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The Underrepresentation of Women in STEM: The Contributing Factors to Differences in Attitude Between Young Men and Women Toward STEM

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Abstract:

This study explores gender-specific differences and influencing factors in attitudes toward Science, Technology, Engineering, and Mathematics (STEM) in the Netherlands, where women remain underrepresented. The underrepresentation of women in STEM has both economic and social consequences, reinforcing stereotypes and limiting women's economic independence. Using a mixed-methods approach, the research included a questionnaire to assess attitudes and influencing factors, followed by interviews with five students. The results revealed that encouragement, friends, educational environment, and role models of all genders are important factors in shaping attitudes toward STEM. Even though significant differences in attitude toward STEM between genders were found, none of the factors had a statistically significant effect on gender differences in STEM attitudes. Interviews highlighted the perceived lack of female role models as a contributing factor. The study concludes that fostering encouragement, providing role models, and supportive environments are key to bridging the gender gap in STEM.

Keywords: STEM attitude, Inequality, Underrepresentation of Women, Gender Segregation.

This manuscript underwent peer review. Ricarda Schlimbach served as the managing editor.

1 Introduction

1.1 Problem Statement: Underrepresentation of Women

Despite the Netherlands' relatively high levels of gender equality, women remain significantly underrepresented in technical fields. According to the Emancipation Monitor, a report from the Central Bureau of Statistics (CBS) on the distribution of men and women in various professions, women currently hold only 15% of technical jobs in the Netherlands, despite making up 47% of the employed labor force (Centraal Bureau voor de Statistiek, 2022). Eurostat's data shows that the gap between men and women in technical fields is especially wide in the Netherlands, compared to other European countries (Eurostat, 2022). This shortage is relevant to Information Systems (IS), where low female representation mirrors broader trends across STEM domains. Information Systems, being an integral part of technological innovation and data-driven decision-making, would benefit from a more gender-diverse workforce, which research has shown can enhance creativity, inclusivity, and problem-solving.

While these numbers may seem discouraging, it is worth noting that there has been an increase in the number of women pursuing technical studies in recent years. VHTO, a gender diversity expertise center specializing in technical fields, reports that the number of women pursuing technical degrees has doubled in the past decade, particularly in engineering and IT (VHTO, 2018).

1.2 STEM

The underrepresentation of women is most seen in the fields of Science, Technology, Engineering, and Mathematics. These fields are referred to as STEM fields (VHTO, 2018). While the STEM field encompasses a wide range of disciplines, it is evident that engineering, physics, and mathematical studies in particular are facing challenges with low enrollment from women. The wide range of disciplines causes STEM to be inconsistently defined (Kahn & Ginther, 2017). To ensure clarity, this study considers Natural Sciences, Engineering, and Technology as STEM-related disciplines, while excluding 'soft' sciences such as Medicine and Health Sciences. The lack of interest in STEM fields, especially among women, can be attributed to various factors, including sociological factors like stereotypes and biases, as well as psychological factors related to motivation and interest (Van Tuijl & Van Der Molen, 2016). These factors will be further addressed in the Possible Influencing Factors section of this report.

1.3 Leaky Pipeline

The "leaky pipeline" refers to the gradual loss of women in STEM fields as they progress through key stages such as high school, university, and employment (Liu et al., 2019). Despite increasing numbers of women entering technical fields, more tend to drop out at each critical decision point, such as subject selection in high school, transitioning to higher education, and career choices (Blickenstaff, 2005; Centraal Bureau voor de Statistiek, 2019; VHTO, 2022). Even when women choose STEM, they often face obstacles that divert them from their path, leading to their departure from the field (SHThree, 2022).

1.4 Negative Effects

The underrepresentation of women in STEM has significant economic, social, and healthcare-related consequences. Figure 1 illustrates these effects using a causal loop diagram, which captures the critical relationships while recognizing that other factors may exist outside this scope (Tip, 2011).

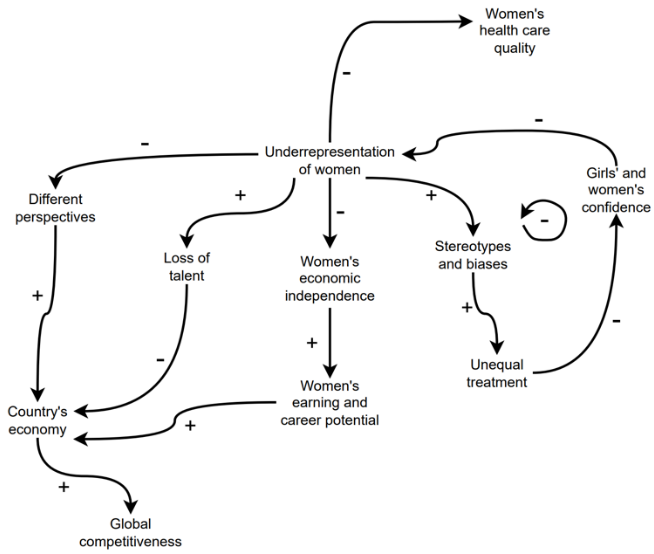

Figure 1. Effects of the Underrepresentation of Women Presented in a Causal Loop Diagram

The underrepresentation of women in STEM has significant economic consequences for both individuals and the country as a whole. STEM graduates tend to earn higher incomes, and their roles are critical to economic growth and stability (Kahn & Ginther, 2017; STE(A)M Truck, 2020). Women's limited participation in technical fields can hinder their economic independence (Shapiro & Sax, 2011). With STEM jobs often being high-paying and in demand, this underrepresentation restricts women's economic opportunities (McKinsey Global Institute, 2018).

Moreover, the lack of women in STEM impacts the Netherlands' global competitiveness, resulting in lost talent and innovation (Shapiro & Sax, 2011). Shapiro and Sax highlight that this absence of diverse perspectives can limit innovation and creativity and hinder the development of new technologies. A lack of diversity also limits the growth of new industries and job opportunities (Blumberg et al., 2023). Given the tight labor market in STEM, increasing the number of women could help narrow this talent gap (De Vries et al., 2018; McKinsey, 2023). Diverse tech companies outperform their less diverse counterparts by up to 25 percent (McKinsey, 2023). Furthermore, McKinsey (2018) reports that aligning women's paid hours and sector distribution with those in other West-European countries could boost the Netherlands' GDP by over €100 billion.. Thus, the economic implications are substantial.

There is also a big social impact of the underrepresentation of women in STEM. The underrepresentation of women in STEM can reinforce gender stereotypes and biases that suggest that women are not suited for these types of careers (De Vries et al., 2018). This can lead to discrimination and unequal treatment, such as being passed over for promotions or being paid less than male colleagues for the same work. This again makes it harder for women to join this sector and difficult to advance in their careers, which discourages them to pursue a career in STEM fields altogether (De Vries et al., 2018).

Gender segregation affects how women see themselves and how men see women, as well as how they influence their children (De Vries et al,m 2018). It contributes to a lack of confidence among young women and girls, which can limit their choices and opportunities, and this can again lead to more gender inequality. In this way, a reinforcing cycle is created. It ultimately leads to (re)production of social inequality.

The underrepresentation of women in STEM also has a negative effect on health care. When women are not equally represented in STEM fields, the research and development of new technologies, medicines, and treatments may not take into account the unique needs and experiences of women (De Vries et al., 2018).

1.5 Attitude

The underrepresentation of women in STEM is partly facilitated by the leaky pipeline; however, this concept does not fully explain why women choose to leave the pipeline. Attitude, defined as the feelings and judgments individuals have toward a situation (Regan & DeWitt, 2015), plays a significant role in predicting behavior. Social psychologists view attitudes as evaluations involving preferences for or against an object, often expressed in terms such as like, dislike, hate, or love (Jhangiani & Tarry, 2022). These evaluations can be directed toward people, objects, or concepts, referred to as attitude objects (Jhangiani & Tarry, 2022).

Attitudes consist of three interrelated components: cognitive, affective, and behavioral (Jhangiani & Tarry, 2022). For example, an individual's attitude toward STEM might include positive beliefs about the importance of STEM (cognitive), enthusiasm or anxiety when engaging with STEM activities (affective), and consistent behavior, such as choosing STEM-related courses or avoiding them (behavioral). These components shape attitudes and their strength, influencing behavior over time.

Examining the influencing factors that shape women's attitudes toward STEM can reveal the root causes of the leaky pipeline. Influencing factors include societal stereotypes, lack of role models, educational environments, and biased perceptions, which will be discussed in the Possible Influencing Factors section. Understanding and addressing these root causes is crucial for promoting gender equity in STEM. By fostering positive attitudes and challenging negative perceptions, we can encourage more women to pursue and thrive in STEM fields.

1.6 Research Questions

The main question for this research is: What factors contribute to the differences in attitude toward STEM between young women and men in the Netherlands? Answering this question will provide new insights into the influencing factors for students at universities in the Netherlands.

The sub-questions will be answered at first, which will provide a clear understanding of the theories and expectations. The answers found by addressing these questions will contribute to answering the main question more effectively.

To address this main question, the research explores the following three key areas:

- Why is the underrepresentation of women in STEM a problem?
- What is the current state of this underrepresentation in the Netherlands?
    - This includes an examination of its situation in high schools, universities, and STEM job positions.
- Which factors contribute to the differences in attitude toward STEM between women and men?
    - This includes the influence of stereotypes, educational biases, role models, and perceptions of the STEM work field.

1.7 Relevance

Social and economic relevance

The social and economic relevance of the underrepresentation of women in STEM is evident in the described negative effects. This underrepresentation reinforces gender stereotypes and biases, resulting in discrimination and unequal treatment. By identifying the factors that contribute to differing attitudes toward STEM between men and women, this research can explain why women and girls are underrepresented in these fields. Understanding these factors will enhance interventions to address barriers and increase women's participation in STEM, ultimately promoting equality and fostering a more inclusive society.

Additionally, the economic consequences of women's underrepresentation in STEM limit their economic independence and potential for financial success in these high-paying, in-demand fields. By addressing the factors contributing to this underrepresentation, this research can help reveal women's untapped potential and help close the gender gap in STEM, leading to a stronger economy for the Netherlands.

Scientific relevance

The Netherlands is at the bottom of the list of European countries when looking at equality in STEM fields (Eurostat, 2022). Even though there has been a lot of research on the topic of inequality in this sector globally, the specific factors that influence the differences in attitudes toward STEM between men and women are still relatively unknown, especially in the context of the Netherlands. This research aims to fill this gap by combining studies on attitudes toward STEM and factors influencing these attitudes with a focus on gender differences. This research will provide insight into the influencing factors and the differences between men and women, which contributes to the scientific understanding of gender differences in STEM, and can be of help for improvement in interventions to reduce inequality. The findings will also help guide future research in this field.

2 Conceptual Framework

2.1 Current State

High school

One critical decision moment for students is choosing a profile in high school, where they select from four options: Nature and Technology, Nature and Health, Economy and Society, and Culture and Society (Ministerie van Onderwijs, Cultuur en Wetenschap, 2021). This choice not only determines the subjects they will study in their final years but also influences their eligibility for university programs (Studiekeuze123, 2023). For instance, the Nature and Technology profile emphasizes STEM subjects like advanced mathematics, physics, and chemistry, preparing students for technical fields, while Nature and Health focuses on biology and chemistry, often leading to healthcare or life sciences. Therefore, the profile choice significantly impacts students' educational pathways.

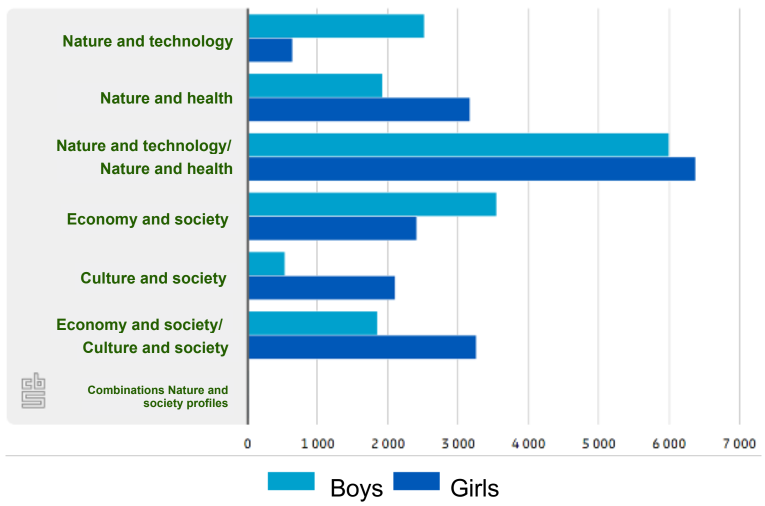

Figure 2. Distribution of Boys and Girls on Profile Choices (Reprinted from 'Geslaagd! Profielen, vakken en cijfers van geslaagden in vwo, havo en vmbo-t.' by Centraal Bureau van Statistiek, 2019.)

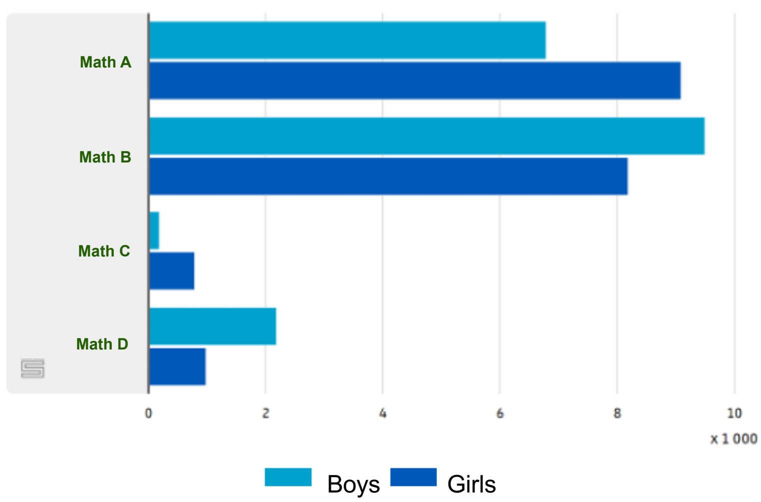

Figure 3. Distribution of Boys and Girls on Different Types of Mathematics Courses (Reprinted from 'Geslaagd! Profielen, vakken en cijfers van geslaagden in vwo, havo en vmbo-t.' by Centraal Bureau van Statistiek, 2019.)

As illustrated in Figure 2, the most considerable gender disparity occurs in the Nature and Technology profile, which is predominantly chosen by boys. This trend reflects an early preference among girls for non-technological paths, marking a significant 'leak' in the pipeline. Figure 3 further demonstrates this leak, showing that boys tend to select Mathematics B more frequently, while girls lean toward Mathematics A. Despite these choices, there is no significant difference in academic performance between boys and girls in Mathematics B (Centraal Bureau voor de Statistiek, 2019), indicating that girls are equally capable of succeeding in mathematically intensive subjects.

University

In recent years, more women have been choosing beta-technical studies, indicating positive changes in influencing factors. Beta-technical studies refer to academic programs focused on fields within the natural sciences, engineering, and technology disciplines, such as physics, chemistry, mechanical engineering, and computer science. Data from Techniekpact (2022) shows the share of women in beta-technical studies increased from 12% in 2011/2012 to 18% in 2021/2022, alongside a rise in women in higher education, from 4,760 in 2010/2011 to 10,687 in 2020/2021 (Techniekpact, 2022). Although the percentage of women remains relatively small, it is noteworthy that the number of women attaining beta-technical degrees has doubled in the past decade.

Figure 4 illustrates the gender distribution in STEM studies in the Netherlands from 2017 to 2021 (Dienst Uitvoering Onderwijs, 2023), highlighting a persistent gender imbalance despite the noted increase. The rising number of women in beta-technical studies and STEM degrees suggests a shift in factors influencing women's attitudes toward these fields. This change may be attributed to evolving societal perceptions of gender roles, increased visibility of successful women in STEM, and efforts to promote diversity and inclusion. However, significant gender disparity in STEM studies remains evident.

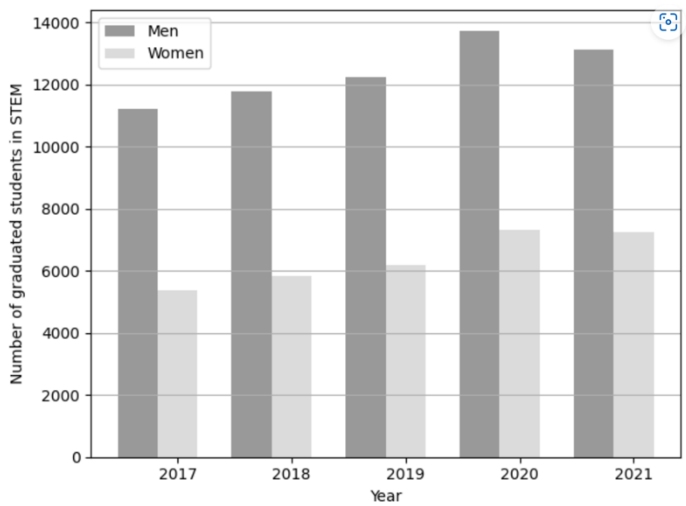

Figure 4. Distribution of Men and Women in STEM Studies (The figure presents data on all graduate students for each year and was created using a dataset from Dienst Uitvoering Onderwijs, 2023.)

STEM jobs

Figure 5 shows the current distribution of occupations in the Netherlands (Centraal Bureau voor de Statistiek, 2022). This graph represents the entire population, not just those with higher education, but the categories combine occupations based on skill level and field (Centraal Bureau voor de Statistiek, 2022). Notably, the ICT segment refers to higher-level jobs, revealing that women occupy only 18.2% of ICT positions.

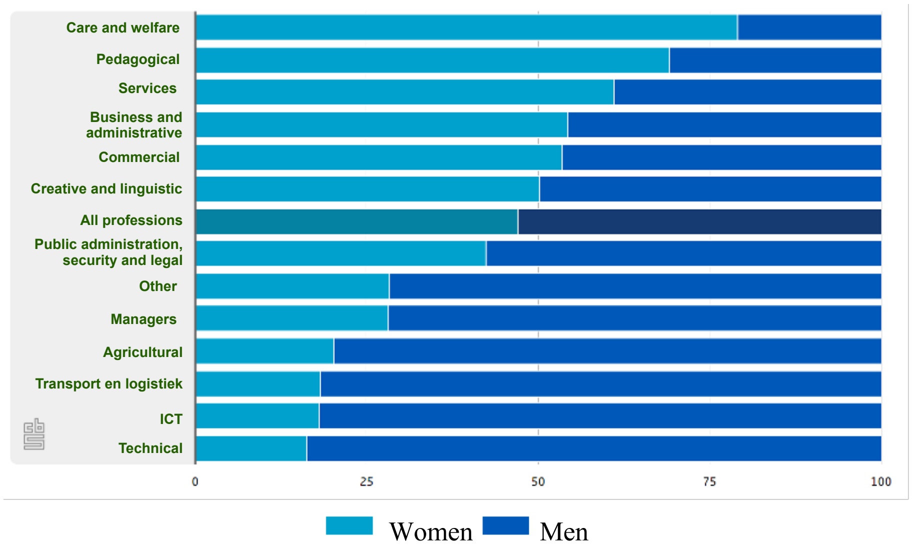

Figure 5. Women and Men by Occupational Class (Reprinted from 'Beroepen van werkenden' by Centraal Bureau van Statistiek, 2022.)

2.2 Possible Influencing Factors

Stereotypes

STEM fields are still widely viewed as masculine, reinforcing stereotypes that favor men and leading to discrimination in hiring and career advancement for women (Avolio et al., 2020; (Casad et al., 2021). Women often experience stereotype threat, where fear of confirming negative stereotypes about their gender increases anxiety and stress, hindering their engagement in STEM (Blackburn, 2017). These stereotypes damage women's confidence, motivation, and sense of belonging in STEM (Blackburn, 2017).

Additionally, women may show less interest in STEM when romantically involved with a partner perceived as more intelligent, further intensifying stereotype threat (Blackburn, 2017). It is important to consider that societal expectations and biases are reinforcing stereotypes, which causes higher demands on women in STEM compared to men (VHTO, 2022). Stereotype threat gives insights into the psychological barriers that women have to face when working or studying in STEM.

Teacher bias

Gender biases are prevalent in STEM education. Teachers often exhibit sexist bias favoring boys, being more flexible in adjusting boys' test grades while underestimating and rarely changing girls' grades (Avolio et al., 2020). Kahn and Ginther (2017) further note that teachers spend more time teaching math to boys in early grades, which can hinder girls' cognitive development in math (Kahn & Ginther, 2017). Girls with boy-biased teachers are less likely to take advanced math courses in high school, pursue STEM majors, or enter STEM careers (Kahn & Ginther, 2017).

Role models

Women often have less confidence in their STEM abilities compared to men, largely due to the scarcity of female role models in STEM fields (VHTO, 2022). Stout et al. (2011) found that exposure to same-sex experts in STEM boosts women's self-concept, attitudes toward STEM, and motivation to pursue STEM careers, highlighting the importance of role models. The lack of representation undermines women's self-belief.

VHTO (2022) also notes that while women are present in technical organizations, they often occupy non-technical roles, such as administrative positions, which can further discourage women from pursuing technical careers. Building a network of women in STEM, akin to a mentoring program, could help women connect and support one another, reducing these barriers.

Family

Family support and background play a key role in the underrepresentation of women in STEM in different ways, as outlined by Social Cognitive Career Theory (Lent et al., 2002). Firstly, parental encouragement significantly impacts the development of children's interests and skills. When parents promote STEM careers or studies, it positively affects children's motivation and engagement in STEM (Avolio et al., 2020). This support can take forms such as discussions about STEM, exposure to STEM activities, and providing learning opportunities. Additionally, parents with a science background influence their children's career choices - 75% of women in science have parents with a science background (Avolio et al., 2020). Lastly, parental education levels also matter, as highly educated parents tend to emphasize academic success and are better equipped to support their children financially (Avolio et al., 2020; Lent et al., 2002)

Friends

The Theory of Planned Behavior suggests that friends can influence attitudes toward STEM. This theory posits that behavior is shaped by attitudes and subjective norms (Ajzen, 1991). Positive interactions with friends passionate about STEM can improve one's perception of the field. People tend to develop more positive attitudes toward STEM when they see friends engaged in STEM activities (Ajzen, 1991). Additionally, having friends in STEM creates a support network that can boost self-belief and confidence, as discussed in the role models section.

Household demands

Another factor is the existence of household demands. Avolio et al. (2020) state that in many cases, women choose to give up their science career path to create more personal time for starting a family or for pressure relief. Also, female scientists are often married to other, male scientists who are usually in a further stage of their career, making it so that the career of the man is seen as more important and thus getting prioritized (Avolio et al., 2020).

2.3 Hypotheses

Based on the reviewed studies and theories, several hypotheses can be formulated about the relationships between influencing factors and students' attitudes toward STEM. The hypotheses are as follows:

H0: There is no significant effect of factor X on students' attitudes toward STEM.

H1: There is a significant effect of factor X on students' attitudes toward STEM.

Factor X refers to variables like stereotypes, role models, family, and friends, and the goal is to determine their impact on attitudes, whether positive or negative. Additionally, to explore gender differences, the hypotheses are:

H0: There is no significant influence of factor X on gender differences in attitudes toward STEM.

H1: There is a significant influence of factor X on gender differences in attitudes toward STEM.

The study aims to test these hypotheses and understand how these factors shape students' attitudes and contribute to gender disparities in STEM participation. The findings will provide insights into the factors that shape students' attitudes toward STEM and how they contribute to gender disparities in STEM participation.

3 Methods

3.1 Research Design

This study used a mixed methods approach to explore factors influencing attitudes toward STEM among men and women. The research combined a correlational quantitative phase with qualitative interviews.

In the quantitative phase, a survey was distributed to university students in the Netherlands. The survey was split into two parts: one assessing students' attitudes toward STEM, and the other examining the factors influencing those attitudes. This enabled the identification of significant factors affecting attitude differences and addressed the research question.

Figure 6 shows the conceptual model, with gender and influencing factors treated as dependent variables in relation to the independent variable, attitude. Influencing factors were also examined as moderators of the relationship between gender and attitude. Specific factors tested included stereotypes (male-oriented perception, perceived suitability), teacher bias (teacher perception), role models (network of gender), encouragement, family and friend influence, perceived career opportunities, and perceived family time. Table 1 provides an overview of the survey questions corresponding to each influencing factor, presenting how these variables were measured.

After the survey, interviews were conducted to deepen the understanding of the quantitative results. These interviews provided detailed insights into the influencing factors and allowed for an exploration of students' personal experiences and perspectives. This combination of methods created a comprehensive view of the factors shaping attitudes toward STEM, linking statistical findings to real-world experiences.

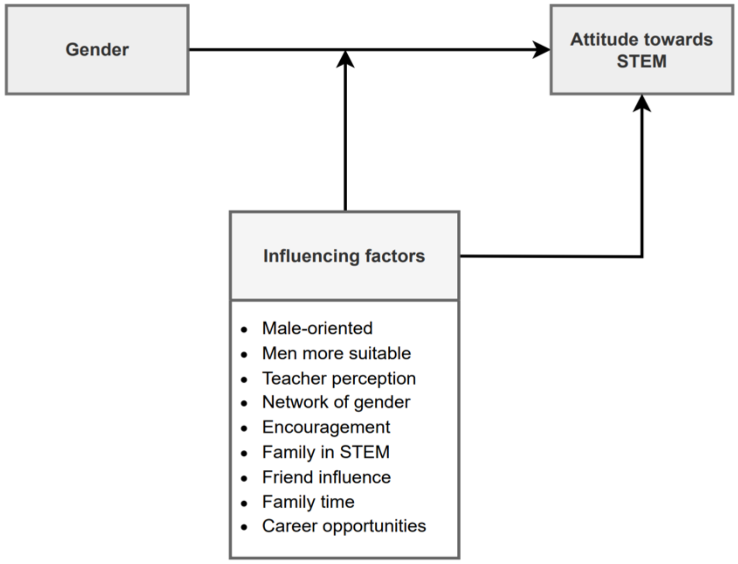

Figure 6. Conceptual Model

Table 1. Survey Questions Corresponding to Influencing Factors

Influencing Factor	Survey Question
Encouragement to pursue	My parents encourage me ot pursue a career ni STEM.
	My teacher encouraged me ot perform wel ni science or mathematics.
	My parents encourage me ot participateni activities outside schol that are related ot STEM.
Influence of friends	Most of my friends like science or mathematics.
	I have friends that are studying or working in STEM-related fields.
	Most of my friends want ot engage in STEM careers.
Perception of teachers	I liked my teacher(s) in Math/Science in pre-university education.
Network of gender	I know someone of my gender outside my family with a STEM career.
	I do not know any role models of my gender in STEM.
Family in STEM	There are members of my family who are involved in STEM careers.
Career opportunities	The income of workers in STEM fields is high.
	STEM fields can provide greater career opportunities.
	Those in STEM fields can get jobs easily.
Family time perception	Workers in STEM fields have enough time with their families.
Masculine field	I believe STEM is a masculine field.
	STEM-related workplaces are male-oriented.
Men more suitable	Men are more suited for STEM studies and jobs.
	Women are often less skiled in mathematics.

3.2 Participant Selection

Survey

The study involved students from various Dutch universities, using a non-probability sampling method to gather a sufficiently large sample for reliable conclusions. Participants were selected through snowball sampling, where initial respondents were asked to share the survey with their networks (Jalali & Wohlin, 2014). To ensure broad participation, the survey was also distributed via multiple channels, including WhatsApp, Instagram, LinkedIn, and email. Additionally, posters were placed on notice boards at the University of Amsterdam and Vrije Universiteit Amsterdam, and an email invitation was sent to students in Information Science at the University of Amsterdam.

A total of 126 students completed the survey, with 54 women, 69 men, and 3 non-binary participants (whose responses were excluded from comparisons between genders due to the small sample size). The nearly equal gender distribution allowed for a balanced analysis. Participants' ages ranged from 18 to 31 (mean age = 21.5, SD = 2.3). The survey covered students at different academic levels (Bachelor's, Master's, PhD) and included both Dutch and non-Dutch citizens. The mean attitude toward STEM was 3.3 (SD = 0.7).

Interviews

Interview participants were selected from survey respondents who expressed interest in a follow-up conversation. Five interviews were conducted, with participants from different genders and fields of study. Three were STEM students, and two were from non-STEM fields. This diversity provided insights into attitudes toward STEM from different perspectives.

3.3 Data Collection

Literature review

Before addressing the main question, the sub-questions were answered through an extensive literature review. The search string method was used to find relevant literature, primarily through Google Scholar, with search terms like attitude toward STEM, STEM gender differences, underrepresentation of women, and influencing factors. To explore concepts in more depth, the snowballing method was applied. Backward and forward snowballing helped identify additional sources by reviewing cited references and finding articles that cited the relevant sources (Jalali & Wohlin, 2014).

The gathered literature was analyzed by summarizing key findings, which were then compared and combined to identify major themes. These summaries formed the foundation for answering the sub-questions and finding the most important aspects of the topic.

Questionnaire

A questionnaire with closed questions based on existing surveys was used to measure attitudes and influencing factors, and can be found in Appendix A. The Attitudes toward STEM survey by Faber et al. (2013), validated by Unfried et al. (2015) and used in various studies (Binns et al., 2016; Halim et al., 2018; Kucuk & Sisman, 2020), was modified to suit university students. Popa and Ciascai's (2017) version for Romanian university students was also incorporated for this purpose.

To measure influencing factors, questions based on surveys by Halim et al. (2018) and Kricorian et al. (2020) were used. The survey covered two categories: Motivation (family, friends, teachers, role models) and Perception (STEM career views, stereotypes). The final factors included encouragement, friend influence, teacher perception, and gendered networks, among others.

A pilot test with 17 students helped refine the questionnaire's clarity, remove errors, and estimate the completion time (5-10 minutes). The survey, distributed via Qualtrics, included instructions for participants and a definition of STEM to ensure clarity and encourage honest responses.

Interviews

Following the statistical analysis, five semi-structured interviews, each lasting around ten minutes, were conducted to gain deeper insights into the factors contributing to gender differences in attitudes toward STEM. These interviews explored both the factors identified in the quantitative phase and participants' personal experiences. To ensure ethical standards, participant identities were anonymized, and recordings were made with their consent. The interview topic list is in Appendix B. The qualitative data added valuable context and deeper understanding to the findings from the quantitative analysis.

3.4 Data Analysis

Survey questions

The survey used a 5-point Likert scale (1 = "strongly disagree", 5 = "strongly agree") to measure attitudes toward STEM. Statements focused on math, science, engineering, technology, and career interests, adapted from Faber et al. (2013) to suit university students. Math-related statements included "Math is hard for me" and "I am good at math", while science-related statements included "I can obtain good grades in science". Engineering and technology were assessed with statements like "If I learn engineering, I can improve things people use every day". Career interests were measured using various STEM-related fields, each with a brief description.

The mean scores from the math, science, engineering, and career interest domains were combined to form an overall attitude toward STEM measure. Negatively phrased statements were reversed, and two statements ("I am sure I could do advanced work in math" and "I could not do a good job with science") were excluded due to low correlations with other statements in their respective domains ($r < 0.57$). This ensured the reliability and internal consistency of the attitude measure, confirmed by a Cronbach's alpha of 0.894 (95% CI [0.865, 0.919]).

Statistical analyses

Statistical analyses included descriptive statistics like means and standard deviations to summarize the data. ANOVA tests were conducted to assess the influence of gender and various factors on students' attitudes toward STEM. Each test used attitude as the response variable, with gender as the grouping variable and specific factors (e.g., family influence, teacher perception) as conditions. By conducting separate ANOVA tests for each potentially influencing factor, it was possible to examine the contribution of each factor to the differences in attitudes between men and women, as well as the independent influence of the factor on attitudes. Correlation analyses were performed for factors showing significant effects, with a significance level set at $p < 0.05$. The analyses were performed using Python in Jupyter Notebook.

Interview data

The interviews were transcribed and analyzed to complement the quantitative findings. Main insights were identified from each transcript, which helped highlight personal experiences related to STEM attitudes. The qualitative findings were integrated with the survey data, providing a more in-depth understanding of how various factors shape attitudes toward STEM. Each influencing factor was categorized based on how important it was to the participants' experiences, helping to provide a clearer picture of these factors' significance. A table was created to summarize the degree of influence for each factor across participants.

4 Results

This study examined the factors contributing to gender differences in attitudes toward STEM in the Netherlands through a survey and brief interviews.

4.1 Descriptives

Students with a positive attitude toward STEM were almost always studying in STEM fields; only eight out of the 126 respondents had a positive attitude (above 3.3) and did not choose a STEM study. This suggests that a positive attitude toward STEM is a very important motivator for individuals to choose STEM as their study field. The influencing factors of attitude will therefore give valuable insights into why students do not have a positive attitude toward STEM and thus do not choose a STEM study.

The mean scores were calculated to determine the average level of agreement or disagreement with each concept. The standard deviation was also calculated, to measure the extent of variability in the responses for each concept. The results can be found in Table 2.

Table 2. Mean and Standard Deviation for Each Concept

Concept	Mean	Standard Deviation
Attitude	3.35	0.64
Encouragement to pursue	2,83	0.83
Friend influence	3.29	0.78
Teacher perception	3.32	1.11
Network of gender	3.64	0.97
Family in STEM	3.21	1.33
Career opportunities	3.93	0.50
Family time perception	3.24	0.74
Male-oriented field	3.23	0.79
Men are more suitable	1.88	0.83

Figure 7 shows the distribution of participants across study fields, with the majority of participants studying in STEM fields, mostly Science and Technology. Non-STEM fields such as Law and Behavior and Society were also represented but to a lesser extent.

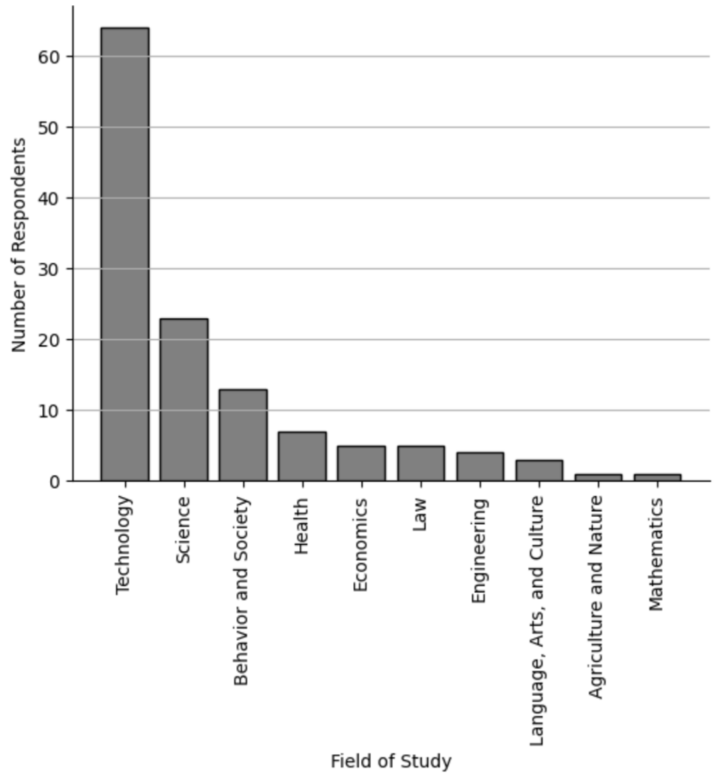

Figure 7: Distribution of the Respondents Across Different Study Fields

To assess differences between STEM and non-STEM students, the fields were categorized as STEM (92) or non-STEM (34). Students in STEM fields generally expressed a more positive attitude toward STEM ($M = 3.5$) compared to non-STEM students ($M = 2.9$). A Mann-Whitney U test confirmed a statistically significant difference in attitudes between these groups ($U = 2366.5$, $p < 0.001$).

4.2 Gender Differences in Attitude Toward STEM

To examine the relationship between gender and attitude toward STEM, a Shapiro-Wilk test was conducted, revealing that the attitude variable was not normally distributed ($W = 0.992$, $p = 0.649$). Due to this, a Mann-Whitney U test was used instead of a t-test. The test showed a statistically significant difference in attitudes between genders ($U = 2531.5$, $p < 0.001$), with a moderate effect size ($d = 0.626$), indicating a meaningful difference. A statistical power analysis also showed high power (0.954), confirming the reliability of these results, showing that men and women hold different attitudes toward STEM, with men expressing a more positive attitude toward STEM than women.

4.3 Influencing Factors, Gender, and Attitude

This section examines the interaction effects of gender with each influencing factor and discusses the individual effects of each influencing factor on attitudes toward STEM.

Encouragement to pursue

The encouragement respondents received from parents and teachers regarding STEM was combined into the “pursue” variable. While the interaction effect of gender and pursue on STEM attitudes was statistically non-significant ($F(1,122) = 0.144$, $p = 0.705$), the individual effect of pursue was significant ($F(1,122) = 31.236$, $p < 0.001$). A Pearson correlation also showed a strong positive relationship between encouragement and attitudes ($r = 0.462$, $p < 0.001$). Respondents with a higher level of encouragement from their environment to pursue STEM had more positive attitudes.

Influence of friends

This variable captured the overall impact of friends interested in STEM. The interaction effect of gender and friends was non-significant ($F(1,122) = 0.484$, $p = 0.488$), but the friends variable had a significant independent effect ($F(1,122) = 19.514$, $p < 0.001$) and a positive correlation with attitudes toward STEM ($r = 0.415$, $p < 0.001$). This shows that the respondents who stated having friends interested in STEM or studying/working in STEM-related fields had more positive attitudes toward STEM.

Perception of teachers

The perception of pre-university teachers in math and science did not show a significant interaction with gender ($F(1,122) = 0.191$, $p = 0.663$), but the teacher variable had a significant effect on attitudes ($F(1,122) = 9.318$, $p = 0.002$) and a significant, moderate positive correlation ($r = 0.296$, $p < 0.001$). This suggests that having a positive perception of one's math or science teacher in pre-university education is associated with a more positive attitude toward STEM.

Network of gender

The network variable, which measured role models of the same gender in STEM, did not show a significant interaction effect ($F(1,122) = 1.358$, $p = 0.246$), but the independent effect was significant ($F(1,122) = 7.986$, $p = 0.005$) with a moderate positive correlation ($r = 0.337$, $p < 0.001$). This suggests that the network of their gender that a respondent has in STEM positively influences their attitude toward STEM.

Family

Having family members in STEM did not show significant interaction ($F(1,122) = 0.138$, $p = 0.711$) or individual effects on attitudes ($F(1,122) = 0.754$, $p = 0.387$).

Career

Perceptions of income and career opportunities in STEM had no significant interaction with gender ($F(1,122) = 0.572$, $p = 0.451$) or individual effect on attitude ($F(1,122) = 0.596$, $p = 0.441$).

Family time

Perceived family time in STEM careers showed no significant interaction ($F(1,122) = 0.336$, $p = 0.563$) or individual effect ($F(1,122) = 0.602$, $p = 0.439$) on attitudes.

Masculine field

The belief that STEM is masculine did not show significant interaction ($F(1,122) = 2.746$, $p = 0.100$) or individual effect ($F(1,122) = 0.172$, $p = 0.679$) on attitudes.

Suitable for men

The perception that men are more suited for STEM showed no significant interaction ($F(1,122) = 0.764$, $p = 0.384$) or individual effect ($F(1,122) = 2.613$, $p = 0.109$) on attitudes toward STEM.

4.4 Interpretation

The survey results indicate a significant difference in attitudes toward STEM between women and men. A summary of the findings can be found in Table 3. The coefficient column shows the direction and strength of the relationship between the influencing factor and attitude toward STEM.

Encouragement from parents and teachers significantly influenced attitudes, with higher levels of encouragement leading to more positive views. Friends who were interested in or working in STEM also had a positive impact, underlining the importance of social connections. A positive perception of STEM teachers in pre-university education was linked to more positive attitudes, highlighting the role teachers play in generating interest in STEM. Additionally, having a network of same-gender role models in STEM positively influenced attitudes, reinforcing the idea that representation matters in fostering positive perceptions of STEM.

Other factors such as family involvement in STEM, career and income opportunities, family time for STEM workers, and the perception of STEM as a masculine field or more suitable for men did not have statistically significant effects. None of the factors showed significant interactions with gender, suggesting they did not explain the differences in attitudes between men and women.

During the interviews, participants elaborated on their experiences with the influential factors, as well as the non-significant ones, and discussed additional factors that might have shaped their attitudes toward STEM.

Table 3. Effect of Each Influencing Factor on Attitude toward STEM

Influencing Factor	Significant Effect	P-value	Coefficient
Encouragement to pursue	Yes	<0.001	0.462
Friend influence	Yes	<0.001	0.415
Teacher perception	Yes	0002	0.296
Network of gender	Yes	0.005	0.337
Family in STEM	No	0.387	N/a
Career opportunities	No	0.441	N/a
Family time perception	No	0.602	N/a
Male-oriented field	No	0.679	N/a
Men are more suitable	No	0.109	N/a

4.5 Interviews

Five interviews were conducted to gain qualitative insights into actual experiences and students' attitudes toward STEM, particularly gender differences. Three STEM students (two males, one female) and two non-STEM students (both female) participated. The interviews aimed to explore factors influencing their attitudes and preferences regarding STEM. Contact the email address on the title page for more detailed summaries.

Table 4 outlines the key influencing factors for each participant. Student 1 and 2 are the male participants, students 3, 4, and 5 are the female participants. An empty circle indicates no influence or experience with a factor, a half-full circle shows it was somewhat relevant but not significant, and a full circle means the factor was important in shaping the participant's decisions or attitudes. Encouragement to pursue STEM varied; some students experienced little to no motivation from their environment, while others were encouraged to continue in STEM. Friends were seen as having some influence, although not all participants believed their friends directly affected their study choices. All participants found teachers of STEM subjects to be a relevant influence.

A gender-specific network was viewed as important by all participants, and the perception of STEM as a male-oriented field influenced the female participants' attitudes more than the male participants'. Family involvement in STEM was not considered an important factor by any of the participants. The perception that STEM workers have less family time also did not influence their decisions. Career opportunities were acknowledged as relevant but not the most significant factor in choosing STEM. Finally, all participants rejected the idea that men are more suited for STEM than women.

Table 4. The Extent to Which Each Participant Experienced an Influencing Factor

	STEM			Non-STEM	
Influencing Factor	Student 1 (m)	Student 2 (m)	Student 3 (f)	Student 4 (f)	Student 5 (f)
Encouragement to pursue	◑	○	●	○	◑
Friend influence	●	●	○	○	●
Teacher perception	●	●	●	◑	●
Network of gender	●	●	●	●	●
Family in STEM	○	○	◑	○	◑
Career opportunities	◑	●	◑	◑	○
Family time perception	○	○	○	○	○
Male-oriented field	●	●	●	●	●
Men are more suitable	○	○	○	○	○

5 Analysis

5.1 Questionnaire

This study's findings support existing research on the factors influencing STEM attitudes. Encouragement from parents and teachers was a key factor, aligning with social-cognitive career theory, which emphasizes how supportive environments and encouragement from influential figures can boost interest and confidence in STEM. This also aligns with Aviolo et al. (2020), who found that parental support fosters greater interest and skills in science.

The impact of friends on STEM attitudes matches the theory of planned behavior, which suggests that social interactions shape beliefs and attitudes. However, the study acknowledges a limitation here, as many of the respondents were studying in STEM fields, and students already interested in STEM may naturally form friendships with others in STEM.

Teacher biases lead to girls being less interested in STEM and less likely to end up in a STEM-related field (Kahn & Ginther, 2017). The findings of this study add to this that the perception of teachers in STEM is important in shaping the attitude toward STEM. The study also found a positive correlation between having gender-specific role models in STEM and more favorable attitudes, supporting identity theory (VHTO, 2022).

It is important to note that no interaction effects between gender and the influencing factors were observed, suggesting these factors do not fully explain gender differences in STEM attitudes. This highlights the complexity of the issue and the need for additional variables to better understand the gender gap in STEM attitudes. A complete understanding of the inconsistency between genders in STEM attitudes most probably requires a more complicated approach with more variables.

5.2 Interviews

Comparing the survey analysis with the interview findings shows that while the survey provides a broader perspective, the interviews offer a more personalized and nuanced understanding of individuals' experiences. The interviews gave insights into the impact of social networks, personal contacts, and specific field preferences on choices in STEM. Overall, the combination of survey data and interview insights offers a comprehensive view of the factors influencing women's representation in STEM, highlighting both common themes and individual variations.

A notable contrast is that all interviewees perceived a lack of female role models and networks in STEM as important for gender differences, though the survey showed no interaction effect between this variable and gender. This suggests the influence of role models may not be fully captured in the survey data. Career opportunities, though not significant in the survey, were a key factor for interviewees, mainly when choosing academic paths rather than STEM specifically. Lastly, most interviewees did not see encouragement as highly influential. However, it is worth noting that the only female STEM student in the interviews emphasized the importance of encouragement. This suggests that while the overall impact of encouragement may be small among interview participants, it could still be significant when motivating women to pursue STEM.

6 Conclusion

This study explored factors influencing university students' attitudes toward STEM in the Netherlands, focusing on gender differences. Key factors included encouragement from parents and teachers, positive experiences with STEM teachers, friends in STEM, and gender networks in STEM. Students who received encouragement and had positive interactions with STEM educators and peers demonstrated more positive attitudes, emphasizing the importance of supportive environments and networks. Additionally, the role of female role models and gender-specific networks was highlighted as crucial for fostering interest and persistence in STEM. The findings revealed that other factors, such as family members in STEM, perceptions of career opportunities, and the view of STEM as a masculine field, had no significant effect on attitudes. The qualitative interviews expanded on the survey results by emphasizing the importance of encouragement, social connections, and the need for diverse role models in inspiring positive attitudes toward STEM.

These results are particularly relevant for Information Systems (IS), a field that, like other technical domains, suffers from underrepresentation of women. Targeted encouragement and relatable role models could significantly increase female participation in IS. For the broader IS community, the findings reinforce the need for inclusive practices and initiatives to reduce the gender gap and help cultivate a more diverse and innovative IS workforce.

To make these findings more actionable, practical interventions should be considered. Educational institutions could develop mentorship programs to connect students with diverse role models in STEM, while implementing gender-inclusive programs to create a welcoming environment for all students. Policymakers can support outreach initiatives or quotas to ensure equal representation in positions. By promoting supportive networks and gender-specific representation, educational institutions, policymakers, and families can contribute to a more inclusive STEM and IS landscape in the Netherlands.

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Appendix A: Survey STEM Attitudes & Influencing Factors

Hi! I am an Information Science student and I am currently writing my thesis. This survey is for students who study at any university in the Netherlands, applied sciences (HBO) or academic (WO). If you are part of this group and have 5-10 minutes spare, it would be appreciated if you fill in this survey. The questions are about your thoughts on study fields. The responses to the survey are anonymized. Two bol.com gift cards of €10 will be raffled off among the participants. Thanks in advance!

Sanne van den Berg

For questions, email sanne.van.den.berg2@student.uva.nl

General information

What gender do you identify as?

- Man
- Woman
- Non-binary / other
- I prefer not to say

What is your age (in years)?

At which level of education are you studying?

- Bachelor
- Master
- PhD

What is the main field that you're studying in?

- Economics
- Behavior and Society
- Health
- Agriculture and Nature
- Law
- Language, arts, and culture
- Science
- Technology
- Engineering
- Mathematics

Are you a Dutch citizen?

On the following pages, you will find lists of statements. Please mark how you feel about each statement by filling in the circle that describes how much you agree or disagree.

There are no right or wrong answers! The only correct responses are those that are true for you.

Subjects of pre-university education

Math

- Math has been my worst subject
- Math is hard for me
- I am the type of student to do well in math
- I could handle most subjects well, but I could not do a good job with math
- I am sure I could do advanced work in math
- I am good at math

Science (subjects like Chemistry, Biology, and Physics)

- I am sure of myself when I do science
- I expect to use science when I am finished studying
- I am the type of student to do well in science
- I know I can do well in science
- Science will be important to me in my life's work
- I could handle most subjects well, but I could not do a good job with science subjects

Engineering and technology

- If I learn engineering, then I can improve things people use everyday.
- I am good at building and fixing things
- I am interested in what makes machines work
- Designing products or structures will be important for my future work
- I am curious about how electronics work
- I would like to use creativity and innovation in my future work
- Knowing how to use match and science together will allow me to invent useful things
- I believe I can be successful in a career in engineering

Here are descriptions of subject areas that involve math, science, engineering and/or technology, and lists of jobs connected to each subject area. As you read the list below, you will know how interested you are in the subject and the jobs. Fill in the circle that relates to how interested you are.

Your future / interests

- Physics
    - studies laws of motion, energy matter and the universe. Career options include aviation engineer, energy technician, physicist, astronomer.
- Environmental Work
    - involves improving the environment by solving problems like pollution and waste. Careers in this field include environmental engineer or scientist, energy systems engineer, and more.
- Biology and Zoology
    - involves the study of living organisms and their processes. This includes working with plants and animals, and careers in the field include biological technician, scientist, geneticist, and more.
- Veterinary Work

  - focuses on preventing and treating animal diseases. Careers include veterinarian, veterinary assistant, livestock producer, and animal caretaker.
- Mathematics
  - is the science of numbers and operations used to solve problems and summarize data. It includes fields such as accounting, finance, and statistics.
- Medicine
  - involves maintaining health and preventing and treating disease, includes professions like physician's assistant, nurse, doctor, nutritionist, emergency medical technician, physical therapist, dentist.
- Earth Science
  - is the study of earth, including the air, land, and ocean. Careers include geologist, weather forecaster, archaeologist, geoscientist/
- Computer Science
  - involves developing and testing computer systems, designing programs, and helping people use computers. It includes jobs like computer programmer, software engineer, and IT specialist.
- Medical Science
  - involves researching human disease and finding solutions to human health problems. It includes professions such as clinical laboratory technologist, medical scientist, biomedical engineer, epidemiologist, and pharmacologist.
- Chemistry
  - uses math and experiments to search for new chemicals, and to study the structure of matter and how it behaves. Careers include chemical technician, chemist, chemical engineer.
- Energy
  - involves generating and studying power, such as electricity and heat. Jobs in this field include electrician, electrical engineer, nuclear engineer, and alternative energy systems installer or technician.
- Engineering
  - involves designing and manufacturing products using math, science, and computers. Examples of jobs include civil, industrial, and mechanical engineering, as well as welding, automotive repair, and construction management.

This is the last part of the survey. The following questions are about your motivation and experiences.

STEM stands for Science, Technology, Engineering, and Mathematics.

Motivation

- My parents encourage me to pursue a career in STEM
- My parents encourage me to participate in activities outside the school that are related to STEM.
- There are members of my family who are involved in STEM careers.
- Most of my friends like science or mathematics.
- I have friends that are studying or working in STEM-related fields
- Most of my friends want to engage in STEM careers.
- My teacher encourages me to perform well in science or mathematics
- I liked my teacher(s) in Math / Science in pre-university education
- I feel like some of my teachers have underestimated me
- I know someone of my gender outside my family with a STEM career.

- I do not know any role models of my gender in STEM
- I feel like there is no network of my gender in STEM
- There were no people in my surroundings regarding STEM related subjects

Perception

- The income of workers in STEM fields is high.
- The condition of a STEM related workplace is safe.
- Workers in STEM fields have enough time with their families.
- Those in STEM fields can get jobs easily
- STEM fields can provide greater career opportunities
- I believe STEM is a masculine field
- STEM related workplaces are male-oriented.
- Men are more suited for STEM studies and jobs
- Women are often less skilled in mathematics
- Men are more interested in STEM than women

If you want to add anything else, please let me know here:

If you would enjoy participating in a short (online) interview on this topic, please leave your email address here:

If you want to participate in the raffle to win a gift card from bol.com, leave your email address here:

Appendix B: Topic List Interviews

Introduction

Thank you for participating in this interview. The purpose is to explore factors that influence attitudes toward STEM fields, with a focus on gender differences. Your insights will contribute to understanding these influencing factors. Your responses will be kept confidential, and there are no right or wrong answers. Please feel free to share openly and share any additional factors you believe are important.

General information

- Gender identity and study field?
- Any experiences or observations related to gender differences in STEM?

Encouragement to pursue STEM

- Encouragement from parents, family members, or teachers to pursue STEM?
- Affected your decision and motivation to study STEM?

Influence of friends

- Influence of friends on attitude toward STEM?
- Any specific instances where friends' opinions or experiences influenced your perceptions of STEM?

Teacher perception and support

- Interactions with teachers and how teachers influenced your interest in the field?

Network of gender

- Influence of role models of your gender in academic choices?

- Do you believe this influences gender differences in attitudes?

Other factors

- Family in STEM? Career opportunities? Family time of STEM workers? STEM masculine field? Men more suitable for STEM?
- Any additional factors that impacted your perception of STEM?

Overall influencing

- Do you believe these factors really influenced you?
- What do you think would work as promotion of gender equality in STEM?

Closing

- Thank you for the insights and contributions.
- Any questions or additions?