Seeing is being

Female role models in Dutch biology and physics secondary education textbooks

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Abstract

To date, the field of science, technology, engineering, and mathematics (STEM) is male-dominated, causing women to experience a low sense of belonging to the field and leading them to refrain from pursuing a science related career. In the Netherlands, a person's first decision towards a possible career in the field of science takes place in secondary school during the subject cluster choice. Here, a similar pattern is found with very few girls choosing physics, a science field with a male image, when compared to biology which has a gender neutral image. This paper investigates the female role model availability in Dutch physics and biology textbooks, supported by exploratory interviews on the influence of girls' social environment on their subject cluster choice.

Twelve textbooks on the subjects of biology and physics were analysed and Dutch female secondary school pupils were interviewed on the factors of their subject cluster choice. The results indicate a significant difference in male and female role model availability in both biology and physics textbooks. Women are mentioned significantly less regarding a science related occupation. Both fictional and non-fictional individuals were more likely to be male than female. Additionally, both subjects were found to use male pronouns to refer to (previously) gender neutral individuals significantly more than female pronouns. Furthermore, images in biology textbooks show women and men at a similar frequency, while physics textbooks depict in images men significantly more often than women. Finally, girls perceive their career aspirations and interest to be the main factors of their subject cluster choice. The influence of the media, and a parent figure or teacher is mentioned as a factor for their decisions as well.

The underrepresentation of women in relation to science in Dutch secondary school textbooks of biology and physics, can result in a lower sense of belonging, self-efficacy, and interest of girls to STEM and maintain the male image within science. Inclusion of more female role models in education could change the male stereotype and be the start of a more diverse and inclusive science.

Key words: 'gender', 'role model', 'science education', 'Dutch subject cluster choice', 'science textbooks', 'secondary school students'

Introduction

To date, the field of Science, Technology, Engineering, and Mathematics (STEM) is dominated by men. In Europe, female researchers working in the field of Natural Sciences and Engineering & Technology make up less than 40% of researchers on average (European Comission, 2021). This is an example of the existing gender gap in the scientific world, as it demonstrates *a gap between men and women in terms of their levels of participation, access, rights, remuneration or benefits* (definition by the European Institute for Gender Equality). The inclusion of different perspectives on scientific subjects, of men and women for example, will lead to a more enriched view and overall better science and solutions to the problems humankind faces (Leggon, 2010). Further, the gender-gap in the working field of STEM is found as a cause for the difference in economic status between the genders (Card & Payne, 2021). The pay in STEM fields, dominated by men, is higher than in fields with female over-representation, e.g. Education and Humanities (European Comission, 2021; Rollor, 2014), leaving women with a lower income on average. From the 40 European countries examined, the Netherlands has the lowest proportion of women amongst researchers (European Comission, 2021). Moreover, Dutch female professors are more likely to earn less as opposed to a Dutch male professor in the field of STEM (Landelijk Netwerk Vrouwelijke Hoogleraren, 2021). In 2020, 38.2% of male professors are placed in a salary scale of 17 or higher, in contrast to 19.8% of female professors in the Netherlands (Landelijk Netwerk Vrouwelijke Hoogleraren, 2021).

Additionally, in Europe the gap between male and female graduates in STEM-related fields is the biggest in the fields of physics, engineering, and computer science (Card & Payne, 2021). The gender-gap in graduates results in an unequal representation of gender in the working field of STEM, as it functions as the supply of new researchers. This gap is also found in the Netherlands specifically (OECD, 2019). Furthermore, the gender gap in STEM can already be observed in Dutch secondary school. In the Netherlands, when pupils enter secondary school at 11-12 years of age, they are divided between three educational levels: pre-university (vwo), pre-higher-vocational (havo) and pre-vocational (vmbo). Thereafter, at the age of 14-16, secondary school pupils decide on a subject cluster (SC). At this age, the pupils decide on their first choice towards a future study, having great impact on their future career options. They can choose between four SCs, two of which are STEM-related. When a pupil chooses a STEM-related SC, three different variations are possible in each of the three educational levels: only biology, only physics, or both biology and physics. On all three educational levels, vwo, havo, and vmbo, biology is chosen in girls' SC more often than physics. When pupils chooses only biology in their SC, this highly limits their career options in the technical- or natural sciences.

A well-researched cause of women's choice to pursue a certain STEM-related field following secondary school is the sense of belonging they do or do not feel with the particular field (e.g. Master et al., 2016; Rainey et al., 2018; Starr, 2018). Women who do not identify with the stereotype related to the STEM-related field are less likely to pursue a career in this field. They are more likely to pursue a career with a stereotype they do feel a sense of belonging to (Rainey et al., 2018). As science is dominated by men, the main stereotype is considered male (Nosek et al., 2009; Steffens et al., 2010). The overrepresentation of male scientists can have an negative influence on females' sense of belonging. For example, research by Murphy et al., (2007) studied the influence of watching a science conference video with either an imbalanced (more male than female) or balanced gender presence on women's sense of belonging. They found women who viewed the video with an unbalanced gender presence to report a lower sense of belonging and willingness to attend the conference as opposed to women who viewed the video with an equal gender presence. For women to feel more included and consequently enter the field of science, this male stereotype has to change and become more gender inclusive.

Diversifying stereotypes by including more female role models in the communication and education of all areas of science can change the male image of science (Cheryan et al., 2015). Research shows that the inclusion of female professors in science college mayors, results in pro-science career aspirations and leads female students to identify with them and perceive science as more feminine (Young et al., 2013). Furthermore, the presence of female role models in textbooks aid female pupils to relate to the

characters portrayed in the textbook and can influence their future academic aspirations (Mburu & Nyagah, 2012). Thus, the appearance of female models in girls' social environment as well as their textbooks can influence their sense of belonging to a STEM-related field and their future career choices.

Correspondingly, research about women's choice to pursue a career in a STEM-related field in general, has been conducted (e.g. Blickenstaff, 2005; Kessels, 2015; Murphy et al., 2007; Rainey et al., 2018). However, the influence of female role models on girls' subject cluster choice in Dutch secondary school, and the choice between STEM-related subject clusters specifically, has not yet been researched. As, within Europe, the gender-gap in STEM is the biggest in the Netherlands, and already present in secondary school, research on girls' first choice towards a future career is needed. Furthermore, the influence of the presence of role models for girls in their textbooks, on their choice of biology over physics in their SC has not been researched for the various educational levels in the Dutch school system. Textbooks have a major impact in science teaching, and thus can be seen as an important element to stimulate or hinder girls to study science (Potter & Rosser, 1992). A change in STEM education could stimulate girls to choose a SC that includes physics and keep their options for a technical STEM-related career open. Thus, this study aims to identify the presence of female role models in Dutch secondary school textbooks and the potential influence thereof on their STEM-related subject cluster choice. In particular girls' choice for physics and biology is studied as this has a major influence on their options for a future STEM-related study and career.

Theoretical framework

Women in STEM

To date, STEM is a male dominated field, persistently maintaining the association of science with men (Nosek et al., 2009). Consequently, female scientists with relatively more feminine characteristics are less likely to be judged as competent in the field of science as opposed to female scientist with relatively more masculine characteristics (Banchefsky et al., 2016). This masculine stereotype of STEM makes it more difficult for females to get into this field and have a science related career. For example, when applying for a job, even if the CV's are completely identical, the candidate with a male name is favoured and seen as more competent compared to the candidate with a female name (Moss-Racusin et al., 2012). This can have impact on the career development of women as well as their income level which can result in an increasingly bigger gap between men and women (Card & Payne, 2021). Thus, women do not have an equal chance when they want to work in the field of science, which in turn will keep science a non-diverse and male dominated field.

In the Netherlands specifically, a male dominance is clearly visible in the difference of the number of men and women working in science related jobs (European Comission, 2021). The European commission reported that the Netherlands has the lowest percentages of female researchers (European Comission, 2021). Only 26.4% of researchers in the Netherlands are female, whereas the highest percentage of female researchers in Europe is 52.2% in Latvia. The gap between male and female graduates in STEM-related fields is the biggest in the fields of physics, engineering, and computer science (Card & Payne, 2021), while in the field of biology, this gap seems to close with women even outnumbering men.

Girls and their subject cluster choice in the Dutch educational system

The Dutch secondary education system, divides pupils based on their performance during primary education. Pupils can either get placed in a vmbo class, a havo class, or a vwo class, which takes four, five, and six years respectively and prepares the pupils for either further vocational education (mbo), higher vocational education (hbo), or university (wo) respectively. All students, regardless of their educational level, decide on a subject cluster (SC) during their secondary school education. Additional to pupils' SCs, they follow core subjects mandatory for all students, for example Dutch language.

Havo and vwo pupils decide on their SC choice at the end of their third year. They can choose between four SCs: Nature and Health, Nature and Technology, Economics and Society, and Culture and Society. Every SC has their specific mandatory core subjects, with electives the pupils can choose to complete their personal SC. The SC Nature and Health together with Nature and Technology represents the STEM-related SCs. The difference in core subjects between these two SCs are biology and physics (see table 1 for an overview of the STEM SCs).

Table 1 | *Overview of mandatory subjects and electives for SCs Nature and Health, and Nature and Technology available to havo- and vwo-level pupils.*

Subject type	Nature and Health	Nature and Technology
Mandatory	Mathematics A or B Chemistry Biology	Mathematics B Chemistry Physics
Electives	Physics Research & Design Nature, Life, Technology Geography	Biology Research & Design Nature, Life, Technology Computer Science Mathematics D

Vmbo-pupils decide on their SC at the end of their second year. For this educational level, the SC choice is more complex as opposed to havo and vwo levels as they have four sublevels. The highest of these sublevels contains four SCs like havo and vwo and was therefore used in this study to compare to havo and vwo (table 2).

Table 2 | *Overview of mandatory subjects and electives for SCs Technology, Healthcare and welfare, and Agriculture, available to vmbo-level pupils.*

Subject type	Technology	Healthcare and welfare	Agriculture
Mandatory	Mathematics Physics and chemistry	Biology	Mathematics
Electives		Mathematics Geography History Social studies	Physics and chemistry Biology

Statistics Netherlands (CBS) publishes the number of pupils choosing each SC, as well as the specific subjects within these SCs, yearly. Girls tend to choose the SCs that include biology over those that include physics regardless of their educational level (CBS, 2021). In the schoolyear of 2019-2020, 49% of girls, who chose a STEM-related SC, chose the subject of physics, in contrast to 78% who chose the subject of biology on vwo level (figure 1.A). These numbers for havo are 24% physics, and 86% biology (figure 1.B). For vmbo this is 10% physics, and 90% biology (figure 1.C). Thus, a difference is found for all educational levels with a greater gap between the subjects at vmbo level as opposed to havo level, and the gap being the smallest at vwo level. Based on these numbers, the gap between the amount of girls who choose biology and physics does not seem to close.

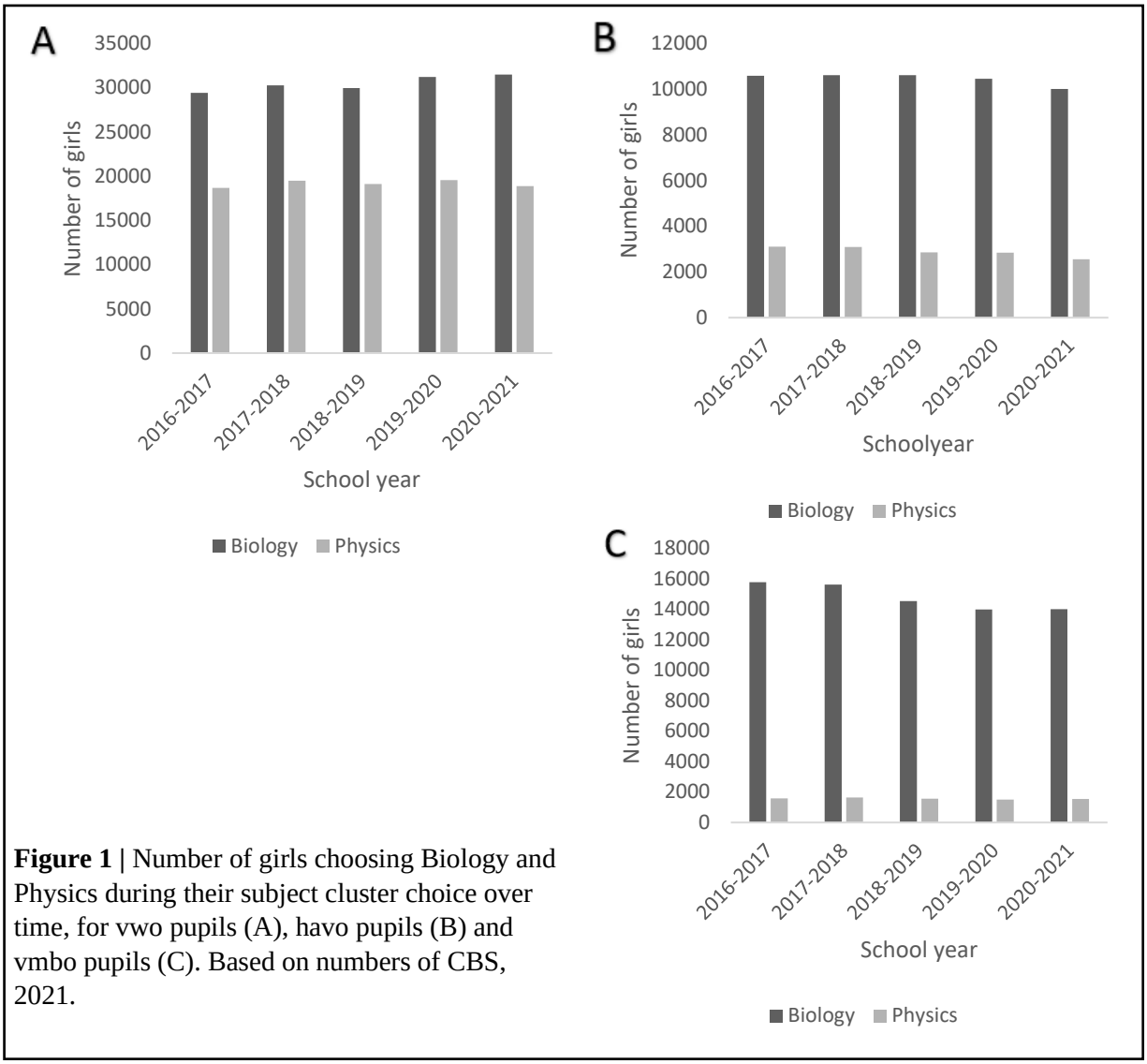

Figure 1 | Number of girls choosing Biology and Physics during their subject cluster choice over time, for vwo pupils (A), havo pupils (B) and vmbo pupils (C). Based on numbers of CBS, 2021.

Factors in education that impact girls' schooling and career choices

The field of STEM is stereotyped as a male working field (Nosek et al., 2009; Steffens et al., 2010). Notwithstanding, the gender stereotype of science differs between the field of physics and biology. In secondary school, female pupils perceive physics as non-female, while male pupils perceive this as a 'male subject' (Makarova et al., 2019; Makarova & Herzog, 2015). On the other hand, as the gender gap in the field of biology is closing with females even starting to dominate the field, it is often labelled as gender-neutral or a 'non-male domain' in research (Ertl et al., 2017). Thus, physics is perceived as a male-domain, while biology is seen as a gender-neutral domain.

Furthermore, if a stereotype threat related to gender, the specific mentioning of the better performance of males, is imbedded in the problem pupils have to solve, a different result is found between the subjects of physics and biology. If a stereotype threat was given in a physics related question, females performed worse than if a stereotype threat was not present in the question (Marchand & Taasoobshirazi, 2013). Contrary, this difference in performance was not found when a gender-related stereotype threat was given in a biology related question (Taasoobshirazi et al., 2019). A similar study of stereotype threat in relation to images among female high schoolers found that female participants who were given a text on chemistry including images of female scientists comprehended the information better as opposed to female participants who were shown male scientists in their text (Good et al., 2010). Likewise, although not statistically different, male participants performed better when being exposed to images showing male scientist as opposed to female scientists. These results indicate that an equal number of female and male individuals in images is preferred to ensure a good comprehension of information for both genders.

Still, to this day, the stereotype of physics is male and results in females not having a sense of belonging within this field, while they do feel a sense of belonging in the field of biology (Rainey et al., 2018). Consequently, this could lead them to choose a different career path or specialization of which females do identify with the image (Starr, 2018). How staff members of secondary schools, like teachers, deal with this stereotype has an influence on the career choice of their female pupils (Ertl et al., 2017). Girls' self-concept is positively related to their own interest in STEM subjects as well as role modelling of their teachers. This indicates that schools explicitly reinforcing female pupils to engage with STEM subjects could have a positive influence on them pursuing a career in the field of STEM. However, if only female pupils are supported in this way about their STEM subjects, their self-concept is influenced negatively, because their gender is overemphasised and they perceive their individual ability as not sufficient enough (Ertl et al., 2017). Thus, a less explicit, but far-reaching, way of female role modelling during secondary school STEM subjects is preferable.

A far-reaching and common factor between secondary school pupils around the world is their exposure to textbooks, which they spend around 80 to 95% of their schooltime using (Sadker & Zittleman, 2007). These textbooks are made to introduce pupils to science, directly and indirectly showing which people are associated with the field of STEM. Blumberg (2008) found that females were underrepresented in educational textbooks around the world, in mentions of female names as well as presence in images. Furthermore, stereotypical male and female characteristics and occupations were frequently described in textbooks (Blumberg, 2008). Males are portrayed as being assertive and having paid work, while women are nurturing and take care of the housework to make sure their husband is happy. Another research on the presence of females in chemistry textbooks found a bias towards famous male scientists in text, as well as the number of males shown in images (Murray et al., 2021). Additionally, men are shown more often in scientific context and scientific roles, while women are represented less in the field of science and more often associated with domestic activities (Murray et al., 2021). While this is an issue of notable inequality between gender representation in science, it can also be used as an opportunity to change and reduce the existing gender-gap by introducing a more equal gender representation in textbooks and thereby start breaking the gender stereotype of science.

To change the image of a STEM field, female role models can be introduced. Role models are found to improve females' sense of belonging in STEM (Breda et al., 2021). As role models have an influence on the sense of belonging and that in turn has influence on females' choice for a STEM-related career, the presence of female role models in secondary education textbooks (Bax, 2021) could influence girls' SC choice. The underrepresentation of females in physics could be maintained by the lack of female role models in the environment of girls' (Murphy et al., 2007). The presence of relevant females in textbooks could help change the image of science as a male-field.

Research question

In this research, the presence of female role models in Dutch secondary school textbooks will be studied for both the subject of biology and physics. The textbooks used in the year pupils decide on their SC specifically, as they actively consider their SC choice at that time. This is studied to give insight in role model availability during girls' SC choice in Dutch secondary school education. Thus, in this study the following questions will be researched:

1. *To what extent and in what variety are female role models present in Dutch biology and physics textbooks in the year pupils are deciding on a subject cluster choice?*

It is expected that fewer (relevant) females will be present in physics and biology textbooks as opposed to (relevant) males as this is found in Dutch upper secondary physics textbooks (Bax, 2021) as well as science textbooks overall (Elgar, 2004). Thus, this difference is expected in Dutch lower secondary physics and biology textbooks as well.

2. *Does the presence and variety of female role models in Dutch textbooks differ between biology and physics, and between the three levels of education: vwo, havo, and vmbo?*

As physics is perceived as a male-domain, while biology is seen as a gender-neutral domain (Ertl et al., 2017; Makarova et al., 2019; Makarova & Herzog, 2015), it is expected that this is reflected in female role model availability of biology and physics textbooks as well. Physics textbooks are expected to have a less equal gender representation as opposed to biology textbooks. Moreover, as the difference between girls choosing biology and physics is greatest on educational level vmbo, and least on educational level vwo, it is expected that the difference in female representation between the two subjects is the highest at vmbo level and the lowest at vwo level. Additionally, to investigate the possible difference of role model availability in girls' social environment for physics and biology and the influence thereof on their SC choice will be explored by interviewing Dutch secondary school girls. As role models are perceived as influential on people's future career aspirations (e.g. Blickenstaff, 2005; Kessels, 2015; Murphy et al., 2007; Rainey et al., 2018), the influence of role models on female Dutch secondary school pupils is expected to be mentioned as a factor for deciding on girls' final SC.

Methods

In this study the presence of female role models, in Dutch secondary education textbooks for biology and physics is researched. This research focusses on a quantitative study on Dutch biology and physics textbooks, and supports this with a qualitative study on girls' perspective of the influence of role models and their social environment on their SC choice.

Textbook analysis

Data collection

In this study, twelve Dutch physics and biology textbooks of vmbo2, havo3, and vwo3 of the publisher Malmberg were analysed. These specific textbooks were chosen as they are used by pupils in the year they decide on their SC. Two textbooks per educational level have been analysed for both biology and physics (table 4). The unit of analysis in this study was defined as a mentioned individual in the textbook. Every individual that gets mentioned was given their own unique code to identify each unit of analysis. If the same individual was mentioned more than once per paragraph, they were only noted once. However, if the same individual was mentioned again in another paragraph, they were noted again with the same unique code. This could result in an unique code being present more than once in the dataset. For example, if Charles Darwin got mentioned in two consecutive sentences, he was noted only once. But if Charles Darwin was mentioned in chapter 1 and again in chapter 4, this individual was included in the dataset twice, as the pupil has been reminded of this individual once again.

Table 4 | *Overview of analysed secondary school textbooks*

Biology		**Physics**	
Biologie voor Jou – VWO|GYMNASIUM 2A	265 pages	NOVA – VWO|GYMNASIUM 3A	186 pages
Biologie voor Jou – VWO|GYMNASIUM 2B	295 pages	NOVA – VWO|GYMNASIUM 3B	192 pages
Biologie voor Jou – HAVO|VWO 2A	250 pages	NOVA – HAVO 3A	180 pages
Biologie voor Jou – HAVO|VWO 2B	271 pages	NOVA – HAVO 3B	192 pages
Biologie voor Jou – VMBO-KGT 2A	274 pages	NOVA – VMBO-KGT 1|2A	207 pages
Biologie voor Jou – VMBO-KGT 2B	273 pages	NOVA – VMBO-KGT 1|2B	249 pages
Total	*1628 pages*	*Total*	*1206 pages*

Instrument of analysis

The textbooks were analysed on the presence of role models using a modified version of the textbook analysis tool created by Bax (2021). This textbook analysis tool was adjusted in three different sections to fit the textbooks analysed in this study (table 3). Firstly, the original textbook analysis tool included a section on the order in which male and female individuals were mentioned in a paragraph or sentence, called 'firstness'. This firstness-section was removed as two individuals with different genders in the same sentence or paragraph did not occur regularly in the textbooks, leading to little data collection. Secondly, a third option for the relevance of an individual has been added to fit the textbooks analysed for this study. The option 'relevant' is noted if an individual is working in the field of the subject and 'irrelevant' if they are not related to the subject. However, as these textbooks include assignments which the pupils have to make, many individuals are in positions similar to 'peers' of the reader in these assignment sections. These individuals are, for example, conducting a practical similar to the ones the pupils will perform or simply 'biking to school'. These individuals are fictional and could have been given any male or female name, as the gender of this individual does not matter. Thus, these individuals were not noted as 'relevant' or 'irrelevant', but as 'representative' to indicate a potential 'peer' position in relation to the reader (see appendix B). This distinction is made to investigate a possible difference between individuals mentioned in the assignment sections of the textbooks and the rest of the text. Lastly, as this research is focused on the difference between male and female, mentions of a group of people (e.g. 'scientists') or an unknown gender (e.g. 'a cyclist') were not included in this research. The mentioning of an individual with an unknown gender, even if a male-gendered word is used, was not included in this research as in the Dutch language the masculine generic is commonly used. For example, a 'wielrenner' (cyclist) is a male-gendered noun in Dutch language, but it is not uncommon to use this word when speaking of a female individual. The female-gendered noun 'wielrenster' ('cyclist') does exist, but is not often used. Thus, if only the male-gendered noun without a male or female pronoun is used, this individual was not included in this study, as the gender was unclear. However, if the previously gender neutral individual in the textbook was later referred to with a specific pronoun (male or female), this individual was included in this study. For example, 'The cyclist speeds up from 45 to 68 km/h in a short amount of time. This made his teammates lose track of him.', this individual would have been noted with the gender 'male'.

Table 3 | *Adjusted textbook analysis tool (orginal by Bax (2021)). Example sentence: "The theory of evolution was mainly developed by Charles Darwin, an English researcher from the nineteenth century." (BvJ, HAVO 3B, p. 125).*

Name	**Definition**	**Example**
School level/system	Educational level of textbook: vmbo/Havo/Vwo	Havo
School subject	Subject of textbook: biology or physics	Biology
Page	Page the individual is mentioned	125
Individual	Unique number of the individual	76
Gender	Gender of the individual: male/female	Male
Occupation	Occupation of individual as mentioned in the textbook	Scientist
Educational level	Minimum educational level required for the mentioned occupation	WO
Relevance	Relevance of the individual related to the subject (biology or physics): Relevant/Representative/Irrelevant	Relevant
Existence	Individual is fictional or non-fictional	Non-fictional
Time	If individual is non-fictional, when did they live: historical/contemporary	Historical
Additional remarks	For example: famous scientist, image, example for assignment	Famous scientist
Name	Name of individual if mentioned, otherwise 'No name'	Charles Darwin

This modified textbook analysis tool focusses on the gender, educational level, existence, and relevance of the mentioned individual (table 3). The number of female and male individuals presented in the textbook were quantified to determine the balance between (potential) male and female role models. Additionally, to note a certain individual as a potential role model, their relevance to the subject of the textbook (biology or physics) had to be determined. The educational level of the individual has been based on their occupation. The minimum educational degree required for the occupation was determined using the *Nationale Beroepengids* ('National Career Guide'). Lastly, the individuals were coded as either fictional or non-fictional characters. If they were non-fictional, the time period where they were active in their field was noted as either historical (before 2008) or contemporary (2008 or later). The year 2008 has been used to distinguish time periods based on the age of the participants, as this is the average year of birth of the participants.

To test the reliability of the adjusted textbook analysis tool, an inter-reliability check was conducted by a second coder. The second coder was given a random chapter of both a biology and physics textbook and asked to code these sections given only the textbook analysis tool and no further instruction. The code categorization was compared and discrepancies were discussed, resulting in tweaking of the codes' definitions (appendix B).

Data analysis

Statistical analysis on the data of textbook has been performed using Rstudio (version 2022.07.1). Differences between two groups were assessed using exact binomial tests. The results of the male/female ratio of individuals in the textbooks of the three education levels were analysed by a chi-square test. Differences were considered significant if the p-value < 0.05. As the number of individuals related to an occupation were low, the male/female-ratio of the level of education of persons was reported descriptively. The male/female ratio of subject-related individuals of biology and physics textbooks have also been described because the number of non-fictional individuals were too low to conduct statistical analysis on. For the same reason, a descriptive analysis instead of statistical analysis was performed for the male/female ratio between historical and contemporary individuals.

Interviews

Participants

To explore girls' perspectives on role models in their social environment and the influence thereof on their SC choice, a qualitative study was included by interviewing four female secondary school pupils of 14-15 years old in their 3rd year of the educational level vwo. This number of participants was for reasons of feasibility within the timeline of the project and intended as an exploratory study to provide context surrounding the factors determining girls' SC choice. Data was collected according to ethical guidelines of Utrecht University. Parents or guardians, and participants were informed about the content and purpose of the interviews and a signed informed consent was obtained. After completion of interviews the data was anonymised. Pupils were selected who were deciding on their SC, and thus would be actively thinking of what subjects to choose. To conclude, the requirements for pupils to participate were threefold: they identify as female[1], were choosing their subject cluster in the current schoolyear, and wanted to include either biology or physics in their subject cluster for their upper level secondary school education.
The secondary school at which these interviews were conducted is called Lek en Linge and is based in the city of Culemborg in the Netherlands. This school intensively helps pupils with their SC choice. They provide tests to help pupils find out what interests them, what they might need for possible future careers, and what their potential is. Besides these tests they also speak with mentors on their SC choice, have to defend their SC choice to their peers, and organise an informative presentation in which the pupils themselves have to present the four SCs to their parents and/or guardians.

[1] In this thesis a 'female individual' is defined as a person who identifies as female. A 'male' individual is a person who identifies as male. The scope of this thesis is limited to the binary gender system. Individuals who do not (always) identify as either of these genders are not taken into account by lack of prior research. A follow-up study including all genders is recommended.

Data collection

Data was collected from semi-structured interviews using guide questions (appendix C) with room to ask participants further about their answers. The questions for this semi-structured interview were based on different studies on people's sense of belonging and making a choice towards the field of STEM (Bax, 2021; Rainey et al., 2018), and Dutch SC choice (Bax, 2021; Survey used in GirsClub WIN[2]). The interview consisted of 18 questions on role models and sense of belonging in either the field of biology and physics. The data collected with the interviews give insight on the influence of girls' social environment on their subject cluster choice for biology and physics.

Data analysis

The data collected with the interviews were analysed using a combination of a top-down and bottom-up approach by Corbin and Strauss (1990) until saturation. The codebook has been designed by a top-down approach using literature on the influence of other people on the career choices children make (Bax, 2021; Ikonen et al., 2017; Rainey et al., 2018). Subsequently, the codebook was adjusted in a bottom-up manner based on the answers of the interviewees (appendix D). The interviews were transcribed and coded in NVivo (version released in March 2020) to get an overview of the collected data

The interviews were conducted to provide insight in how girls perceive role models in their social environment and other factors to influence their subject cluster choice for biology or physics. This information has been used to support the implications based on the textbook analysis.

Results

In this study, the presence of female role models in Dutch secondary education textbooks of physics and biology have been researched using a textbook analysis tool. Additionally, a small-scale explorative study on girls' perspectives on the presence of role models in their social environment and other factors influencing their STEM-related subject cluster (SC) choice has been investigated by conducting interviews.

Textbook analysis

For this part of the research the physics and biology textbooks of the publisher Malmberg for educational levels 2-vmbo, 3-havo, and 3-vwo have been analysed by using an adjusted textbook analysis tool based on Bax (2021). Individuals mentioned in text or visible in images are noted with information on their gender, occupation and relation to educational level, relevance, and existence (if given). Firstly, the general findings in the biology and physics textbooks related to these topics are presented, followed by findings on the non-fictional individuals and lastly fictional characters specifically.

Gender in general

On the total of 1628 pages of analysed biology textbooks, 474 times an individual is mentioned[3] (see table 5). These individuals consists of 280 men (59%) and 194 women (41%) which is a statistically significant difference (binomial test, N= 474, $p<0.001$). This same percentage of male and female individuals is found in the 1206 pages of analysed physics textbooks, with 268 male (59%) and 184 female individuals (41%) which shows a significant difference as well (binomial test, N= 445, $p<0.001$). A similar pattern is found in all three educational levels of the textbooks, with the difference between presence of men and women being statistically significant in the vmbo textbooks (biology: binomial test, N= 155, $p<0.05$; physics: binomial test, N= 133, $p<0.01$), havo textbooks (biology: binomial test, N= 156, $p<0.05$; physics: binomial test, N= 150, $p<0.05$), and vwo textbooks (biology: binomial test,

[2] The U-Talent Girlsclub is an initiative of Utrecht University for secondary school girls to encourage them to study physics or computer science at university. They organise modules related to mathematics, physics, and computer science at university.

[3] Note that this number consists of mentioned individuals and not unique individuals. This has been done to get an indication of how many times a pupil gets exposed to an individual. For example, if Charles Darwin is mentioned ten times throughout the book and Liesbeth Woertman once, it does not give a representative view of the presence of male and female role models if they would both be counted as 1 in this analysis. However, in the section on non-ficional individuals, the number of unique individuals is analysed.

N=155, $p<0.01$; physics: binomial test, N= 160, $p<0.05$). No difference in the gender ratio is found between the three educational levels of textbooks (biology: chisquared test, N= 466, $p>0.05$; physics: chisquared test, N= 443, $p>0.05$), meaning the textbooks of all three educational levels are significantly imbalanced separately but this imbalance does not differ significantly between the three educational levels.

Table 5 | *Proportions of individuals mentioned in all the physics textbooks and biology textbooks combined.*

Subject		**Total**	**Female**		**Male**	
		Number	Number	Percentage	Number	Percentage
Biology	Individuals	474	194	41%	280	59%
	Relevant	62	17	27%	45	73%
	Representative	35	12	34%	23	66%
Physics	Individuals	445	184	41%	261	59%
	Relevant	52	7	13%	45	87%
	Representative	120	64	53%	56	47%

Gender and relevance

The difference in gender representation regarding relevance is present in both biology and physics textbooks. On the subject of biology, females are underrepresented in both the category of relevant (27%, binomial test, N= 62, $p<0.001$) and representative (34%, binomial test, N=35, $p=0.045$) individuals. The gender imbalance in physics textbooks is found in regards to relevant individuals (13%, binomial test, N= 52, $p<0.001$), but not representative individuals (53%, binomial test, N=120, $p=0.79$). Thus, for both the subject of biology and physics, the difference between the presence of relevant male and female individuals, in general, is statistically different in favour of male individuals compared to female individuals. However, the statistically significant imbalance in gender representation of representative individuals in favour of men is only found in biology textbooks.

Gender and educational level

To determine the educational level of an individual the minimum educational level required for their mentioned occupation is considered. In total, 107 individuals mentioned in the biology textbooks were related to an occupation and thus could be paired to an educational level (see figure 2A). For example, 39 male individuals have an occupation that requires a minimum educational level of wo, while for females 8 individuals with this educational level are mentioned. In biology textbooks, individuals with an occupation which requires a mbo or wo education are relatively more often men than women, while individuals with an hbo education are more often women. These women with an hbo education are mostly dieticians or midwives.

In physics textbooks, a total of 98 individuals were connected to an occupation. The minimum educational level required for these occupations have been visualised in figure 2B for both male and female individuals separately. For all levels of education, individuals are relatively more often men than women. The biggest difference between male and female individuals is found at wo-level (91% male, 9% female).

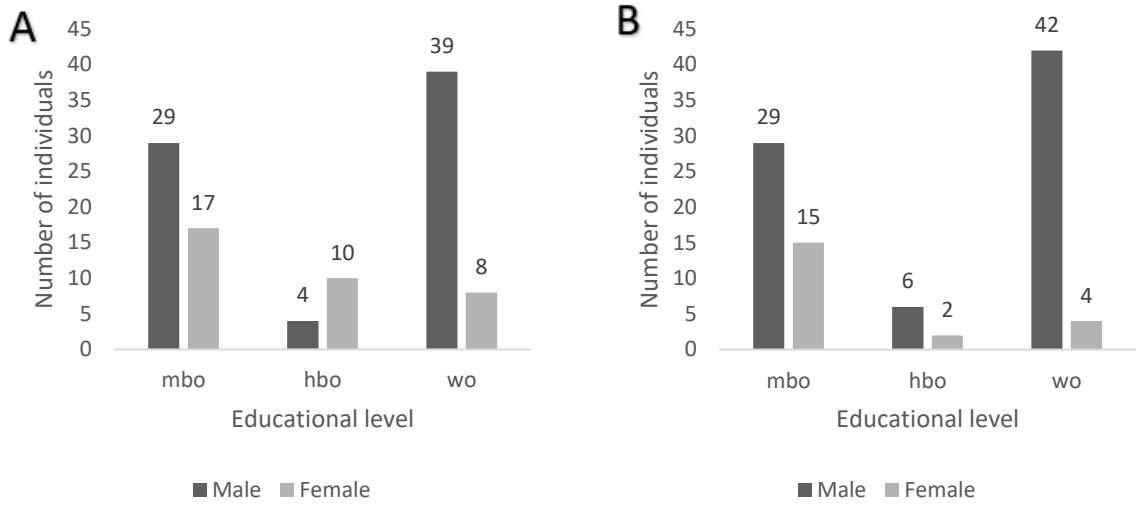

Figure 2 | *The number of individuals mentioned in biology textbooks (A) and physics textbooks (B) categorized by the educational level of the occupation per gender.*

Thus, the difference in gender representation is greatest for careers which require the highest level of education (wo) in both biology (83% male, 17% female) and physics (91% male, 9% female). Careers which require an mbo level of education are more likely to be related to a male individual for both biology (63% male, 37% female) and physics textbooks (66% male, 34% female). In biology textbooks, more female individuals are related to a hbo level education (71%) as opposed to male individuals (29%). However, in physics textbooks this level of education is more often related to men (75%) as opposed to women (25%).

Gender and non-fictional individuals

The number of unique non-fictional individuals are noted and visualised in table 6 below. The list with the names of all non-fictional individuals mentioned in both the biology and physics textbooks are included in appendix E.

In total, 33 unique non-fictional individuals are mentioned in the biology textbooks (table 6), consisting of 24 male individuals (73%) and nine female individuals (27%). A similar pattern is found in physics textbooks, which contained 27 unique individuals, of which 24 were male (89%) and three were female (11%).

Table 6 | *Proportions of unique non-fictional individuals in all the physics textbooks and biology textbooks combined.*

Subject		**Total**	**Female**		**Male**	
		Number	Number	Percentage	Number	Percentage
Biology	Individuals	33	9	27%	24	73%
	Biology related	19	3	16%	16	84%
Physics	Individuals	27	3	11%	24	89%
	Physics related	18	2	11%	16	89%

Non-fictional individuals are categorized in *related* and *unrelated* to the field of biology or physics. As this research focusses on role models for these specific fields of science, the non-fictional individuals related to the appropriate field of science are further analysed based on the time period they were active in their field.

Gender and time period

Non-fictional individuals are categorized as an either historical or contemporary figure. An historical figure is defined as an individual who was active in their field of work before 2008, contemporary figures are individuals who are or were active in their work field in 2008 or later. Both historical and contemporary individuals are more often male than female in both the textbooks of biology (figure 3A) and physics (figure 3B). However, the number of contemporary individuals is higher in biology textbooks (17) as opposed to historical individuals (2). This difference is the opposite in physics textbooks, with more historical individuals (14) contrary to contemporary individuals (4). Though, the common ground in both biology and physics textbooks, is the absence of historical non-fictional females (both 0).

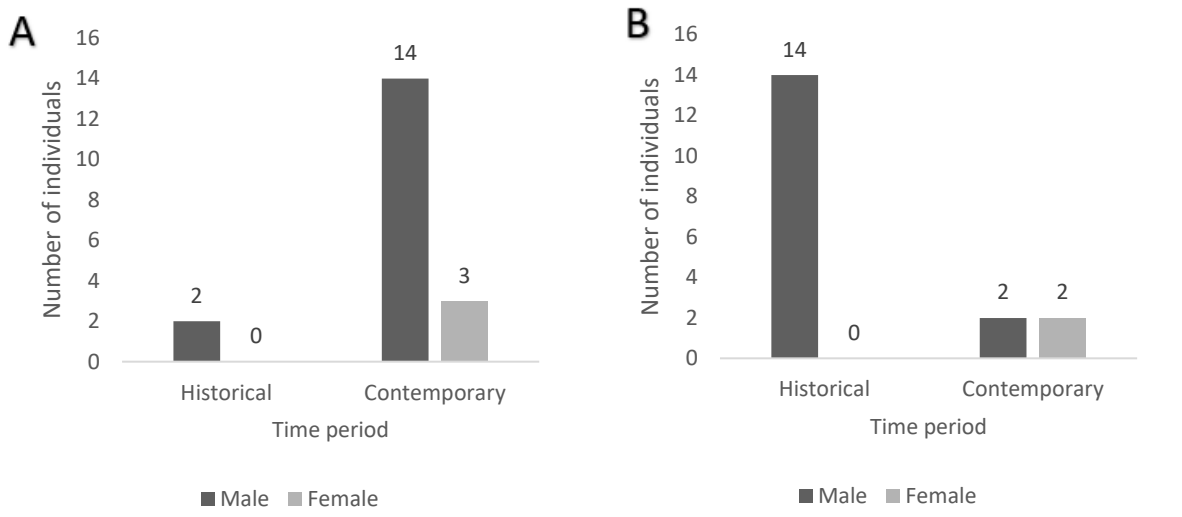

Figure 3 | *The number of non-fictional individuals mentioned in biology textbooks (A) and physics textbooks (B) categorized by their gender.*

Gender and fictional individuals

The number of unique fictional individuals are noted and visualised in table 7. In the biology textbooks, a total of 391 fictional individuals are mentioned of which 222 (57%) are male and significantly less are female (169, 43%, binomial test, N= 391, $p<0.01$). This gender difference is not statistically significant in physics textbooks (binomial test, N= 374, $p>0.05$), of which 200 male characters (53%) and 174 female characters (47%) were mentioned. When assessed further on relevance, 10 relevant females (40%) and 15 relevant males (60%) are present in biology textbooks, alongside 12 representative females (41%) and 17 representative males (59%). The number of relevant characters is lower in physics textbooks, consisting of one relevant woman (17%) and five relevant men (83%), but the number of representative characters is higher, with 56 men (47%) and 64 women (53%). Thus, overall less fictional women are present in biology and physics textbooks, with the exception of the number of representative characters in physics, consisting of more women than men.

Table 7 | *Proportions of fictional characters in all the physics textbooks and biology textbooks combined.*

Subject		**Total**	**Female**		**Male**	
		Number	Number	Percentage	Number	Percentage
Biology	Individuals	391	169	43%	222	57%
	Relevant	25	10	40%	15	60%
	Representative	29	12	41%	17	59%
Physics	Individuals	374	174	47%	200	53%
	Relevant	6	1	17%	5	83%
	Representative	120	64	53%	56	47%

Gender(neutrality) and pronoun usage

In the textbooks, some individuals are not linked to a name and can be perceived as gender neutral. However, some of these gender neutral individuals are referred to with a pronoun in the text, linking these characters to a specific gender.

In the biology textbooks, these gender neutral individuals are linked to a specific gender pronoun in 64 cases. Of these cases, 54 times (84%) the previously gender neutral characters are referred to with a male pronoun, and 10 times (16%) with a female pronoun. This gap is a bit smaller in physics textbooks, with 24 cases (69%) of male pronoun use and 11 cases (31%) of female pronoun use. These differences between previously gender neutral individuals receiving a male or female pronoun is significant in both biology and physics textbooks (binomial test, N=64, $p<0.001$; and binomial test N=35, $p=0.02$, respectively).

Gender and images

A total of 229 individuals are present in images of the analysed biology textbooks, 113 of these individuals were male (49%), while 116 were female (51%). This difference in favour of female individuals, was not significant (binomial test, N=229, $p=0.6042$). Contrary, the difference between the number of 90 male (61%) and 58 female (39%) individuals seen in images in physics textbooks is significant (binomial test, N=148, $p<0.01$).

Thus, in biology textbooks the statistically significant gender imbalance in pronoun usage for previously gender neutral characters is not found in the gender presence of men and women in the images (see figure 4). The statistically significant gender imbalance is however, present in both pronoun usage and images in physics textbooks.

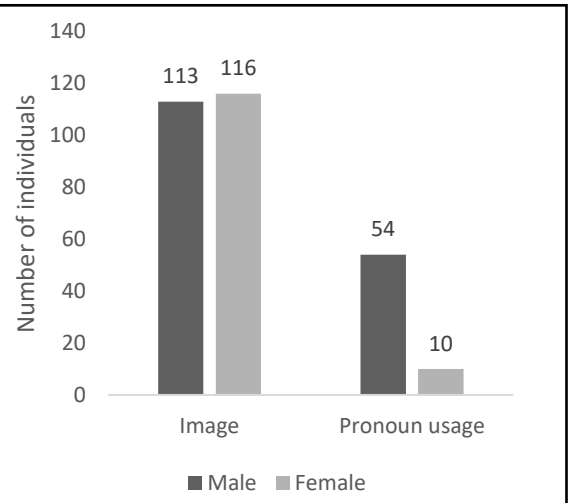

Figure 4 | *The number of male and female individuals in images and pronoun usage in biology textbooks categorized by their gender.*

Gender and specific observations

During the textbook analysis, a few striking and relevant observations have been made. The two most relevant observations in relation to this research are briefly described below.

Firstly, the physics and biology textbooks include information on practicals the pupils can perform during class. in these explanations the teacher is often mentioned as a person who can help or will give the pupils the right instruments to perform a certain practical. In the physics textbook for educational level vmbo, the teacher is referred to as a ‘he’ instead of having the teacher remain gender neutral (NOVA, vmbo-2A, p. 18). Hinting to a subconscious association of physics teachers to men.

Secondly, one non-binary person in total is mentioned per educational level in biology textbooks. Leonne Zeegers is mentioned in the vmbo textbook (BvJ, vmbo-2B, p. 46) and Marieke Lucas Rijneveld in the havo textbook (BvJ, havo-2B, p. 42) and vwo textbook (BvJ, vwo-2B, p. 46). Both of them are, however, referred to with an incorrect pronoun (she/her, 'zij/haar') instead of their right pronoun (they/them, 'hen/hun').

Interviews

Four pupils on the educational level of vwo of the Lek and Linge secondary school were interviewed to explore the factors of girls' SC choice. To illustrate the findings, multiple quotes are presented using aliases of the participants' names. The main factors mentioned in these interviews are a) their interest in the subject and b) their future career or study goals. All participants mentioned both these factors multiple times, for example:

Taylor mentioned an argument for not choosing physics based on interest: *"And I don't really feel excited to know how force works when something falls down. That's, yeah, a little too abstract or something. It doesn't interest me that much either."*

Taylor mentioned an argument for choosing biology based on interest: *"I have actually always had a great interest in nature and in animals. [Also] other subjects that they discuss in biology, I find very interesting."*

Luca mentioned an argument for choosing physics based on possible future studies: *"Well, when we had to choose a subject cluster and looked at [the options]. It was also a bit like: 'Which study do you want to do later?' And then I was soon [looking] in the technical direction"*

Cameron mentioned an argument for not choosing biology based on possible future studies: *"But I [also] don't really see myself working in the medical field or anything."*

The pupils also mentioned the influence of their parents and teachers. They expressed reconsidering not choosing a specific subject if their parent or teacher would advise against doing so, but not the other way around. They would not reconsidering choosing a specific subject they initially did not choose themselves, if they were stimulated to do so by their teacher of parent.

Luca mentioned an argument for not choosing a subject even when being stimulated to do so:
"Interviewer: What if a teacher said: But [I think] biology suits you very well!", would you reconsidering choosing the subject or not?

Luca: Well, that's [still] my own choice. And if a teacher says that to me, it's nice to know that they think I can do that, but no [I would not reconsider]."

Luca mentioned an argument for reconsidering choosing a subject by being advised against choosing the subject:
"Interviewer: "But if they [teacher/parent] say, 'I don't know if that's a good choice [for you],' would that affect your decision?

Luca: Yes, maybe a little, because I mean, they are also older and they have more insight into what studies entail I think. So if they told me, "well, I don't know if that's a smart decision," we'd have a conversation about that. So, maybe [it would] influence [me] too."

All pupils mentioned being in charge of their own SC choice and not being influenced by the choices of their friends: *"Interviewer: And if your friends hadn't chosen this subject? Alex: Then I would still have chosen it"*.

All pupils were able to name a male biologist, namely Freek Vonk, but none was able to name a female biologist. Three out of four participants were able to think of a male physicist, namely Albert Einstein and James Watt, and one participant could name a female physicist, namely Marie Curie.

Further, one pupil, Taylor, mentioned the influence of the media on her inability to name a female physicist:

"I think that more male biologists and physicists are in the news a lot. And then the women remain in the background or something. […] I see quite some female biologists in the news. But you also see some men. I don't think it differs that much [in biology].".

Discussion

In this research, the extent and variety of female presence in biology an physics textbooks and the factors of role models on girls' STEM-related subject cluster (SC) choice in Dutch secondary education has been studied. A textbook analysis has been performed on biology and physics textbooks, which secondary school pupils use in the year of their SC choice, which have a significant influence on their future career path. This analysis has been supported by exploratory interviews, with female secondary school pupils, about their view on the influence of role models and other factors on their SC choice.

Firstly, we studied to what extent and in what variety female role models are present in Dutch biology and physics textbooks in the year pupils are deciding on a subject cluster choice. We found the female presence in both the biology and physics textbooks to be significantly lower compared to male presence, which is not an accurate representation of society, as this would be 50/50[4]. Furthermore, female role models are significantly less available for girls in Dutch secondary school textbooks of both biology and physics. Both non-fictional individuals and fictional characters, related and unrelated to STEM, are more often men than women. This is in line with research on Dutch secondary school textbooks of computer science, upper education physics (Bax, 2021), and mathematics (Derks, submitted 2022). The absence of relevant female role models has an influence on women's sense of belonging in the field of STEM (Cheryan et al., 2015) and their self-efficacy (Quimby & DeSantis, 2006). This leads women to feel as if they do not belong or are not capable to develop a career in STEM and thus not doing so (Avargil et al., 2020; Kalender et al., 2019; Rainey et al., 2018).

Furthermore, the pronoun usage for, previously, genderless fictive characters, tends to be significantly more often male than female in both the biology and physics textbooks. If a gender-specific pronoun is used, the subconscious association of that specific gender to a certain occupation can have unforeseen consequences. Women feel less connected to a certain text if male pronouns are used as opposed to using both female and male, or only non-binary pronouns (Keener & Kotvas, 2022). This indicates that the (possible) subconscious use of male pronouns, can influence the connectedness of female pupils to the subject.

Secondly, we studied the difference in presence and variety of female role models in Dutch textbooks between biology and physics, and between the three levels of education: vwo, havo, and vmbo. Differences between biology and physics textbooks are found in the number of fictive representative characters. These individuals were almost strictly found in the assignment sections of the textbooks. In biology textbooks, a significant difference is found between female and male representative individuals, while this difference is not found in physics textbooks. Like role models, relevant individuals are known to increase ones sense of belonging to a field (Cheryan et al., 2015), the presence of representative individuals can lead to a different relatability towards a certain work field. The representative characters in the analysed biology and physics textbooks are mostly 'peers' of the readers as they are characters who perform practical's the readers will or can do themselves. Studies show that students who have a peer-lead team in face-to-face situations will view their peer as relatable and a good role model (Winterton et al., 2020). Having a peer mentor also increased middle schoolers' self-efficacy and interest in the field of computer science (Clarke-Midura et al., 2018). These studies have taken only face-to-face

[4] The 50/50 ratio is based on the binary gender system used in this study.

peers into account, the influence of fictive peers in textbooks have not been studied yet. Still, it can be imagined that a minimization of the gender gap by introducing fictive female representatives could be beneficial as they could improve pupils' self-efficacy and increase their interest in the field of biology and physics. Furthermore, the choice for an either male or female fictional name can be viewed as an active process, which could explain the inclusion of more women as representatives in physics textbooks. This active process makes a possible gender imbalance more likely to stand out during the writing process.

Another difference between Dutch physics and biology textbooks lies in the number of female and male individuals shown in images. This shows a gender imbalance in physics textbooks, but not in biology textbooks. This is in line with research studying textbooks on other male dominated fields including politics in which 28% of images included a woman (Olivo, 2012) and chemistry textbooks in which this amounted to 6% of the images (Murray et al., 2021). Inclusion of female scientists in images of secondary school textbooks results in a good comprehension of information and a better performance by girls (Good et al., 2010).

Furthermore, a difference between female presence in images and pronoun usage in text is found in biology textbooks. The male/female ratio in images is close to equal, whereas male and female pronoun usage for nameless characters is significantly favoured towards men. Research by Mesman et al., (2019) studied mathematics and Dutch language textbooks on variety of ethnicity and found a bigger variety in text when compared to the presence in images. In an interview on their research with a Dutch journal (Trouw, 2019), Mesman speculated this difference to be of subconscious nature: "*"So it seems that the people responsible for the illustrations in the books are more conscious of depicting different ethnic backgrounds," Mesman says. "Perhaps because an image simply stands out more than a name in a text"*.". This would support the hypothesis that male pronoun usage in text is a subconscious act which should be made aware to correct this imbalance.

Finally, the difference of male/female ratio between the three educational levels of the textbooks was not significant, meaning that all three levels of education (vmbo, havo, and vwo) have significantly less female presence as opposed to male representation, but that not one level of education was significantly more gender imbalanced than the others. This is not in line with the difference in number of girls choosing biology and physics in their SC between the three levels of secondary education, as the difference is biggest at the educational level vmbo and lowest at vwo-level. This could indicate that either the female presence in textbooks do not have an impact in girls' SC choice or that a significant difference in male and female representation has the same negative effect regardless of the degree of the imbalance. Nevertheless, we believe the later explanation to be more likely, because many studies on the effect of female/male ratio in textbooks support an association between the representation of gender in educational textbooks and the representation of gender in the STEM working fields (Mburu & Nyagah, 2012; Potter & Rosser, 1992).

Additionally, girls perception of role models in their social environment and other factors to influence their STEM-related subject cluster choice was studied. Four main factors are found to influence their SC choice: interest, future career, parent and teacher, and portrayal of scientists in the media. Firstly, interest in the subject seemed to be a main factor as all participants mentioned choosing subjects based on either liking or disliking it. The factor of interest in a certain subject has a positive influence on a person pursuing a career in this field later in life (Morgan et al., 2001). The participants mentioned being influenced by how well they performed in different subjects and based their future sense of belonging to their current efficacy. Focussing on both interest and ones self-efficacy is found to be significant factors affecting the certainty of a person's future career choice (Tracey, 2010). Secondly, the preparation for girls' future career itself was found to be a main factor in their SC choice. All four participants mentioned thinking about their possible future studies and discussing their thoughts with others. These findings are in line with research of (Derks, 2022) for which 8 female Dutch secondary school pupils are interviewed on their SC choice and how they perceive the image of scientists. They also found this to be one of the main factors for girls' SC choice. Thirdly, the influence of a parent figure or teacher is considered as a factor for girls' SC choice. A positive or negative remark about a girl

choosing a specific subject, seems to bring about a different response. If a girl gets a positive remark about their efficacy or sense of belonging to a certain subject, she does not reconsider their SC choice. However, if they are questioned on their self-efficacy or sense of belonging to a subject, they do reconsider and potentially adjust their previous SC choice. In a Finish study on ninth graders' educational and career choices, parents were found to be a main source of speaking in a gender-stereotypical way about career possibilities to their children (Ikonen et al., 2017). Parents of adolescents also believe science to fit better with their sons as opposed to their daughters, resulting in a lower self-efficacy of the daughters (Tenenbaum & Campbell, 2003). Lastly, one interviewee mentioned her observation of an imbalance in gender representation of scientists in the media. She mentioned seeing more male compared to female scientists on tv and in the news. Middle school pupils tend to gather their information and base their view on the image of science on media sources (Steinke et al., 2007). This can be seen in the results of the interviews as well, because all participants named the same male biologist Freek Vonk. This particular biologist is frequently seen in the media, with a target audience ranging from primary school children to university students and adults. An implementation of more female biologists and physicists in the media could potentially lead to a changed perception of science from male-dominated to gender equal and positively influence girls' sense of belonging.

However, as these results are based on a total of four interviews, the indications resulting from it, should be studied more thoroughly. This research was further limited to include only vwo3 pupils and could be expanded to different educational levels and involve more participants, including male pupils. Furthermore, the participants were asked by the teacher themselves and thus the results could be biased towards a certain type of pupil who is confident and comfortable with talking about their decisions, possibly having weighed their options relatively more than other pupils. Interviewing different types of schools could possibly yield different results, as the school accommodating the research was thoroughly encouraging pupils to weigh their options and be able to defend their decisions. Pupils from a school with less assistance relating to a pupils' SC choice could have different factors weighing more heavily on their decisions. Furthermore, the semi-structured interviews were performed with neutrality in mind, however certainty of the interviewer having no influence whatsoever on the interviewee cannot be guaranteed.

Further research regarding textbooks could be done by expanding the analysis to books from different publishers and on different (science-related) subjects. A possible difference on role model availability between science-related and non-science-related textbooks could be investigated. As this research included textbooks of one schoolyear only, textbooks from other grades could be analysed as it could influence girls' perceptions towards science as well. Finally, next to not fitting the male-stereotype of science leading to a difficulty in feeling a sense of belonging by women, not fitting the white-stereotype of science is another big issue in feeling a sense of belonging and diversifying science (Rainey et al., 2018). Further research and awareness on ethnicity in science textbooks is recommended.

Finally, this research focussed on gender representation based on the binary system, taking only the male and female gender into account. This choice was made due to the lack of studies on non-binary gender representation in textbooks. As this analysis showed a total of one non-binary person per educational level, addressed with an incorrect pronoun, awareness of this subject instigated by further research is recommended.

This research can, however, be used to create awareness of the gender gap present in existing educational textbooks and possibly lead to adjusting future textbooks, or current lesson contents, to include more female (non-)fictional individuals related to a study or occupation in the field of STEM. Specifically, inclusion of female contemporary physics individuals could help girls to identify with a possible role model and follow in their footsteps in the current society. Additionally, teachers could diversify their education by including a guest lecture by a female scientist or by incorporating a visit of female science students in lesson programs as well. Furthermore, the difference in gender imbalance between informative text and names in assignment sections should be made aware, as assignment sections tend to be more balanced compared to the informative text. The more gender balanced representation in the

assignment sections is also found in the images, and hints to a possible last check by editors in these two categories. A gender representation check by editors should not only exist for images and assignment sections, but also to the rest of the text. A diverse writing and editing staff at publishing firms, as well as a possible course on inclusive writing, could help diversify gender representation in textbooks. Finally, awareness on the masculine generic in Dutch language and subconscious use of male pronouns could help pupils who do not identify as male to feel more included and possibly at home in the field of science in the end. A possible way to include more genders, next to female and male, is the inclusion of more gender neutral (pro)nouns.

The underrepresentation of women in STEM should not be reflected in secondary school textbooks, as it could be maintained by doing so. Female role models should be available in textbooks and girls' social environment to show them science is not only for men, so girls see what they could be.

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Conflict of Interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix

A. List of analysed textbooks

- NOVA – VWO|GYMNASIUM 3A (release 2020)	186 pages
- NOVA – VWO|GYMNASIUM 3B (release 2020)	192 pages
- NOVA – HAVO 3A (release 2020)	180 pages
- NOVA – HAVO 3B (release 2020)	192 pages
- NOVA – VMBO-KGT 1|2A (release 2021)	207 pages
- NOVA – VMBO-KGT 1|2B (release 2021)	249 pages
Total physics	1206 pages

- Biologie voor Jou – VWO|GYMNASIUM 2A (release 8.1)	265 pages
- Biologie voor Jou – VWO|GYMNASIUM 2B (release 8.1)	295 pages
- Biologie voor Jou – HAVO|VWO 2A (release 8.1)	250 pages
- Biologie voor Jou – HAVO|VWO 2B (release 8.1)	271 pages
- Biologie voor Jou – VMBO-KGT 2A (release 8.1)	274 pages
- Biologie voor Jou – VMBO-KGT 2B (release 8.1)	273 pages
Total biology	1628 pages

B. Adjusted textbook analysis tool

List of codes of the adjusted textbook analysis tool with description and marking options. This textbook analysis tool is based on Bax et al., (2022).

Code name	Description	Marking options
School level	Educational level of pupils who use the textbook	Vmbo/havo/vwo
School subject	Subject of the textbook	Biology/physics
Page	Page the individual is mentioned	1/2/3/etc.
Individual code	Specific code for the individual, starting from 1[5] Individuals present in images have "IM" before their number	1/2/3/etc. IM1/IM2/IM3/etc.
Gender	Gender of the individual[6]	Male/female
Occupation	Occupation of individual as mentioned in the textbook. If no occupation is mentioned, note '-'.	e.g. general practitioner/-

[5] Specific fictional individuals mentioned a second (or third etc.) time in the same chapter get the same individual code. Non-fictional individuals get the same code throughout the textbook (e.g. Einstein is always coded by '46').
If individual is mentioned more than once in the same paragraph, they are noted once. However, if they are mentioned again in the next paragraph, they are noted again.

[6] Individuals without an indication of 'gender' are not listed, because the use of male-gendered words is common in the Dutch language (masculine generic).
- Eg. Havo-nat3B, p.15: "A cyclist accelerates from 45 to 68 km/h in a short time". There is no 'gender neutral' term for 'cyclist'. The male gendered form is in many cases seen as gender neutral. This individual is not listed.
- However, the use of male-gendered words without a male pronoun are noted if this can only apply to a man. Eg "brandweermannen" instead of "brandweerlieden". (havo-nat3A, p. 142)
- If a male-gendered word is used and later referred to with a male or female pronoun, the individual is noted: "A skydiver jumps out of an airplane. In figure 12 you see two snapshots of his jump." HAVO3-natB, p. 17
- In the chapter on reproduction of the biology textbooks, all 'women/girls' and 'men'/'boys' denoting the general female or male population are not listed, because they do not fall under role models (e.g. 'A woman has a uterus and ovaries ' – vwo2_bioB, p.18)

Educational level	Minimum educational level required for the mentioned occupation using the National Job Guide (nationale beroepengids)	Wo/hbo/mbo
Relevance	Relevance of the individual in relation to the subject (biology or physics). Irrelevant: not related to physics. Relevant: related to physics and individual is important to the field of physics (e.g. famous physicist). Representative: related to physics, but only individuals name is mentioned and not important for the rest of the text (could have been any name), individual could be viewed as a 'peer' to the reader.	Irrelevant/ relevant/ representative
Existence	Individual is fictional or non-fictional.	Fictional/non-fictional
Time of fame	if individual is non-fictional, when did they live: historical/contemporary. Contemporary if pupils could have heard of the individual when they themselves were alive. For my target group: individuals who are still active in their work field from 2008. Historical is used for individuals active in their field before the year 2008.	Historical/ contemporary
Additional remarks	For example: famous scientist, image, example for assignment. Also note here if no name is mentioned ("No name"), this is relevant for individuals who have a specific gender, but is not linked to a name. For example: Een wiel-renner heeft een snelheid van 36 km/h, hij legt 450 km af.	e.g. famous scientist/image/no name
Name	name of individual. For images without a name mentioned: note 'image'. For nameless individual: note how they are mentioned, e.g. 'de huisarts'.	e.g. Amy/image/ general practitioner

C. Questions semi-structured interviews

List of questions asked in semi-structured interviews.

Question	Based on literature of
Why did you choose the subject of biology/physics?	Survey GirlsClub WIN
- Who were important for you when choosing the subject of biology/physics?	Survey GirlsClub WIN Bax, et al. (2021)
- Did your friends also choose this subject?	Bax, et al. (2021)
- Can you describe the image of a biologist/physicist? And does this image also suit you?	Rainey, et al. (2018)
- Do you know anyone who works in the field of biology/physics?	Rainey, et al. (2018)
- Do you have a man or woman as biology/physics teacher?	Rainey, et al. (2018)
Why didn't you choose the subject of biology/physics?	Survey GirlsClub WIN
- Did your friends choose this subject?	Bax, et al. (2021)
- Can you describe the image of a biologist/physicist? And does this image also suit you?	Rainey, et al. (2018)
- Do you know anyone who works in the field of biology/physics?	Rainey, et al. (2018)
- Do you have a man or woman as biology/physics teacher?	Rainey, et al. (2018)

Do more boys or girls choose biology/physics in your class and what do you think about that?	Rainey, et al. (2018)
Is it important to you that other people think that your study/education after secondary school suits you?	Rainey, et al. (2018) Bax, et al. (2021)
What is the publisher of your biology/physics textbooks you use in class?	Context
Which textbook do you prefer to read/work with? Biology or physics? And why?	Bax, et al. (2021)
When you hear the word "physicists" do you think of a man or a woman or both? And what about 'biologists'? "Scientists"? 'Researchers'?	Rainey, et al. (2018)
Can you name a male biologist/physicist?	Bax, et al. (2021)
Can you name a female biologist/physicist?	Bax, et al. (2021)

D. Codes for interviews

Overview of codes used for analysing semi-structured interviews

Code name	**Description**	**Example**
Demotivating	A remark in which the interviewee states that a factor has had a negative influence on their subject cluster choice or the image/connection that the person has about the biology/physics subject	"A teacher told me on choosing the field of nature and health [that I should not do it], so I thought: 'yes maybe I should choose something else'. So I am sure that it will influence your choice in the end."
Not demotivating	A remark in which the interviewee states that a factor has had a positive or neutral influence on their subject cluster choice or the image/connection that the person has about the biology/physics subject	"In the end I chose for myself and my parents think it is very important that I really choose for myself and not because they like it so much."
Teacher	A comment in which the teacher is mentioned in a non-neutral way (can be both positive or negative)	*"Q: And for physics, do like the teacher for that subject?* *A: Well….. the teacher we have now…. His teaching is 'okay', but his explanation is sometimes not that great."*
Parent/guardian	A comment in which a parent/guardian is mentioned with regard to subject cluster choice or the biology/physics subject	"Yes, I have discussed [my SC] with my parents and they also said that [me choosing a science-related subject cluster] is useful, but that the subject of physics may not be necessary."
Friend	A comment in which a friend is mentioned in a non-neutral way (can be both positive or negative)	NA
Potential role model	A comment mentioning an individual who can be related to physics/biology in a positive way. The code 'potential' role model has been chosen, because an individual can also	"Q: Do you know people who work in the field of biology? A: Yes, my mother, she worked in the hospital, so I think you also need biology for that. And my aunt also works in the hospital."

	subconsciously influence a student's image of the field of biology or physics.	
Media	A comment in which the media is mentioned in the context of the biology and/or physics subjects	"I get the feeling that more male biologists and physicists are making the headlines. And then the women remain in the background or something. That's why I find it hard to think of [a female physicist/biologist]."
Future aspirations/career	A comment mentioning the student's future in the context of their subject cluster choice or the subjects of biology/physics	"So I added physics [to my subject clucter] because it is useful for later [in my studies]"
Subject cluster choice	Remarks on the subject cluster choice. These are further subdivided into: independency, interesting/fun, not interesting/fun, easy subject, difficult subject.	-
Independency	Remarks on choosing subjects of their SC independently and without influence from others/environment	"Q: What if, for example, your biology teacher were to say, "Oh, but I think biology would suit you very well!"? A: Well, then it's still my own choice."
Interesting/fun	Comment from the student who expresses himself positively about the feeling he has about the biology/physics subject	"Q: Can you tell me why you chose physics? A: I find it interesting and it is logical and understandable"
Not interesting/fun	Comment from the student who expresses himself negatively about the feeling he has about the biology/physics subject	"Well, I didn't find it that interesting either. [learning about] the human body is fine, but you also have [lectures] about plants and things like that. I didn't find those interesting. Yes, boring, so just not my thing."
Easy subject	Comment from the student who expresses a positive opinion about taking the biology/physics subject with regard to their own abilities/self-efficacy.	"I really wanted to keep chemistry in my subject cluster. I find that very interesting and it comes naturally to me. "
Difficult subject	Comment from the student who expresses a negative opinion about taking the biology/physics subject with regard to their own abilities/self-efficacy.	"In first and second [year] I got taught biology and my grades for that were not very impressive."

E. List of non-fictional individuals

List of non-fictional individuals mentioned in biology and physics textbooks. Individuals related to the subject are written in bold.

Biology

Time period	Male	Female
Historical	**Charles Darwin**	Marion Jones
	Gregor Mendel	
Contemporary	**Stijn Bruers**	**Liesbeth Woertman**
	Jett Rebel	**Stacy Farina**
	Brendon Urie	Caster Semenya
	Maarten van der Weijden	**Rietje Klous**
	Max Verstappen	Caitlyn Jenner
	Tim Montgomery	Prinsessen van Oranje
	Mark Zuckerberg	Dafne Schippers
	Simon Rietveld	Koningin van Oranje
	Ilja van Beest	
	Jaap Seidell	
	Willem de Vos	
	Max Nieuwdorp	
	Mark Siderius	
	Jeroen van Holland	
	Willem-Alexander	
	Armand Leroi	
	John Couwenberg	
	Bart Kruijt (WUR)	
	Nicholas Long	
	Lars van den Heok Ostende	
	Wieger Wamelink (WUR)	
	Jan Dumanski	

Physics

Time period	Male	Female
Historical	**Galileo Galilei**	-
	Isaac Newton	
	Georg Simon Ohm	
	Wilhelm Röntgen	
	Henri Becquerel	
	Rogier van der Weyden	
	Roger van Schoute	
	David Scott	
	Giotto	
	James Watt	
	Charles-Augustin Coulomb	
	Pythagoras	
	Neil Armstrong	
	Max Planck	
	Willebrord Snellius	
	Edmund Halley	
	Ulrich von Kranach	
Contemporary	**Arno (work example)**	Tanya Burr
	Usain Bolt	**Aymee Prinsen**
	Nils Kerkhoven	**Tara Connolly**
	Lewis Hamilton	
	Artur Dalaloyan	
	Epke Zonderland	
	Bert Otten	