A picture containing text

Description automatically generated

Diversity Matters

*The diversity of STEM-representatives in mathematics textbooks and other factors that influence Dutch girls’ choices for their future.*

Valerie Derks

v.m.derks@students.uu.nl

5544718

11/11/22

Research Project (30EC) for Utrecht University

Daily supervisor: Liesbeth de Bakker

First supervisor: Michiel Doorman

Second supervisor: Ralph Meulenbroeks

Intended journal: Educational Studies in Mathematics

# Abstract

In the Netherlands, the first choice girls make towards, or away from, the STEM-field is the choice between humanities focused mathematics and natural sciences focused mathematics in lower secondary education. Girls mostly decide towards humanities focused mathematics, while natural sciences focused mathematics is mandatory for most STEM-studies. As this choice is likely influenced by the lack of diversity in their mathematics textbooks and their sense of belonging towards the STEM-field, these aspects are studied. This research aims to find out which factors influence girls’ mathematics choice and their sense of belonging towards the STEM-field. This is done by analysing the diversity in mathematics textbooks and by interviewing girls about their mathematics choice and their sense of belong towards the STEM-field.

The textbook analysis shows a clear lack of diversity in the textbooks. White men are overrepresented, except in the ‘supportive’ questions. The ‘supportive’ questions are the only part of the books in which women are more present than men. When looking at individuals who represent the STEM-field, white men are overrepresented even more strongly. The interview results indicate the teachers have a big influence on the girls’ mathematics choice and the girls have very stereotypical views of the STEM-field.

The lack of diversity in the textbooks and the girls’ stereotypical views have a big impact on their sense of belonging. In turn, their sense of belonging and their teachers have an influence on their mathematics choice. This choice can already steer girls away from the STEM-field at 15 years old.

Key words: ‘diversity’, ‘STEM-field’, ‘sense of belonging’, ‘mathematics’, ‘textbook analysis’, ‘secondary school students’.

# Introduction

Over the last fifty years, there has been immense growth in equality between genders[[1]](#footnote-1), especially in education. According to the World Economic Forum (2021) 95% of the gender gap in educational attainment has been closed globally. If the world keeps going at the same pace, this gender gap will be completely closed in 14.2 years. The Netherlands is a country in which the closing gender gap in education is definitely visible. In general, women are graded better than men at every academic level (Brakel et al., 2020b; van Groenigen & Hartgers, 2019). Additionally, there have been more women than men studying at college level in the Netherlands since 1997, at university level this has been the case since 2006 (Centraal Bureau voor de Statistiek, 2019). However, these enrolment numbers are not reflected in Science, Technology, Engineering & Mathematics (STEM) studies (Brakel et al., 2020a).

The amount of women studying in STEM at college or university level has been going up, but the percentage of women in STEM-studies equalled only 19.9% at college level and 37.7% at university level in 2019/2020 (Brakel et al., 2020a). This gender disparity in tertiary STEM education is reflected in the rest of Western Europe as well, despite the closing gender gap in education overall (World Economic Forum, 2021). One factor differentiates the Netherlands from other European countries, namely the educational profile students have to choose around the age of fifteen. The educational profile choice is the first educational decision in which the gender gap in the STEM-field becomes visible.

A report on high school graduates (van Groenigen & Hartgers, 2019) shows the gender gap in the educational profile choice is closing, but it is definitely still visible. When choosing a STEM-profile, girls often choose biology and humanities focused mathematics, not physics and natural sciences focused mathematics. As natural sciences focused mathematics is mandatory for most tertiary STEM-studies, the profile choice is the first step towards, or away from, a study and/or a career in the STEM-field. At every step towards a study and/or a career in the STEM-field, more women choose to go in a different direction (Blickenstaff, 2005). This phenomenon is known as the ‘leaky pipeline’ for women towards a career in STEM.

Acccording to Cheryan et al. (2015) the leaky pipeline towards a career in the STEM-field is a problem because of several reasons. First, the jobs available in the STEM-field are generally high-paying and high-status jobs (Kalwarski et al., 2007). Thus, more women in these positions would reduce the economical gender gap. Second, people in the STEM-field help design tools that shape modern society. If the people working in the STEM-field would be more diverse, the designs would be created for a more diverse audience as well (Margolis & Fisher, 2003). Third, the STEM-field is missing out on many women who could have been assets to the STEM-field. For example, the field of computer science is growing every day and needs more computer scientists to keep up with the demand (Soper, 2014). More women in the field of computer science could help meet that demand.

One of the most mentioned causes for this leaky pipeline is that women often experience a low sense of belonging in the STEM-field and feel like the STEM-field just isn’t for them (Kalender et al., 2019). This sense of belonging in the STEM-field can be negatively influenced by stereotypical imagery of the STEM-field (Cheryan & Plaut, 2010; Drury et al., 2011). The Netherlands scores the highest out of 66 countries in stereotypical imagery of the STEM-field (Miller et al., 2015). As the imagery of the STEM-field is often stereotypical, thus white men, it can be difficult for girls to find a relatable role model within the STEM-field. The importance of finding a relatable role model as motivation for a study or a career in the STEM- field has been shown again and again (Blickenstaff, 2005; Cheryan et al., 2013; Cheryan & Plaut, 2010; Kalender et al., 2019). Role models can be found in several forms and places, but a source that is most flexible for improvements are the STEM-representatives found in secondary-education textbooks (Bax, 2021). The potential lack of diversity of STEM-representatives in these textbooks might influence girls’ sense of belonging towards the STEM-field. Therefore, it is important to study the diversity of STEM-representatives in secondary education mathematics textbooks and if this, and perhaps other factors, influences girls’ sense of belonging.

The educational profile choice is the first point of ‘leakage’ towards a career in the STEM-field in the Netherlands. When a student chooses for natural sciences focused mathematics in the educational profile choice, all potential education paths remain open. When a student chooses humanities focused mathematics, most studies in STEM are no longer accessible (Wettenbank, 2019). Because girls choose for humanities focused mathematics most often, this is the first ‘leakage’ that is visible in the path towards the STEM-field. It is important to research the reason for this leakage. The research about the gender gap in the STEM-field in lower secondary education is already not extensive, but the research specifically about the gender gap in the educational profile choice in the Dutch system is almost non-existent. Therefore, it is important to study the factors that influence the choice made by girls between humanities focused mathematics and natural sciences focused mathematics in lower secondary education. This study’s main aim is to find out which factors influence girls’ sense of belonging towards the STEM-field and their decision for a specific type of mathematics.

# Theoretical framework

In this section the theoretical framework on which this research is based is elaborated upon. First, an explanation of the educational system of the Netherlands is given. This explanation focuses mainly on mathematics, since the choice between humanities focused mathematics and natural sciences focused mathematics is the main focus of this study. Second, the term ‘sense of belonging’ is elaborated upon, with a focus on the research on a sense of belonging by Rainey et al. (2018). In this section, information on STEM-representatives is also given. Third, the modified tool for the textbook analysis created by Bax (2021) is explained. At the end of this section, the research questions for this study are specified.

## The educational system of the Netherlands

Here the Dutch educational system is explained based on a summary by Onderwijsloket (2021). When students start lower secondary education, they are divided based on their level. The levels are called VMBO, HAVO, and VWO and take four, five, or six years respectively. This research focuses on the levels HAVO and VWO. While the gender gap is even more present in VMBO than in HAVO and VWO, the gap widens immensely in STEM-studies at college or (applied) university and the careers that follow these studies. Since HAVO prepares students mainly for college or applied university and VWO prepares students mainly for university, the focus is placed on these two levels.

### Educational profile choice

The third year of HAVO and VWO is the year in which a choice for an educational profile has to be made. The students have to choose between four educational profiles, or combinations of those profiles. The profiles are called Nature and Health, Nature and Technology, Economics and Society, and Culture and Society. The first two are known as the N-profiles in which the ‘N’ stands for ‘Nature’, these N-profiles comprise the STEM subjects. Economics and Society and Culture and Society represent the other side of the spectrum.

There are four types of mathematics called mathematics A, B, C, and D. Mathematics A and mathematics B are the main choices, with mathematics C as a more basic option and mathematics D as an extra advanced course. It is important to note mathematics C and D are not available at every high school in the Netherlands, therefore this study focuses on mathematics A and B. Mathematics A is more humanities focused, while mathematics B is focused more on the natural sciences. A detailed difference between the mathematics A and B is explained in Table 1. It is important to note that in the Netherlands, mathematics A is generally seen as the easier type of mathematics. In all profiles but Nature and Technology, the students are free to decide between mathematics A and B. In the profile Nature and Technology mathematics B is mandatory.

Table 1: The topics and descriptions of mathematics A and mathematics B.

|  |  |  |
| --- | --- | --- |
| Type | Topics | Description |
| Mathematics A | Algebra, connections, change, and statistics. | The calculus remains more basic, deeper dive into statistics and probability. More humanities focused. |
| Mathematics B | Formulas, functions and graphs, differentiation and integration, goniometry, and geometry. | Focuses more on calculus and goniometry, no deeper dive into statistics and probability. More focused on natural sciences. |

### Impact on further studies

The choice between mathematics A and B can have an impact on whether a student is accepted to certain studies at college or university. When a student decides to take mathematics B, all further study paths remain open. However, when a student decides to take mathematics A, this is not the case. Most of the STEM subjects at college and (applied) university require for a student to have a background in mathematics B and do not accept mathematics A students (Wettenbank, 2019).

And even though a rise in the number of girls choosing the N-profiles is present, the girls mostly choose a Nature and Health profile with mathematics A (Brakel et al., 2020a; van Groenigen & Hartgers, 2019; VHTO, 2021). Since mathematics B is mandatory for most future STEM-studies, this means that at the age of 15, these girls are already on a path that veers them away from most STEM-studies.

## Sense of belonging

When mentioning a sense of belonging, it means how comfortable a person feels in a certain environment. A high sense of belonging means a person feels like they fit in. While currently not much research is available on sense of belonging amongst secondary education students, there is research available about college and university students in the STEM-field. In this research, it is often seen that women and people of colour report a lower sense of belonging in the STEM field (Rainey et al., 2018; Cheryan et al., 2009; van der Molen, 2020; van Veelen et al., 2021).

An interview analysis about the sense of belonging performed by Rainey et al. (2018) on American college seniors who are majoring in a STEM subject gives an indication of women’s and people of colour’s sense of belonging. For the male STEM majors around 80% reported a sense of belonging in the STEM-field, while around 62% of the female STEM majors reported a sense of belonging*.* When taking race into account, there is also a significant difference visible. The lowest sense of belonging is reported by women of colour, only 48% of the women of colour who are following a STEM major reported a sense of belonging. In comparison, of the white men who follow a STEM major around 86% reported a sense of belonging.

A sense of belonging is of high importance, since a student is less likely to pursue a career in a certain field if a student does not feel like they belong there (Cheryan et al., 2015). Therefore, this research finds its roots in three articles about sense of belonging in the STEM-field and/or the factors that influence it. Firstly, the qualitative interview questions used by Rainey et al. (2018) about sense of belonging form a base for the questions used in this research. Secondly, Bax (2021) has shown that the gender diversity of individuals in a textbook can influence the sense of belonging a student feels. The textbook analysis Bax (2021) describes is used in this research to analyse the mathematics textbooks the girls use. Thirdly, Cheryan et al. (2009) show gender stereotypes and a lack of female representatives of the STEM-field are part of the reason why women and girls report a lower sense of belonging in the STEM-field compared to boys and men. Since the effects of gender stereotypes have already been studied (van der Molen, 2020), this research will focus on the diversity of representatives of the STEM-field. If there is a lack of relatable representatives of the STEM-field for women and people of colour, there are very few potential role models. Many researchers agree a lack of relatable role models definitely plays a considerable part in turning young women away from the STEM field (Blickenstaff, 2005; Cheryan & Plaut, 2010; Drury et al., 2011; Kalender et al., 2019; van der Molen, 2020; van Langen & Meelissen, 2019).

### STEM-representatives

All the representatives of the STEM-field are potential role models for people interested in the STEM-field. A role model is defined as “a person who someone admires and whose behaviour they try to copy”(Cambridge, 2013). Role models can be found in numerous different places, from someone’s personal life to every type of media. The STEM-representatives in secondary-education textbooks are a source for role models which is relatively flexible for improvements (Bax, 2021). A lot of the individuals in textbooks are fictional, because of this the gender and ethnicity of these characters can be changed relatively easy. Therefore, this research partly focuses on the potential lack of diversity in STEM-representatives in Dutch mathematics textbooks used in lower secondary education.

## Analysing diversity in textbooks

Bax (2021) created a tool for textbook analysis. This tool is created specifically to gain insight into the presence of a gender bias in role model availability in secondary education textbooks for physics and computer science. Bax (2021) created a Microsoft Excel Table which is based on previous textbook analyses and research on role models. For more details and theoretical background on the decisions made about the analysing system, the Master’s thesis by Bax (2021) is recommended.

The table is modified to fit the aims of this research, which includes focusing on diversity of the people representing the STEM-field, not only gender bias in role model availability. Because of this, a fifth column called ‘Ethnicity’ was added. Based on the research by Rainey et al. (2018) it was decided to look at more than just gender, as ethnicity of the mentioned individuals is just as relevant.

As the original table by Bax (2021) was developed for computer science and physics textbooks, it is redesigned to fit mathematics textbooks. For this reason, the final two columns called ‘Difficulty level’ and ‘Type of mathematics’ are added to the table. The ‘Difficulty level’ column was made to note anything special about a certain question or section, for example if they were marked ‘supportive’ or ‘challenging’. The ‘Type of mathematics’ column was created for entering mathematics A or B if the question or section was marked this way.

The final change to the analysis tool is removing the ‘Firstness’ column. After looking into the mathematics textbooks used in this research, the situation in which an individual would be first or second in a sentence or paragraph barely seemed to occur. It was discussed with the creator of the analysis tool and Bax agreed analysing the firstness did not provide much results, therefore it was removed for this research.

In Table 2 the analysing tool is shown, including the changes made to it. In green the original table created by Bax (2021) is seen, including the removed column ‘Firstness’, which is indicated by being crossed out. In red the addition ‘Ethnicity’ based on Rainey et al. (2018) is visible. In blue the additions made for the mathematics textbooks ‘Difficulty level’ and ‘Type of mathematics’ are seen.

Table 2: The textbook analysis tool by Bax (2021) is seen in green, the additions made for this research are seen in red and blue.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Individual | Gender | ~~Firstness~~ | Ethnicity | Occupation | Education level | Relevance | Existence | Time | Type of mathematics | Difficulty level |
| Unique | Female/ Male/ Unknown | ~~1~~~~st~~ ~~in sentence/2~~~~nd~~ ~~in sentence/etc~~ | White/ Non-white | Any mentioned occupation | MBO/ HBO/WO | Relevant/ Irrelevant | Fictional/ Non-fictional | Historical/ Contemporary | Math A/ Math B | Supportive/ Challenging/  Etc |

## Research questions

This study’s main aim is to find out which factors influence girls’ choice for a specific type of mathematics and their sense of belonging towards the STEM-field. This aim is portrayed in one main research question and three sub questions, these questions are listed below.

What are the factors that influence fifteen year old Dutch girls’ choice between humanities focused mathematics and natural sciences focused mathematics and the girls’ sense of belonging towards the STEM-field?

1. How diverse are the people representing the STEM-field in Dutch mathematics textbooks used in lower secondary education?
2. Which factors influence fifteen year old Dutch girls’ choice between humanities focused mathematics and natural sciences focused mathematics for higher secondary education?
3. Which factors influence fifteen year old Dutch girls’ sense of belonging towards the STEM-field?

# Methods

The main focus of this study is to find out which factors influence fifteen year old Dutch girls’ choice between different types of mathematics and their sense of belonging towards the STEM-field. When mentioning fifteen year old Dutch girls, this means Dutch girls in the third year of HAVO or VWO who face the educational profile choice. For the focus on the girls’ sense of belonging, their mathematics textbooks are analyzed on the diversity of the people representing the STEM-field and the girls are interviewed about their views of the STEM-field. For the focus on the factors that influence the girls’ choice between the types of mathematics, the girls are interviewed about the choice they are facing. The methods are elaborated in detail below, starting with the textbook analysis.

## Textbook analysis

To answer the first sub question stated below, the mathematics textbooks used in lower secondary education are analysed.

1. How diverse are the people representing the STEM-field in Dutch mathematics textbooks used in lower secondary education?

A quantitative analysis is executed on the books called ‘Moderne Wiskunde’ and ‘Getal & Ruimte’, two of the most used mathematics textbooks for secondary education in the Netherlands.

### Sample: the books

The following eight books are analysed:

* Getal & Ruimte 12e editie 3 HAVO leerboek 1
* Getal & Ruimte 12e editie 3 HAVO leerboek 2
* Getal & Ruimte 12e editie 3 VWO leerboek 1
* Getal & Ruimte 12e editie 3 VWO leerboek 2
* Moderne Wiskunde 12e editie 3 HAVO leerboek A
* Moderne Wiskunde 12e editie 3 HAVO leerboek B
* Moderne Wiskunde 12e editie 3 VWO leerboek A
* Moderne Wiskunde 12e editie 3 VWO leerboek B

The different methods Moderne Wiskunde and Getal & Ruimte are referred to as MW and GR respectively from now on. The books listed above are the textbooks used in the third year of HAVO and VWO. At the end of this year, the definite educational profile choice is made by the students. During the third year, the teachers and the mathematics textbooks start to prepare the students for this upcoming decision. Part of this preparation includes labelling certain chapters or questions in the textbooks as mathematics A or mathematics B. The textbooks also contain questions and sections which are named ‘supportive’, ‘challenging’, ‘inquiring’, ‘in-depth’, and ‘kangaroo’. The supportive questions are for the students who are struggling with the subject, these are generally easier. The challenging, inquiring, in-depth, and kangaroo questions are for the students who want to dive deeper into the subject, these questions are more difficult.

### Data collection: textbook analysis tool

To collect the data on diversity of the STEM-representatives, this study uses the modified textbook analysis tool based on the tool created by Bax (2021) and the research by Rainey et al. (2018). The eight textbooks are checked for individuals in the text or in the images. When an individual is mentioned, every column of the table is filled in for this individual based on the provided information. Every column and the use of this column is elaborated upon below in Table 3.

Table 3: The textbook analysis tool explained.

|  |  |  |
| --- | --- | --- |
| Name of the column | Marking options | Explanation of the marking |
| Individual | *Unique for every individual*  *Example: Petra* | For every individual the given name is filled in, if the individual has no name ‘Unidentified’ is filled in. |
| Gender | *Female / Male /*  *Unknown / etc* | For the column ‘Gender’ Male or Female is filled in if this information is given in the text/image or if there is a consensus on the gender of the name in the top three online results of the name. If this information is not given in the textbook or if there is no online consensus, ‘Unknown’ is filled in. In case of an individual who identifies as neither male nor female, their given gender is noted. |
| Ethnicity | *White / Non-white* | The ‘Ethnicity’ column is only filled in when the individual mentioned was visible in an image and the distinction between white and non-white is clear. |
| Occupation | *Any mentioned occupation* | Whenever the occupation of the individual is mentioned or clearly visible in an image, this occupation is noted here. |
| Education level | *MBO / HBO / WO* | The Nationale Beroepengids (NBG, 2020) is used to determine the minimal education level for the given occupation, this information is entered under ‘Education level’. |
| Relevance | *Relevant / irrelevant* | For this category it is necessary to determine whether the given occupation is relevant to the STEM-field. Every occupation for which the necessary previous studies fall under the STEM umbrella is seen as relevant to the STEM-field. When in doubt, the Nationale Beroepengids (NBG, 2020) is used to check the necessary previous studies. |
| Existence | *Fictional / Non-fictional* | The existence of the individual is checked and marked fictional or non-fictional. Whenever there is an accompanying image it is also checked if this image is an illustration or a photograph. If it is a photograph of the mentioned individual it is marked non-fictional as well, since the individual is a real-life person. |
| Time | *Historical / Contemporary* | The time in which the non-fictional individual was/is alive is marked in the column labelled ‘Time’. If the individual is alive, they are marked contemporary, if they are deceased, they are marked historical. If the individual is fictional or it is unknown when they were/are alive, this marking space remains empty. |
| Type of mathematics | *A / B* | Certain chapters or questions are labelled as mathematics A or mathematics B in the brochures or in the books, when this happens, it is noted in this column. |
| Difficulty level | *Supportive / Challenging /*  *Inquiring / In-depth /*  *Kangaroo* | In the textbooks certain questions or sections can be labelled as supportive, challenging, inquiring, in-depth, or kangaroo. When this happens, it is noted in this column. |

A second coder has used the textbook analysis tool to analyse a total of four subchapters of the used textbooks to account for inter-coder reliability. The few differences between the analyses are found in whether an individual is seen as an individual or not, therefore this is explained more elaborately underneath.

An individual is only noted as an individual if the textbook provides information on at least two out of the first four categories. For example, if only a name is mentioned but no gender, ethnicity, or occupation is available, this is not seen as an individual as there is too little information provided for this research. If a builder is mentioned and the text references to the builder as ‘he’, this is seen as an individual as the categories ‘Occupation’ and ‘Gender’ are now filled in.

### Data analysis

The found data was analysed using RStudio 2022.02.1 (build 461). Any found differences are determined as significant when the relevant tests turn out a p-value of smaller than 0.05. Before running each statistical test, any assumptions for the test at hand were checked.

For all the binary results in this research, the Binomial test is used to check the statistical significance of these results. Most results in this research are binary, for example male/female or white/non-white. Thus, whenever the number of women is compared to the number of men in a specific category, the Binomial test is used. The same approach is used for comparing the number of white individuals to the number of non-white individuals in a specific category, as these results are also binary.

For the non-binary results of this research, another suitable test is found. This is the case when the gender balance in the individuals mentioned in mathematics A chapters is compared to the gender balance in the individuals mentioned in mathematics B chapters. For this situation, a Chi-squared test is used.

## Interviews

Interviews are conducted with girls facing the educational profile choice to answer the two last sub questions stated below.

1. Which factors influence fifteen year old Dutch girls’ choice between humanities focused mathematics and natural sciences focused mathematics for higher secondary education?
2. Which factors influence fifteen year old Dutch girls’ sense of belonging towards the STEM-field?”

### Sample: the participants

Interviews with eight students in the third year of HAVO or VWO are conducted in cooperation with the Jacob Roeland Lyceum (JRL). At the JRL, the students decide on an educational track at the end of their first year. The tracks are: Sport, English plus, Culture, and Technasium. For the interviews two students from every track are asked to participate, one at HAVO level and one at VWO level. Because of the different tracks, the participants are expected to be diverse in their interests and mathematical abilities. Only female students are interviewed to create a clear image of which factors girls consider to be an influence on their choice between the different types of mathematics.

### Data collection: the interviews

The interviews have been conducted in May in 2022, towards the end of the schoolyear 2021-2022. For practical reasons, half of the interviews were done online via Microsoft Teams and half were carried out in real-life, so face-to-face. The intention was to interview all the students one-on-one, this was possible for five out of eight students. The last three students were interviewed as a small group.

It was important for the students to feel as safe and comfortable as possible. To accomplish this, all the interviews started off with an open chat in which the interviewer introduced herself. They also told the students they were allowed to say anything they wanted, this included school gossip and curse words, and the information would remain anonymous. For the online students, it is assumed they are likely to be accustomed to video calling because of Covid-19 and therefore it is expected that they were acting as natural as possible. The other interviews took place at the JRL, a comfortable and familiar environment for the students.

The interview audio was recorded with the student’s permission and stored safely on a separate hard-drive. The interviews lasted a maximum of 30 minutes, or 45 minutes for the interview with the group of three. This maximum length was decided upon to keep the participants as focused as possible. The interviews were semi-structured, with prepared questions but also a fair amount of time to explore the student’s answers. In the situation of a semi-structured interview, it is important for the interviewer to be able to let the students elaborate their answers and even encourage them to do so by asking follow up questions or by staying quiet in specific moments. This was practiced by the researcher by testing the interview multiple times with different people before the real interviews took place.

### The questions

The interview questions are divided into an introduction and four sections. These are elaborated shortly at the end of this section. The full interview script can be found in Appendix A. All the questions are based on questionnaire questions developed by Rainey et al (2018) and Bax (2021). Since this interview is not a questionnaire, the questions are adapted to an interview scenario.

Rainey et al. (2018) based their questions on the research done by Roots of STEM (2013), whose work is supported by the National Science Foundation. Rainey et al. (2018) mainly provide questions on sense of belonging of American university students in the STEM-field. Since the questions by Rainey et al. (2018) are aimed at tertiary education students and the American educational system, the questions used in this research are adapted to this study’s Dutch secondary education student respondents. Some examples of adapted questions are shown in Table 4.

Table 4: How questions written by Rainey et al. (2018) are changed for this research.

|  |  |  |
| --- | --- | --- |
| Question by Rainey et al. (2018) | The changes made | Question used in this research |
| “We are interested in hearing the story of how you came to major in \_\_\_\_\_\_\_\_. Thinking back over the course of your life, what contributed to your becoming a \_\_\_\_\_\_\_\_major?” | The language is simplified for fifteen-year-old girls and where Rainey et al. mentions a major, here the educational profile choice is mentioned. | Which educational profile are you chosing for next year and why? (…) Which experiences/circumstances do you think influences this choice? |
| How do you think your math/science teachers in HS viewed your ability to do science? Did they think you are more or less able that you thought you were? | The language is simplified for fifteen year old girls and instead of ‘teachers in HS’ their current teacher is mentioned. | Do you feel like your teacher thinks you are good at your STEM subjects? And why? |

Bax (2021) wrote a questionnaire including questions about the educational profile choice and the role models of the interviewees. The questions written by Bax (2021) are aimed at students who are following an extra course about computer science and physics, so the questions are adapted to students with no extra interest in STEM and to the choice between different types of mathematics. Bax (2021) also used statements in their questionnaire, these needed to be changed to interview questions. Some examples are shown in Table 5.

Table 5: How questions written by Bax (2021) are changed for this research

|  |  |  |
| --- | --- | --- |
| Question by Bax (2021) | The changes made | Question used in this research |
| “I know which career paths are available for a computer scientist.” | The statement is changed to an interview question and applied to mathematics instead of computer science. | What career paths do you think are available for mathematics A and mathematics B? |
| Which famous female scientists (physics and computer science) do you know (even if it is just by name)? They can be dead or alive. *It is okay if you do not know any!* | It is first asked if they know any scientists, since the girls interviewed in this research project have no extra interest in STEM it seemed reasonable to lower the bar. After the first question, it was asked if they knew any female scientist. Also no specific subject was mentioned while Bax (2021) mentioned physics and computer science. | Can you name a scientist? And a female scientist? |

The interviews start with a short, off-the-record introduction to make the participants a bit more loose and comfortable. In this introduction there is some chatting about their interests and an explanation of the project. It is also made explicitly clear they can say whatever they want and it will stay anonymous.

After the introduction, the recording starts. The first set of questions is created by combining and expanding questions by both Rainey et al (2018) and Bax (2021). This first set of questions is about their educational profile choice, specifically their mathematics choice, and who potentially influenced their decision. After broadly asking them which people are important in their decision-making process, more specific questions were asked about their teachers, family, and friends. This includes asking about the conversations they had about the educational profile choice with their teachers, family, and friends. This also includes the influence of teachers, family, and friends on the girls’ motivation for the STEM-subjects.

The second set of questions is based only on questions by Bax (2021) and is adapted to focus on mathematics. In this set of questions the girls are asked if they can explain what the differences are between mathematics A and B and how they think the choice between mathematics A or B can influence their future. These questions aim to find out on which information their decision is based and from which source they received this information.

The third set of questions is a combination of Bax (2021) and questions created specifically for this research project. The main question is “Can you describe your image of a scientist?” to see which stereotypes the girls might have about the STEM-field. Further questions explore their image of a scientist and whether the girls think this image is realistic and whether this image can potentially influence someone’s sense of belonging. After this, they are asked more general questions about gender and its influence on the path towards a career in STEM.

The fourth and final set of questions is based on Bax (2021) and includes asking the girls about which scientists they know and how they feel about their textbooks.

### Data analysis

The goal of this data analysis is to get a clear view of which factors influence girls’ educational profile choice and their sense of belonging in the STEM-field. The interview answers given by the students are analysed thoroughly by organizing the data. To organize the data, the interviews are coded in NVivo. A codebook is created by a mixed coding strategy of the top-down and the bottom-up approach. For the top-down approach the interview script is analysed on which themes are expected. The results of the research done by Rainey et al. (2018) and Bax (2021) is used to determine which topics are expected to come up about the students sense of belonging and their educational profile choice. These themes and topics are added to the codebook before the interviews are conducted. When the interviews are conducted, it is likely more topics and themes become clear. That is when the bottom-up approach starts. This means more codes are added based on the answers provided by the students. When the data is coded, these codes are used to find the provided answers per theme or topic.

# Results

## Textbook analysis

The quantitative section of this research contains the textbook analysis of the mathematics textbooks used in the third year of HAVO and VWO. All the individuals mentioned in the text or seen in the images are analysed using the following nine categories:

* Gender
* Ethnicity
* Occupation
* Education level
* Relevance
* Existence
* Time
* Type of mathematics
* Difficulty level

Since this research focuses on the diversity of the textbooks, the categories Gender and Ethnicity are analysed in combination with the other categories. Firstly, the individuals mentioned in the text are analysed. As the ethnicity of an individual is only visible if this individual is seen in an image, this category is not analysed for the individuals used in the text. Therefore, the gender of individuals in the text is analysed thoroughly in combination with all categories but ethnicity. Secondly, the imagery of the textbook is analysed. In this analysis the categories Gender and Ethnicity are the main focus. As the other categories are mostly applicable to text, they are not relevant for the results of the individuals seen in the imagery.

### Individuals in the text

As visible in Figure 1, a total of 1009 individuals were identified in the text of all of the books combined. The number of female individuals equals 362 (35.9%) and the number of male individuals equals 587 (58.2%), this is a statistically significant difference (binomial test, *p*<0.001). Of the remaining 60 individuals (5.9%) the gender was not specified or unclear. There were no individuals who had a gender different than female or male.

Figure 1: The total number of individuals in the text and their gender.

#### Occupation and education level

In Figure 2 an overview of the gender of the individuals who have an occupation is given. There is a statistically significant difference in gender within the individuals who have an occupation (binomial, *p*<0.001). The total number of individuals who have an occupation equals 242 and 52 of them (21.5%) are female. Out of the 52 female individuals with an occupation, there are 44 whose education level is MBO. This leaves 8 women who are HBO or WO educated. When looking at all of the education levels, the percentage of women clearly gets lower as the education level gets higher.

Figure 2: The gender of the individuals who have an occupation and the matching education level.

It must be noted that a surprising amount of athletes appeared in the textbooks. These individuals were all given the occupation ‘Sport’ and the minimum education level MBO, therefore this level has a high total of individuals.

#### Existence

In Table 6 the categories Relevance and Existence are visible. This table shows only a small number of the individuals were non-fictional. The small number of non-fictional individuals is partly explained with the design of the mathematics textbooks. The textbooks mostly contain questions introducing fictional individuals, for example: “Jantje bought 300 watermelons” is frequently used in mathematics questions in the Netherlands. When looking at the gender of the non-fictional individuals, the difference is statistically significant (binomial, *p*<0.001). Of the 85 individuals who are non-fictional, only 10 (11.8%) were female.

Table 6: The non-fictional and relevant individuals in the text of all the books combined and their gender.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Total | Female | | Male | | Unknown | |
|  | Number | Number | Percentage | Number | Percentage | Number | Percentage |
| Total | 1009 | 362 | 35.9% | 587 | 58.2% | 60 | 5.9% |
| Non-fictional | 85 | 10 | 11.8% | 75 | 88.2% | 0 | - |
| Relevant | 53 | 4 | 7.5% | 48 | 90.6% | 1 | 1.9% |
| Non-fictional & relevant | 35 | 0 | - | 35 | 100% | 0 | - |

#### Relevance

The relevant individuals are the people representing the STEM field, so it is of importance for this research to see how diverse they are. As seen in Table 6, there are 53 relevant individuals in the text, this is only 5,3% of the total amount of individuals. When looking at the gender of these 53 relevant individuals, there is a statistically significant difference in (binomial, *p*<0,001). Over 90% of the relevant individuals were male, this leaves a total of 4 (7,5%) relevant women. There is one woman mentioned in MW HAVO, one woman mentioned in MW VWO, one woman mentioned in GR HAVO and one woman mentioned in GR VWO. This means every student working with one of these methods on one of these levels will only encounter one relevant woman. These four relevant women are all fictional, as there are zero non-fictional relevant women in the text, next to 35 non-fictional relevant men.

Another thing that stands out is that almost half of the relevant individuals in the text are found in chapters or questions which are labelled as ‘challenging’, ‘inquiring’, ‘in-depth’, and ‘kangaroo’. These chapters and/or questions are for the students who want to dive deeper into the subject and seen as more difficult. This means the average student will most likely never see these relevant individuals.

#### Time

When looking at the list of non-fictional and relevant individuals, one thing immediately jumps out. Most of these individuals are marked as historical, this means most of them are deceased. A total of two individuals are marked as non-fictional, relevant, and contemporary. This means there are only two individuals who represent the current STEM-field. They are white and male.

#### Type of mathematics and difficulty level

When analysing the individuals per type of mathematics, it was very noticeable how much more individuals were present in the text labelled as mathematics A. As seen in Table 7, there were a total amount of 357 individuals in the text labelled mathematics A, while there were only 153 individuals mentioned in the text labelled as mathematics B. The gender distribution was almost the same for both types of mathematics, meaning there is no statistically significant difference visible here (chi-squared, *p*>0.05*)*.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Total | Female | | Male | | Unknown | |
|  | Number | Number | Percentage | Number | Percentage | Number | Percentage |
| Mathematics A | 357 | 136 | 38.1% | 214 | 59.9% | 7 | 2.0% |
| Mathematics B | 153 | 56 | 36.6% | 94 | 61.4% | 3 | 2.0% |
| Supportive | 62 | 31 | 50.0% | 24 | 38.7% | 7 | 11.3% |
| Challenging | 183 | 64 | 35.0% | 113 | 61.7% | 6 | 3.3% |

Table 7: The individuals and their gender per type of mathematics and difficulty level.

However, the gender distribution within the different difficulty levels in the textbooks stands out. When looking at the gender balance of the text labelled as supportive, this differed from the rest of the results. This is the only area in which women are not underrepresented, but men are. While 50.0% of the individuals are women, only 38.7% of the individuals are men. Considering these are the exercises for students who struggle with mathematics, it is quite telling this is the only area in which women outnumber men. While there is no visible difference in gender representation in mathematics A, the ‘easier’ mathematics, there is a clear difference visible in the supportive sections.

### Individuals in the images

When looking at the images in the textbooks, the results in the category gender are slightly less dramatic than in the text. The numbers are seen in Table 8. While the total percentage of women is almost the same as in the text, there are more non-fictional women and more relevant women present in the images. Also, there are zero non-fictional relevant present in the text, while there are two non-fictional relevant women visible in the images.

Table 8: The individuals in the images of all the books combined and their gender.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Total | Female | | Male | | Unknown | |
|  | Number | Number | Percentage | Number | Percentage | Number | Percentage |
| Total | 519 | 182 | 35.1% | 317 | 61.1% | 20 | 3.8% |
| Non-fictional | 152 | 50 | 32.9% | 97 | 63.8% | 5 | 3.3% |
| Relevant | 177 | 72 | 40.7% | 91 | 51.4% | 14 | 7.9% |
| Non-fictional & relevant | 22 | 2 | 9.1% | 20 | 90.9% | 0 | - |

In the images ethnicity was also analysed, these results can be seen in Figure 3. It is clearly visible that white individuals are represented significantly more often than non-white individuals (binomial, *p*<0.001). Out of the 519 individuals seen in the images, a total of 53 were non-white (10.2%) and all of the non-white individuals were fictional.

Figure 3: The ethnicity of the individuals seen in the images.

## Interviews

For the qualitative section of this research, interviews were conducted with eight girls facing the educational profile choice. The results of these interviews are shown in four main sections based on the four different sets of questions. The first section is about their educational profile choice, specifically their mathematics choice, and who potentially influenced their decision. The second section is about the information the girls have on the types of mathematics and from which sources they received their information. The third section is about the girls’ answers on stereotypes of the STEM field and the potential impact on their sense of belonging. Lastly, the remaining notable results are summarized shortly.

### The mathematics choice and who influenced it

The influence of the teachers is discussed first, followed by the influence of family and friends.

#### Influence of the teachers

When asked if their STEM teachers are motivating them and giving them the feeling like they are doing well, the answers differed a lot depending on the teacher the girl had. The girls all mention at least one STEM teacher who told them they were doing well or who motivated them to do better and then they did. These positive experiences only come up after thinking about it for a while and 7 of the girls mention this does not impact their decision to choose the course. One girl was motivated by her mathematics teacher to take mathematics D and did so because of this advice.

The negative experiences come quicker to their minds. These experiences influenced the decision for two of the girls. One girl mentioned how difficult and demotivating it was when her physics teacher said “you should perform well as long as you do the homework”, as it does not always work this way. She pays attention, does the homework, and even has a tutor, but she still does not perform well. Her physics teacher does not help or try to motivate her in any way, which is partly the reason why she dropped the subject.

The other girl shares a story about a big influence by her mathematics teacher. She was performing great in mathematics until she got a new teacher. They did not get along and the teacher would scold her and send her out of the lessons, sometimes for multiple weeks. Because of the lack of education and the lack of motivation she received from the teacher, her achievements decreased. She used to score 90% on average, now she only averages at 50%. The teacher also gave her a negative advice for choosing mathematics B, while the girl did believe she was smart enough. She said: “The teacher was like ‘you can’t do it’ so I thought ‘well, I won’t do it then’”. She decided against mathematics B.

Overall, it seems like negative comments by a teacher are taken more seriously than positive comments.

#### Influence of family and friends

Every girl talks through their educational profile decision with family, yet the family rarely influences their decision. Every girl mentions “my family will support my decision, no matter what it is going to be”. In only one case a parent gave specific advice and the daughter decided to do it mostly because she looked up to her parent.

None of the girls mention advice given to them by their friends. While they did discuss the upcoming decision together, all girls mention they want to choose for themselves, not on the basis of advice from their friends. Nonetheless, one girl did say “Well, all of my friends chose mathematics A and I wasn’t really sure, because if everyone choses mathematics A then you quickly think ‘I should probably also do this, right?’”. She ended up choosing mathematics A. Another girl mentioned having doubts about taking an extra STEM subject because none of her friends were going to take it, but she did end up taking the extra STEM subject.

### Information on the mathematics choice

The girls were asked if they could explain the differences between mathematics A and B and how the decision between these types of mathematics could impact their future. The girls had decent knowledge about the contents of mathematics A and B, but the information they received was very dependent on their mathematics teacher. Half of the girls received a detailed explanation from their teacher, while the other half could only describe the differences between the types of mathematics vaguely and without confidence.

While the teacher who gave the detailed explanation really emphasized the impact the mathematics choice has, the other teacher did not mention it at all. This means half the girls had no clue mathematics B is mandatory for further studies in the STEM-field. The girls who were aware if this impact elaborated on the lesson they received about the mathematics choice. Their mathematics teacher explained in the classroom how she had chosen mathematics A and did not know this would impact her future studies at the time. She had to pass a mathematics B exam later in life to be allowed to enter a studies in mathematics. Because of her experience, she thought it was extra important to explain it clearly to her students.

### Stereotypes and the impact on a sense of belonging

When asked if they could describe a scientist, everyone said at one point it could be anyone. One of the girls said it could really be anyone and no picture came to mind at all. Another girl said it would be a younger nerdy person who wears a lab coat, glasses, and loves to read about science. The gender of this person did not come to her mind. The other six girls all described a man. There were two different descriptions, one for an older scientist and one for a younger scientist. The older scientist they described had grey, messy hair, was a bit wacky, and loves to read about science in his free time. He also loved to play golf. The younger scientist was described as sporty, vegan, and arrogant. The most mentioned sports were cycling and rock climbing. He cares a lot about climate change and activism. The word ‘virgin’ was also mentioned. The younger scientist also reads a lot about science in his free time.

Of all six girls who described the younger scientist, four of them also described the older scientist. It seems like the stereotype is starting to switch from the ‘Einstein’ figure to a younger, arrogant activist. The one common factor for every description is that this person loves reading and science, this takes up a big part of their free time.

When asked if they think it is more difficult to excel in the STEM field if you do not fit the general stereotype, they all said the same thing. As one girl worded it:

“I think it does matter, but I think it should not matter. Let’s leave it at that.”

The girls also mentioned they could imagine being more comfortable in the STEM field if there would be more women. The girls who were choosing for the natural sciences in their educational profile choice all indicated nervousness about having less girls in their classes when starting next school year.

### Other results

When the girls discuss how their description of a scientist came to be, they mostly mention their teachers and movies. Their textbooks do not play a big, conscious role in forming these description. Six of the girls did mention finding their science books a bit stuffy.

One final result from the interviews is the fact that none of the girls were able to name a scientist without help. And even with help, none of them were able to name a female scientist.

# Conclusion

The research questions of this study included one main question and three sub questions, these are repeated below. The sub questions are answered first, followed by the main research question.

What are the factors that influence fifteen year old Dutch girls’ sense of belonging towards the STEM-field and their choice between humanities focused mathematics and natural sciences focused mathematics?

1. How diverse are the people representing the STEM-field in Dutch mathematics textbooks used in lower secondary education?
2. Which factors influence fifteen year old Dutch girls’ choice between humanities focused mathematics and natural sciences focused mathematics for higher secondary education?
3. Which factors influence fifteen year old Dutch girls’ sense of belonging in the STEM-field?

The first sub question is about the diversity of the people representing the STEM-field in certain textbooks. To answer this question, the individuals mentioned or seen in the textbooks were analysed on their gender and ethnicity. Our textbook analysis shows a clear lack of diversity in these textbooks. Women are strongly underrepresented, especially when looking at individuals who are relevant to the STEM-field.

The analysis shows there are barely any STEM-representatives in the text to begin with. Only two individuals in the eight analysed textbooks are alive and working in the STEM-field. These are both white men. If the STEM-representatives also include deceased and fictional individuals who work in the STEM-field, there is a total of 53 individuals. Only four of these individuals are women. Another remarkable results is if the individuals are filtered on education level, the percentage of women present in the text gets lower as the education level gets higher.

Looking at the difference in gender balance between the chapters marked as mathematics A and the chapters marked as mathematics B, nothing stood out. However, the total number of individuals in these chapters was interesting. Chapters marked as mathematics A included over double the amount of individuals compared to chapters marked as mathematics B. When looking at the difficulty levels of specific section, there was one category in which the women outnumbered the men: the sections created for students who struggle with mathematics.

When looking at the images used in the textbooks, the gender balance is a little better than in the text. But, the balance between white and non-white individuals leans a lot towards white individuals. Also, all the non-white individuals in the images are fictional. Overall, white men are very overrepresented and there is a lack of diversity in the individuals present in the textbooks.

The second sub question is about which factors influence girls in their choice between different types of mathematics. To answer this question, eight girls facing the mathematics choice were interviewed. Out of these interviews, a few factors seemed to be of influence.

When discussing the girls’ mathematics choice and who influenced this choice, the conversation went to their teachers, parents, and friends. The family and friends only had a light influence on the girls’ decision. Only one out of eight girls was influenced by a parent and only one girls was influenced by her friends. All of the girls mentioned feeling supported by both family and friends, no matter their decision. The teacher seemed to be a bigger influence, especially when the girls shared a more negative and demotivating experience with a teacher. Teachers also influenced the information the girls received about their mathematics choice. Half of the girls did not have all the information necessary to choose between the different types of mathematics. Which information students receive is very school and teacher dependent.

The third sub question is about the girls’ sense of belonging towards the STEM-field. To answer this question, the girls were interviewed about their stereotypes of the STEM field and the potential impact on their sense of belonging.

The girls definitely had stereotypical views of the STEM-field and indicated they would be more comfortable in the STEM-field if there were more women. While this did not consciously influence their mathematics choice, the girls were nervous about choosing the natural sciences since there were less girls present. This means they did not feel a very big sense of belonging towards the STEM-field yet. When asked if the girls were able to name a scientist, none of the girls could name one without help. Even with help, no one could name a female scientist. The girls were also asked about the potential influence of their mathematics textbooks on their sense of belonging. None of the girls were consciously influenced by their textbooks.

Our main question wondered about the factors which influence Dutch girls’ sense of belonging towards the STEM field and their mathematics choice. As our theoretical framework shows, a lack of diversity in representatives of the STEM-field can negatively influence girls’ sense of belonging towards the STEM-field. Our textbook analysis shows a clear lack of diversity in representatives of the STEM-field in the textbooks. White men are overrepresented in the mathematics textbooks and this can negatively influence the sense of belonging young girls feel towards the STEM-field. The conducted interviews confirm the girls do not experience a big sense of belonging towards the STEM-field and have stereotypical views of the STEM-field.

There is one other important factor which influences the girls’ sense of belonging towards the STEM-field and/or their mathematics choice, namely their teachers. Teachers play a big role in two ways. Firstly, their comments and advice appear to have a big influence on the whole educational profile choice, including the mathematics choice. When the comments are more negative and demotivating, the influence is even bigger. Secondly, the teachers are the main source of information about the mathematics choice the girls have to make. The information the girls received differed a lot per teacher, some girls were unaware of the impacts of their mathematics choice. Uncomplete information can definitely influence the girls’ mathematics choice.

# Discussion

This research studied the factors that influence Dutch girls’ sense of belonging towards the STEM-field and their mathematics choice. The study was divided into two methods, the textbook analysis and the interviews. In the textbook analysis the diversity of the individuals mentioned in the mathematics textbooks was analysed, as previous research indicates a lack of diversity in these textbooks can influence the girls’ sense of belonging. In the conducted interviews the factors that potentially influence the girls’ sense of belonging and their mathematics choice were discussed. The results of these methods and their implications, recommendations, and limitations are elaborated upon in this section, starting with the textbook analysis.

## Textbook analysis

The textbook analysis showed the textbooks used in mathematics in the Netherlands are lacking strongly in diversity. This is in line with previous research about STEM textbooks used in the Netherlands done by Bax (2021) and (Montizaan, 2022). Specifically, white men are strongly overrepresented in the textbooks. When looking at the diversity of the STEM-representatives mentioned in the book, white men are overrepresented even more. For example, there are zero non-fictional women who work in the STEM-field mentioned in the textbooks. This lack of diversity creates an image of a white and male STEM-field, such an image impacts the sense of belonging of anyone who is not white and male in the STEM-field (Rainey & Kalender, Cheryan & Plaut, 2010; Drury et al., 2011). This is worrying, since this impacts girls’ sense of belonging towards the STEM-field and thus their motivation to pursue a career in the STEM-field (Cheryan et al., 2015).

### Recommendations

The amount of STEM-representatives and their diversity can be changed by the creators of these textbooks. Based on the results of this study, some recommendations are elaborated underneath.

The results show the images of the textbooks are more balanced in gender than the text. This gives the idea that the images are checked more thoroughly on diversity by the publishing houses than the text of the books. However, in the images white men are still overrepresented. Right now there seems to be too little focus on a balance in ethnicity, for example, there are zero non-fictional non-white people present in the images. Therefore, it is recommended to improve the image check. It is also recommended to give the same attention to the text of the books. This can be in the same form as they seem to do for the images, but also by introducing a (mandatory) course on inclusive writing for the creators of the books. The results of this research show the writers are in need of more education on inclusive writing, as they seem to have a, probably unconscious, bias about women and people of colour in the STEM-field. This bias is mainly visible in the ‘supportive’ questions of the books, the only area in which women are more present than men. Perhaps the most important recommendation is to prioritize diversity in the writing rooms, as a more diverse staff creates a more diverse product.

The results also show there are very little representatives of the current STEM-field in total. Most representatives are historical instead of contemporary, which means they show an outdated image of the STEM-field. It is recommended to include more current mathematicians in the textbooks. Another relatively easy change to the textbooks is to move the STEM-representatives out of the ‘extra’ chapters. Almost half of them are only visible to students who are willing to do extra work.

### Limitations

The are limitations to the textbook analysis. Firstly, only the textbooks of the third year of HAVO and VWO were analysed. The students are also exposed to a potential lack of diversity in the books in their first and second year of mathematics in secondary education. These first years of secondary education are not taken into account. The students also use a workbook and an online method matching the textbooks, these parts of the educational method were also not into account in this analysis.

### Further research

While conducting this research, there were paths for further research visible which could help gain more insight into impacts of textbooks and the diversity in the textbooks. Firstly, this research focused on a binary representation of gender mostly because there is a lack of non-binary research available. Therefore, it is recommended to start building a base of research focused on how non-binary gendered people are portrayed in textbooks. If they are portrayed at all, which they were not explicitly in these textbooks. It also recommended to conduct more research into the diversity of ethnicity in textbooks, as this focus also lacked strongly in previous research in the Netherlands.

When analysing the two most used methods for mathematics textbooks, the difference in design was visible. One method wrote questions from a third person perspective, for example “Pete bought three melons.”. The other method often used the student’s perspective, for example “You bought three melons.”. Further research into these different approaches and their effects is recommended. Another element in the design stood out for both of the methods, namely how much sports were mentioned and shown. It is recommended to study why this is the case and what kind of effect the amount of sports has on students.

## Interviews

The interview results mainly show the influence of the teachers in two ways. Firstly, it seems like negative comments by a teacher are taken more seriously than positive comments, this is in line with previous research (Gorham & Christophel, 2009). Secondly, the information provided on the educational profile choice and the mathematics choice within is very dependent on the teacher. While all the information is available online, the teachers are the main source for the students on their educational profile information and the teachers can lack in providing this information. Previous research agrees school and teachers should take more responsibility for providing enough information (Broekema & Habraken, 2012).

In the conducted interviews the girls also show stereotypical views of the STEM-field and indicate feeling less comfortable in the natural sciences because of the lack of women present. They were also unable to name scientists, let alone female scientists. This agrees with previous research done by Bax (2021) and Montizaan (2022). The lower sense of belonging the girls seem to experience matches with the results of Rainey et al. (2018).

### Recommendations

Firstly, teachers need to be aware of how much impact their words have, especially when negative. However, the Netherlands is currently suffering a teacher shortage which means teachers are often overworked or in front of a classroom without proper education. This makes it understandable for teachers to have flaws in this department. Another influence the teachers have is through the information they provide to students about the educational profile choice. This information can differ immensely based on their teacher and their school. This can be solved by putting education about this decision higher on the priority list.

Further, the girls are shown to have stereotypical views of the STEM-field and the people who work there. Stereotypes are visible everywhere, in their textbooks, in the media, and online. Showing more women and people of colour as representatives of the STEM-field can help fight the much seen stereotypes.

### Limitations

There are limitations to the conducted interviews. The set-up of the conducted interviews was not as consistent as planned. Half of the interviews were conducted online, while the other half was conducted in real life. On top of this, five out of eight girls were interviewed solo while three of the girls were interviewed together because of practical reasons. This could have influenced the answers of the three girls who were interviewed together. Additionally, people are highly suggestive. While it was attempted by the interviewer to influence the girls as little as possible, some influence cannot by prevented. This also goes the other way around, the answers the girls provide are interpreted a certain way by the interviewer. Therefore, interviews are always slightly limited in the authenticity of their results.

An important limitation is the small group of interviewees, only eight girls were interviewed for this research. The eight interviewed girls all attend the same high school and were quite similar in their hobbies, the similarities between the girls is seen as a limitation for this research. The research also focused only on the levels HAVO and VWO, the level VMBO was not taken into account.

### Further research

During this research, there were paths for further research visible which could help gain more insight into which factors influence girls’ sense of belonging and their mathematics choice. First of all, more interviewees could provide more results. It is also recommended to have less similar interviewees when further research is conducted. Second of all, further research into the VMBO level is recommended. This educational path is very different from HAVO and VWO and is expected to provide different results.

When interviewing the girls, it became clear they received different information about their mathematics choice. This is why a third option for further research is diving into the information provided on the whole educational profile choice. An extensive study on the provided information can help improve the information given to the students about their educational profile choice.

# Acknowledgments

A big thanks to Liesbeth and Michiel for all of the feedback and the many conversations about this thesis. Also a special thanks to Melanie and Joao for their endless support during the writing of this thesis.

# References

Bax, J. B. (2021). *Gender bias in secondary education: An explorative study on the availability of role models for physics and computer science students in Dutch high schools school of Teaching* (Master’s thesis). Retrieved November 11, 2022, from <https://studenttheses.uu.nl/handle/20.500.12932/40019>

Blickenstaff, J. C. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and Education*, *17*(4), 369–386. <https://doi.org/10.1080/09540250500145072>

Brakel, M. van den., et al. (2020a). Meer vrouwen in de techniek en meer mannen in de zorg? *Emancipatiemonitor: 2020*, 127. Retrieved November 11, 2022, from <https://digitaal.scp.nl/emancipatiemonitor2020/meer-vrouwen-in-de-techniek-en-meer-mannen-in-de-zorg>

Brakel, M. van den., et al. (2020b). Meisjes vlijtig door het onderwijs en jongens een flitsende loopbaanstart? *Emancipatiemonitor: 2020*, 127. Retrieved November 11, 2022, from <https://digitaal.scp.nl/emancipatiemonitor2020/meisjes-vlijtig-door-het-onderwijs-en-jongens-een-flitsende-loopbaanstart>

Broekema, A. F., & Habraken, S. M. J. (2012). *Wat zal ik kiezen?*

Cambridge (2013). *Cambridge Advanced Dictionary* (Vol. 58). Cambridge University Press. Retrieved November 11, 2022, from <https://dictionary.cambridge.org/dictionary/english/role-model>

Centraal Bureau voor de Statistiek. (2019). *Evenveel vrouwen als mannen met hbo- of wo-diploma*. Retrieved November 11, 2022, from <https://www.cbs.nl/nl-nl/nieuws/2019/10/evenveel-vrouwen-als-mannen-met-hbo-of-wo-diploma>

Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural stereotypes as gatekeepers: Increasing girls’ interest in computer science and engineering by diversifying stereotypes. *Frontiers in Psychology*, *6*, 49. <https://doi.org/10.3389/FPSYG.2015.00049/BIBTEX>

Cheryan, S., & Plaut, V. C. (2010). Explaining Underrepresentation: A Theory of Precluded Interest. *Sex Roles*, *63*(7–8), 475–488. <https://doi.org/10.1007/S11199-010-9835-X/TABLES/3>

Cheryan, S., Plaut, V. C., Davies, P., & Steele, C. M. (2009). Ambient Belonging: How Stereotypical Cues Impact Gender Participation in Computer Science. *Journal of Personality and Social Psychology*, *97*(6), 1045–1060. <https://oce-ovid-com.proxy.library.uu.nl/article/00005205-200912000-00005/HTML>

Cheryan, S., Plaut, V. C., Handron, C., & Hudson, L. (2013). The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women. *Sex Roles*, 69, 58–71 <https://doi.org/10.1007/s11199-013-0296-x>

Drury, B. J., Siy, J. O., & Cheryan, S. (2011). When Do Female Role Models Benefit Women? The Importance of Differentiating Recruitment From Retention in STEM. *Psychological Inquiry, 22*(4), 265–269. <https://doi.org/10.1080/1047840X.2011.620935>

Gorham, J., & Christophel, D. M. (2009). Students’ perceptions of teacher behaviors as motivating and demotivating factors in college classes. *Communication Quaterly, 40*(3), 239–252. <https://doi.org/10.1080/01463379209369839>

Kalender, Z. Y., Marshman, E., Schunn, C. D., Nokes-Malach, T. J., & Singh, C. (2019). Why female science, technology, engineering, and mathematics majors do not identify with physics: They do not think others see them that way. *Physical Review Physics Education Research*, *15*(2). <https://doi.org/10.1103/PHYSREVPHYSEDUCRES.15.020148/FIGURES/2/MEDIUM>

Kalwarski, T., Mosher, D., Pashkin, J., & Rosato, D. (2007). *Best jobs in America*. CNN Money. Retrieved November 11, 2022, from <http://money.cnn.com/magazines/moneymag/bestjobs/index.html>

Margolis, Jane., & Fisher, A. (2003). *Unlocking the Clubhouse: Women in Computing*. The MIT Press. Retrieved November 11, 2022, from <https://books.google.nl/books?hl=nl&lr=&id=StwGQw45YoEC&oi=fnd&pg=PP9&ots=npK2OU90uJ&sig=XE3azwTYUjuB5zXvXgLXrQKfzRI&redir_esc=y#v=onepage&q&f=false>

Miller, D. I., Eagly, A. H., & Linn, M. C. (2015). Women’s representation in science predicts national gender-science stereotypes: Evidence from 66 nations. *Journal of Educational Psychology*, *107*(3), 631–644. <https://doi.org/10.1037/EDU0000005>

Montizaan, M. (submitted). (2022). *Seeing is being* (Master’s thesis).

NBG. (2020). *Nationale Beroepen Gids*. Retrieved November 11, 2022, from <https://www.nationaleberoepengids.nl/>

Onderwijsloket. (2021). *Het Nederlandse onderwijssysteem*. Retrieved November 11, 2022, from <https://www.onderwijsloket.com/kennisbank/artikel-archief/hoe-zit-het-nederlandse-onderwijssysteem-in-elkaar/>

Rainey, K., Dancy, M., Mickelson, R., Stearns, E., & Moller, S. (2018). Race and gender differences in how sense of belonging influences decisions to major in STEM. *International Journal of STEM Education*, *5*(1), 10. <https://doi.org/10.1186/s40594-018-0115-6>

Roots of STEM. (2013). *Success Qualitative Data Description*. Retrieved November 11, 2022, from <https://pages.charlotte.edu/rootsofstem/>

Soper, T. (2014). *Analysis: The exploding demand for computer science education, and why America needs to keep up*. GeekWire. Retrieved November 11, 2022, from <https://www.geekwire.com/2014/analysis-examining-computer-science-education-explosion/>

van der Molen, J. H. W. (2020). Why do Dutch girls do not choose for science and engineering? A focus on gender stereotypes and a lack of female role models. *SEFI 48th Annual Conference University of Twente* (pp. 1191–1199). <https://doi.org/10.2/JQUERY.MIN.JS>

van Groenigen, E., & Hartgers, M. (2019). *Geslaagd! Profielen, vakken en cijfers van geslaagden in vwo, havo en vmbo-t*. CBS. Retrieved November 11, 2022, from <https://www.cbs.nl/nl-nl/longread/statistische-trends/2019/geslaagd-profielen-vakken-en-cijfers-van-geslaagden>

van Langen, A., & Meelissen, M. (2019). *De lekkende bèta/technische pijpleiding en hoe deze te repareren Samenvatting, conclusies en aanbevelingen*. Retrieved November 11, 2022, from <https://ptvt.nl/wp-content/uploads/2020/11/Overkoepelend-rapportage.pdf>

van Veelen, R., Derks, B., & Ruth Van Veelen, C. (2021). Academics as Agentic Superheroes: Female academics’ lack of fit with the agentic stereotype of success limits their career advancement. *British Journal of Social Psychology*, *00*, 1–20. <https://doi.org/10.1111/BJSO.12515>

VHTO (2021). *Cijfers havo/vwo*. Expertisecentrum genderdiversiteit in beta, techniek & informatica. Retrieved November 11, 2022, from <https://www.vhto.nl/kennis/cijfers/cijfers-havo/vwo/>

Wettenbank (2019). *Regeling aanmelding en toelating hoger onderwijs*. Retrieved November 11, 2022, from <https://wetten.overheid.nl/BWBR0035059/2019-09-01#BijlageA>

World Economic Forum (2021). *Global gender gap report 2021*. Retrieved November 11, 2022, from <https://www.weforum.org/reports/global-gender-gap-report-2021>

# Appendix A

## Semi-structured interview script

This is the script for the interviews conducted with female students in the third year of HAVO/VWO. Questions have been prepared, but there is the option to change to order and to add extra questions depending on the situation. The introduction, the explanation of the conducted research, and the final remarks are prepared more elaborately. This more elaborate preparation is necessary since this is important information for the interviewee regarding privacy and the reasons for this interview. The questions are based on the questions used by Rainey et al (2018) and Bax (2021).

A number of different subjects are discussed in the interview. Some of these subjects have a set place within the interview and for some of these subjects the order is less relevant. Within these subjects, the order of the questions is mostly irrelevant unless mentioned otherwise. The interviewees are Dutch, therefore the script will be written in Dutch.

*Kennismaking*

Leuk je te ontmoeten! Voor we beginnen, ben je er helemaal klaar voor? Zit je op een fijne rustige plek waar je 45 minuten goed kan zitten? Laptop opgeladen, glaasje water etc.

Ik zal eerst iets over mezelf vertellen. Ik ben Valerie en ik studeer aan de Universiteit Utrecht. Ik vind het heel belangrijk dat iedereen gelijke kansen krijgt in de wereld. Zelf heb ik een achtergrond in de wiskunde, hierdoor ligt mijn focus vooral op gelijke kansen binnen de bètawetenschappen. Op de middelbare school zien we dat meisjes steeds vaker een natuurprofiel kiezen tijdens de profielkeuze. Maar we zien ook dat meisjes gemiddeld vaker voor wiskunde A kiezen dan jongens. Om een studie of een baan te vinden binnen de bètawetenschappen is wiskunde B vaak een verplicht vak. Daardoor is het moeilijker voor meisjes die wiskunde A kiezen om na de middelbare school verder te gaan in de bètawetenschappen. Hierdoor gaan er een hoop slimme mensen mogelijk geen bètastudie. Dat is een van de redenen voor dit onderzoek, daarover zal ik zo meer vertellen. Eerst wil ik iets meer over jou weten!

Mogelijke vragen om over de interviewee te leren/de interviewee te helpen loskomen:

* Wie ben je?
* Hoe oud ben je?
* Wat heb je dit weekend gedaan? / Wat zijn je hobbies? / etc
* Wat vind je het leukst aan school?
* Welk niveau doe je?
* Hoe bevalt jaar 3 tot nu toe?

Verder wil ik graag nog weten welke methode jullie gebruiken voor wiskunde?

*Uitleg onderzoek*

Mijn onderzoek gaat over de profielkeuze tussen wiskunde A, B, C of D, iets specifieker over waarom meisjes kiezen voor een bepaalde wiskunde. Het onderzoek bestaat uit meerdere delen, een van deze delen is dit interview met jou. Het duurt in totaal 45 minuten. We gaan het vandaag over een aantal dingen hebben samen. Over de profielkeuze en de verschillende soorten wiskunde, maar vooral over alles om deze keuze heen. We gaan het daarom hebben over alle mogelijke factoren achter deze keuze, dan heb ik het bijvoorbeeld over de mensen in jouw omgeving en het beeld dat jij hebt van de bètawetenschappen.

Om het interview te verwerken in het onderzoek ga ik het opnemen. Ik neem de video en audio op, maar ik zal de video gelijk verwijderen. Ik heb alleen de audio nodig voor mijn onderzoek namelijk. De reden dat ik toch graag de video aanzet tijdens dit gesprek is omdat we elkaar dan toch kunnen zien en dat maakt een gesprek vaak wat prettiger. Vind je het oke als ik zo direct begin met opnemen?

…

Super! Heb je verder nog vragen voor me?

…

Dan gaan we nu beginnen en klik ik op opnemen.

*Interview*

Welk profiel wil je volgend jaar gaan doen? En waarom?

Wat verwacht je daar precies van?

Welke wiskunde ga je hierbij volgen? En waarom?

Welke gebeurtenissen/ervaringen denk je dat impact hebben gehad op deze keuze?

Much more set up

Wie zijn belangrijk geweest in het maken van je keuze?

In hoeverre motiveert je docent jou voor bètavakken? En specifiek je wiskundedocent?

Heb je het gevoel dat je docent denkt dat jij goed bent in beta vakken? En waarom?

Welk profiel kiezen je vrienden en vriendinnen? Wat voor impact heeft dit op je keuze?

Hoe voel je je in een groep van mensen die hetzelfde profiel willen als jij?

Welke rol hadden je ouders in jouw profielkeuze?

Wat voor werk doen je ouders?

Heb je mensen in je familie of je omgeving die werken in een bètagebied?

Wat voor effect hebben deze mensen op jouw profielkeuze?

Motiveren vrienden en familie jou om de bèta-kant op te gaan?

Vind je het belangrijk dat andere mensen vinden dat je studie bij je past?

Kan je me vertellen wat jij denkt dat wiskunde A/B/C/D inhoudt?

Wat is je beeld van de verschillende soorten wiskunde?

Wat is volgens jou de impact van je keuze tussen de wiskundes?

Wat denk je later te kunnen met de verschillende soorten wiskunde?

Wat wil je later worden?

*In hoeverre heb je interesse in wetenschap en het beta werkveld?*

*Hoe is je interesse in het betagebied verandert sinds je jong was?*

*Specifiek, is het veranderd sinds je op de middelbare school zit?*

*Heb je het gevoel dat je een HBO/WO studie kan en waarom?*

Kan je het beeld dat jij hebt van een bètawetenschapper beschrijven?

Wat voor hobbies heeft deze wetenschapper?

Is dat denk je zo voor alle wetenschappers?

Hoe stel je jezelf voor als wetenschapper?

Pas ik in jouw beeld als wetenschapper?

Waarom niet/wel?

In hoeverre moet je passen in het stereotype van een wetenschapper om echt wetenschapper te worden?

In hoeverre vind je dat gender uitmaakt in de bètawetenschappen?

Kiezen er meer jongens voor bètavakken in jouw klas en wat vind je daarvan?

Denk je dat jij je minder thuis voelt in de bètawetenschappen omdat je geen man bent?

Welk beeld van een bètawetenschapper schetsen jouw schoolboeken?

Enthousiasmeren jouw schoolboeken jou om richting de bètawetenschappen te gaan?

Welke mannelijke wetenschappers kan je opnoemen?

Welke vrouwelijke wetenschappers kan je opnoemen?

*Afsluiten*

Dat was het! Ontzettend bedankt voor je antwoorden. Hoe vond je het?

…

Nog noemen:

* Bol.com bon komt via de mail
* Onderzoeksresultaten met je delen?
* Melanie’s onderzoek: bio of natuurkunde en mag ik je nog benaderen
* Enkel de audio wordt opgeslagen volgens de richtlijnen van de Universiteit Utrecht. Mocht je hier zorgen over hebben kan je mailen naar [privacy@uu.nl](mailto:privacy@uu.nl). Het mailadres staat ook in het ingevulde formulier.

Nogmaals ontzettend bedankt en een hele fijne dag verder!

1. When discussing gender in this research, a binary distinction is made between cisgender men and people who identify as women. The existence of genders outside of this binary distinction are acknowledged, but could not be taken into account for practical reasons. [↑](#footnote-ref-1)