed research of what students report on the reasons for pursuing the STEM field should be analysed including all genders, to find out why so few female students pursue the STEM field in higher education, whilst having a STEM background as well as an increasing number of female students choosing the subject cluster in secondary school. Future researchers should consider adding a bigger size in general and especially in the group of male students to compare the results with - as there may be some male students that experience the same obstacles of stereotypes and not feeling as if they fit in. The study should be more diverse, including more schools from different area's in the Netherlands to interview the fifth and sixth year pre-university students along the achievement distribution.

Implications

On the basis of our results, some advice can be formulated for secondary schools in the Netherlands, schools can create gender awareness and increase their efforts into changing the stereotype that people have of the STEM field. This could be done by organising meetings with non-stereotypical STEM professionals, giving information, organising events and showing the opportunities possible with a STEM study. Gender awareness created by teachers can help them to consciously approach the students in a certain way, and be transparent about stereotypes that may be present, to increase the self-confidence of the students.

Consequently, a broad range of career options shall open up for female students and this will help diversify the field. In turn, this shall help deliver products and designs for a broader population which attracts females, as their needs and preferences will now also be considered. This will increase the general benefits for females in society, and will encourage female students to choose STEM fields, or at the very least perceive as an option without being restricted by what stereotypically suits qualities of female students. Furthermore, this will help with the high demand for STEM scientists, specifically in the Netherlands, and decrease male domination within the STEM field.

Perhaps in this way, female students would not perceive themselves in communion roles, demotivating them to choose technological pathways and causing them to consider only communion career options. To counter this problem, we therefore must start at the core - that is, to examine the perception that is being created from a young age by role models for female students. Changing the role models and giving them more autonomous roles, shall therefore change their perception and females entering the technological field will encourage more female students to consider it as an educational pathway.

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Appendix 1

Interview questions for students that did consider STEM

1. Which study do you like most?
2. Are there fields that you would not consider at all?
3. In the questionnaire you mentioned having considered a STEM study. Which study is it and why did you consider it?
4. Describe a typical STEM scientist.
5. Describe a typical STEM study.
6. Do you see yourself following a STEM study?
7. Do you think you will be able to succeed in a STEM study.

Interview questions for students that did not consider STEM

1. Which study do you like most?
2. Are there fields that you would not consider at all?
3. Have you ever considered a STEM study? (Why)?
4. Describe a typical STEM scientist.
5. Describe a typical STEM study.
6. Do you see yourself following a STEM study?
7. Do you think you will be able to succeed in a STEM study.