Motivating Pre-Vocational Female Students for Technical Education

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Abstract

This research aimed to identify and contextualise factors influencing female pre-vocational students' choices for technical education, with a focus on the reasons behind women's underrepresentation in technical fields and explored potential interventions to encourage their participation. Using the Educational Design Research model, the study combined a literature review with a case study involving interviews with nine female students and five teachers at a technical pre-vocational school in the Netherlands. Girls' decisions to pursue technical education are influenced by societal factors, such as gender stereotypes and social dynamics, which often portray technical careers as male-oriented. A lack of female role models in the media and technical fields reduces girls' motivation and confidence as well. Limited female-specific facilities and projects that do not align with their interests further discourage engagement with technical subjects. Nine targeted interventions were derived, ranging from short-term solutions aimed at creating a more welcoming and supportive environment for female students to long-term strategies designed to challenge stereotypes and shift perceptions about technical education for girls.

Keywords: technical education, female pre-vocational students, female underrepresentation, educational design research model, societal influence

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1 Introduction

The shortage of skilled professionals in technology and Information Technology (IT) poses a risk of slowing down the energy transition, digitalisation, and sustainability efforts while undermining the Netherlands' competitive position (Ministerie van Algemene Zaken, 2023). According to the Dutch government, the shortage is becoming increasingly visible, with long waiting times for solar panel installers and a lack of IT professionals for innovation in healthcare (Ministerie van Algemene Zaken, 2023). The government aims to increase enrolment in Science, Technology, Engineering and Mathematics (STEM) education, improve the alignment between technical education and the labour market, and ensure the retention of skilled technical professionals. Employers, educational institutes, and the government are working together to address this issue. Strengthening the role of pre-vocational education plays a significant role in addressing the gap of skilled professionals, as it can help create a stronger pipeline of technically skilled workers to meet the demand.

Technical education[1] focuses on the practical application of science and math, covering areas like engineering, IT, computer science, electronics, and mechanics, which will now be referred to as technical themes, subjects or fields. At the pre-vocational level, these subjects often emphasise hands-on learning (Sterk Techniek Onderwijs, 2021).

Girls are significantly underrepresented in technical areas (UNESCO, 2024). Throughout this research, references to girls or female students will define them as individuals who identify as female. Currently, women hold only 22% of all technology roles across European companies, underscoring their underrepresentation (Blumberg et al., 2023; Hill et al., 2010; Sydon & Phuntsho, 2022). Girls have consistently shown a lower tendency to choose technical subjects compared to their male counterparts (De Witte & Haan, 2013). According to De Witte and Haan (2013), in 2013, the percentage of female students graduating with technical profiles from pre-vocational schools in the Netherlands was only

[1] Throughout this research, the terms technical, technology, and STEM will be used interchangeably.

1.7%. A couple of years later, the percentage was slightly higher, 4%, but still very low (Kaiser & Vossensteyn, 2019). This percentage is significantly lower than the proportions for Higher General Secondary Education and Preparatory Scientific Education (the Dutch HAVO and VWO), graduating with a technical profile at 28% and 50%, respectively. Only 10% of female pre-vocational students in the Netherlands chose a technical secondary vocational education pathway in the 2022/2023 academic year, and this dropped to 9% in the following year (Techniekpact, 2024a; Techniekpact, 2024b).

Addressing this gap at pre-vocational schools will bring several benefits (Philips, 2024). First, it will promote gender diversity within those schools, which, in turn, will attract more female students and ultimately increase gender diversity in the workforce. A diverse workforce contributes to better-designed scientific and technological products, services, and solutions that are more representative of the users (Hill et al., 2010; Phillips, 2024). Phillips (2024) concludes that decades of research by organisational scientists, psychologists, sociologists, economists and demographers show that diverse teams excel in problem-solving and innovation. Blumberg et al. (2023) also emphasise the crucial societal need to enhance gender diversity within the technical workforce to mitigate talent shortages and sustain Europe's competitiveness in technological growth and innovation.

Second, increasing women's participation in technology will advance economic and career opportunities for women and financial independence (Blumberg et al., 2024; Powell & Chang, 2016). According to the European Institute for Gender Equality (2024), women in technology are more likely to secure high-paying jobs and achieve financial stability, which significantly enhances their economic well-being and empowers them to make independent life choices (European Institute for Gender Equality, 2024). In this way, gender diversity benefits both industry and women themselves.

This thesis will explore how (future) pre-vocational students can be motivated and inspired to engage with technical subjects and view technical careers as viable options for their future. The main focus of this study is to understand what motivates female students to choose technical education and

investigate how these insights can be used to attract more female students to pre-vocational education. This will provide valuable insights for pre-vocational schools into the reasons why girls choose technical education and how to increase the female influx.

2 Theoretical Framework

Gender diversity in technical education refers to the balanced representation of all genders in technical programs (Blumberg et al., 2023). Historically, technical education has been dominated by males with females significantly underrepresented (Hill et al., 2010). Over time, initiatives to promote gender diversity have evolved, reflecting changes in societal attitudes and educational policies (Sydon & Phuntsho, 2022).

2.1 Contributing Factors

Multiple factors contribute to girls' reluctance to choose pre-vocational technical subjects. Addressing these factors through targeted interventions can help increase girls' participation and interest in technical education.

2.1.1 Gender Stereotypes

One of the main reasons for girls' reluctance to choose pre-vocational technical subjects is the persistent influence of gender stereotypes (De Blank et al., 2020). According to De Blank et al. (2020), gender stereotyping generalises attributes, characteristics, and roles for men and women. De Witte and Haan (2013) highlight that persistent gender stereotypes significantly influence girls' educational choices, steering them away from technical fields. These stereotypes are deeply embedded in societal and cultural norms.

Societal norms often, both consciously and unconsciously, dictate that technical careers are "not for girls," as discussed by Kaiser and Vossensteyn (2019), reinforcing the idea that such fields are masculine domains. Elfering et al. (2016) and Sultan et al. (2018) agree that girls may perceive technical subjects and careers as male-dominated, further discouraging their participation.

Cultural norms play a crucial role in shaping girls' educational choices (De Witte & Haan, 2013). Early socialisation processes, as noted by De Witte and Haan (2013), often steer girls towards traditionally feminine roles (e.g. childcare or nursing) and away from technical fields. De Witte and Haan

(2013) emphasise that cultural expectations about gender roles contribute to girls' reluctance to engage in technical education. This cultural conditioning is reinforced by broader societal expectations and norms that define suitable careers for different genders. It's essential to challenge the biases caused by gender stereotypes and societal and cultural norms to create supportive environments that empower girls to explore and excel in technical fields.

2.1.2 Self-Confidence

Elfering et al. (2016) point out that stereotypes can eat into girls' confidence, making them less likely to pursue technical subjects. The authors emphasise the importance of positive reinforcement from teachers and parents to boost girls' confidence in technical fields. Huguet and Régner (2009) also discuss the impact of stereotype threat on girls' self-efficacy and that it can lead to a self-fulfilling prophecy where girls underperform in technical subjects due to lowered expectations.

It is remarkable that once girls choose to pursue a technical education, they demonstrate academic and practical performance on par with, if not exceeding, that of their male peers (Elfering et al., 2016). This suggests that the barriers preventing girls from entering technical fields are less about capability and more about access and encouragement.

2.1.3 Female Role Models

A lack of female role models in technical fields further discourages girls from choosing technical subjects. Elfering et al. (2016) and Sultan et al. (2018) both stress the importance of having visible, successful women in technology to inspire and motivate girls. The lack of such role models perpetuates the belief that technical careers are not suitable for women.

2.1.4 Media Representation

Media representation of women in technology also significantly affects girls' motivation (Sultan et al., 2018). However, women are currently underrepresented in media coverage related to technical fields (Jansen & Derksen, 2015). Sultan et al. (2018) argue that the portrayal of women in technical roles

in media can either positively or negatively influence girls' perspectives of these fields. Positive representations of successful female technologists can inspire girls to pursue technical fields, whereas negative or stereotypical depictions may reinforce existing biases.

2.1.5 Social Dynamics

According to Elfering et al. (2016), career choices and the related educational pathways are not fixed decisions, but rather dynamic processes shaped by ongoing influences from a person's social environment. Family, friends, and broader social contexts—such as schools, hobbies, and extracurricular activities—play significant roles in this development.

Once girls have chosen technical education, the social dynamics within technical classrooms can impact their willingness to participate (Elfering et al., 2016). Elfering et al. (2016) highlight that male-dominated classrooms may create an unwelcoming environment for girls, discouraging them from engaging.

2.2 This Study

This study is conducted in the context of an external organisation, Nehem, a strategic and educational consultancy company. It is part of a project for a technical pre-vocational school in the Netherlands.

This research seeks to contribute significantly to scientific knowledge and theory by addressing the reasons behind pre-vocational female students' reluctance to pursue technical subjects. By applying the Educational Design Research model, as proposed by McKenney and Reeves (2018), the study aims to deepen our understanding of motivational factors and educational interventions, blending theory with practice to solve practical problems and generate theoretical insights simultaneously.

This research aims to provide empirical evidence that can inform educational policies and practices by conducting a thorough literature review and field-based investigation.

2.2.1 Research Questions

Main research question: *How can potential female pre-vocational students be motivated to explore, embrace, and start technical subjects in the pre-vocational education curriculum?*

Sub questions:

1. Why are girls less inclined to choose technical pre-vocational education compared to boys?

   A literature review will focus on answering this question.

2. What is currently being done to encourage girls to pursue pre-vocational technical education, and how can these efforts be improved and expanded?

A literature review will provide theoretical insights, whereas a case study conducted in a pre-vocational technical school will provide practical insights through interviews.

3. Case: How can the technical pre-vocational school in this study improve the influx of girls in their technical programmes to fulfil the societal need for technical skilled staff?

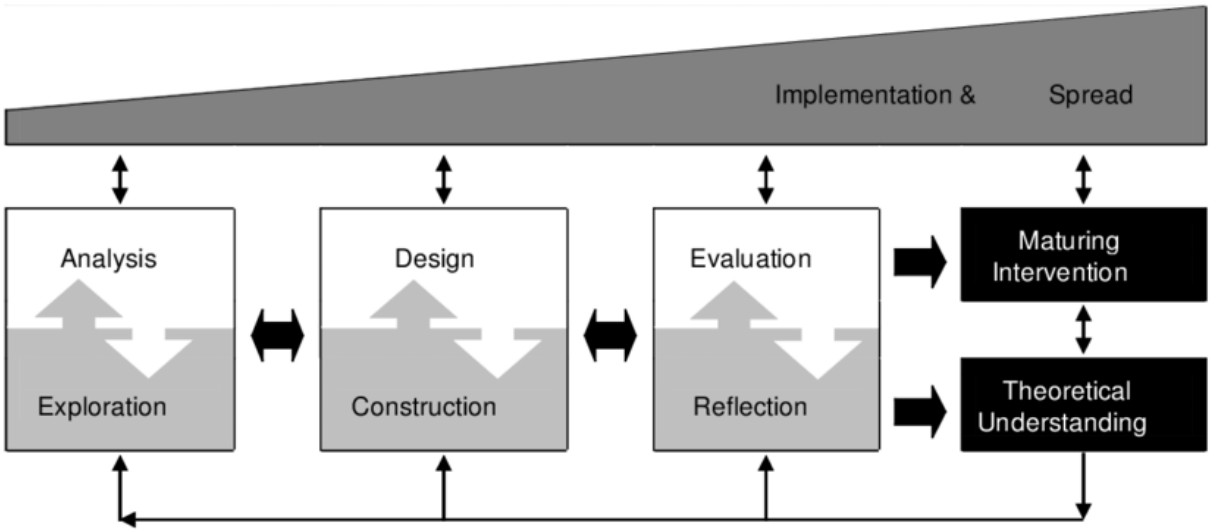
A case study will provide specific measures for the school that could serve as a blueprint for wider application through interviews.

2.2.2 Educational Design Research Model

This thesis follows the Educational Design Research model, which blends theory with practice, solving practical problems and generating theoretical insights simultaneously (McKenney & Reeves, 2018). The model consists of three core phases (as seen in Figure 1): Analysis and Exploration, Design and Construction, and Evaluation and Reflection. This thesis will focus on the Analysis and Exploration and the Design and Construction phases.

Figure 1

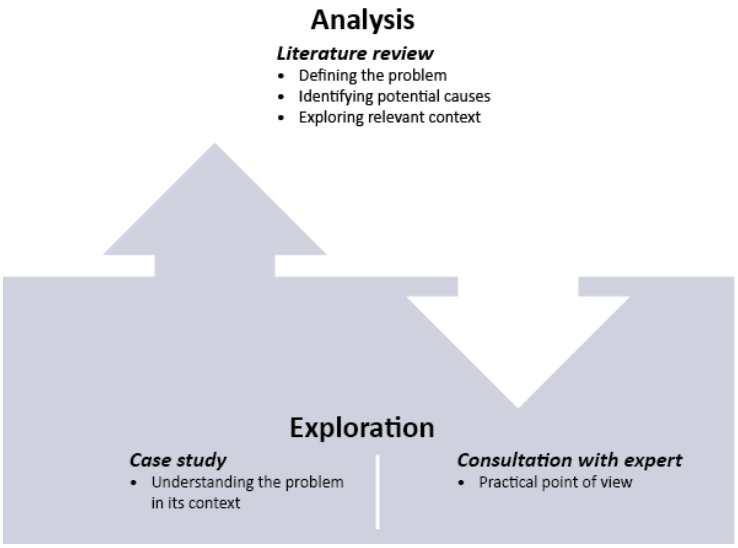
A generic model for conducting design research in education (McKenney & Reeves, 2018)



The Analysis and Exploration phase consists of four research activities: initial orientation, literature review, field-based investigation, and exploration (see Figure 2), all conducted to guide intervention (McKenney & Reeves, 2018). The theoretical framework (Chapter 2) served as the problem's initial orientation. During the Analysis and Exploration phase, the literature review was conducted to define the problem, identify potential causes, and explore the relevant context. Furthermore, a case study at a pre-vocational school in the Netherlands and an informal interview with an expert from Nehem were carried out to understand the problem within its context, covering the field-based investigation and exploration (see Figure 2). The primary outcome of the Analysis and Exploration phase was a clearer understanding of the problem.

Figure 2

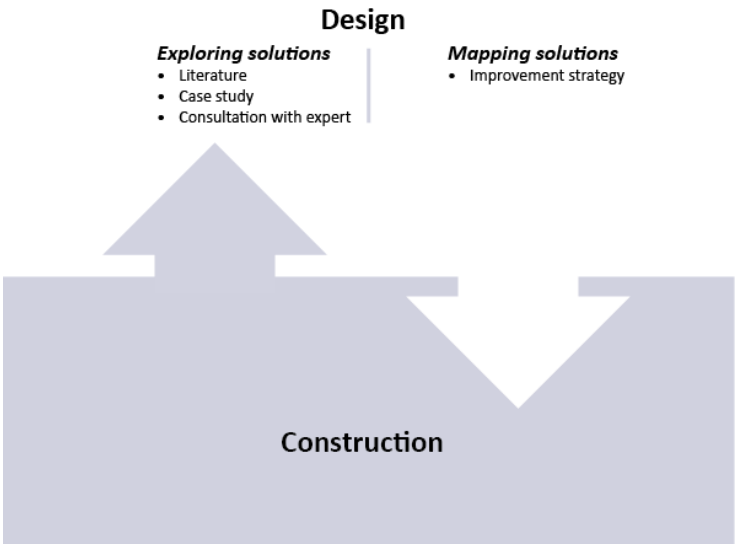
Main processes within the analysis and exploration phase (adopted from McKenney & Reeves, 2018)



The results from the Analysis and Exploration phase were used to develop advice on how to improve the gender balance in pre-vocational education in general and, more specifically, for the technical pre-vocational school in the case study (advisory report) during the Design and Construction phase. The Design and Construction phase involves three activities: exploring solutions, mapping solutions, and construction (see Figure 3; McKenney & Reeves, 2018). Literature, the case study, and the expert consultation were utilised during the exploration of solutions (see Figure 3). Ideas were generated and assessed, and once refined, a skeleton design of the improvement strategy was created. However, further activities within this phase were not completed for this research.

Figure 3

Main processes within the design and construction phase (adopted from McKenney & Reeves, 2018)



2.2.3 Context

This study is conducted in the context of and to provide advice for a leading pre-vocational technical education school in the Netherlands. At this school, they believe in technical education, where personal attention makes a significant difference. They focus on developing technical craftsmanship and essential soft skills, preparing students for immediate employment and ongoing professional growth. The school works closely together with regional businesses and the Wetech Foundation to ensure their students meet the needs of the industry. According to the website, the school aims to be an inspiring model of technical education that is both motivating and closely aligned with industry demands. However, currently, the school only has 23 female students out of 622, and they would like to improve their gender balance significantly.

3 Analysis & Exploration

3.1 Literature Review

3.1.1 Gender Stereotypes

Gender stereotyping involves attributing specific roles and characteristics to individuals based solely on their gender (De Blank et al., 2020; De Witte & Haan, 2013; Langen & Driessen, 2006). These stereotypes are deeply embedded in societal and cultural norms, influencing behaviour and expectations across various contexts (De Blank et al., 2020). According to De Blank et al. (2020), traditional gender roles, which dictate specific behaviours and responsibilities for men and women, often restrict personal freedoms and perpetuate gender inequality. In many cultures, men are seen as the primary breadwinners and decision-makers, while women are typically assigned the roles of caregivers and homemakers.

The impact of gender stereotypes extends beyond familial roles, shaping perceptions, behaviour, and opportunities from an early age and affecting various domains, including education, the workplace, and personal relationships (De Witte & Haan, 2013). WOMEN Inc. (2021) points to the consequences of these stereotypes, showing that, for instance, the technical and IT sectors remain highly male-dominated, with 86% of workers in technical fields being men.

As noted by Brussino and McBrien (2022) and De Blank et al. (2020), these stereotypes are perpetuated through multiple channels, such as family dynamics, media representations, and educational institutions. These channels reinforce societal norms, often creating pressure to conform to traditional gender roles.

Moreover, stereotypes can have a profound effect on self-concept and self-esteem, encouraging individuals to align with societal norms instead of pursuing their true interests and potential (De Blank et al., 2020). Children and young individuals are particularly vulnerable to these influences. Common Western gender stereotypes suggest that boys should be strong, assertive, and independent, while girls

should be nurturing, passive, and compliant (Brussino & McBrien, 2022; De Blank et al., 2020). From a young age, children are often directed towards gender-specific toys and colours; girls are given dolls and encouraged to like pink, while boys are given trucks and encouraged to favour blue (De Blank et al., 2020).

The consequences of gender stereotyping are both extensive and, at times, subtle (De Blank et al., 2020). Stereotypes are reinforced in two ways: explicitly, for instance, through direct communication, such as parents telling children which toys or activities are appropriate depending on their gender, and implicitly, through unconscious biases that individuals internalise without overt instruction (De Blank et al., 2020). These implicit messages are embedded in societal expectations and often go unnoticed, yet they significantly shape perceptions of gender roles.

Furthermore, gender stereotypes can influence cognitive development and educational choices. Jolles (2010) argues that these stereotypes can limit aspirations by promoting the belief that boys are naturally better at maths and sciences while girls excel in humanities. Such biases not only affect individual development but also have broader societal implications, particularly in technical fields, where women continue to be underrepresented (Jansen & Derksen, 2015).

Schools play a crucial role in either reinforcing or challenging gender stereotypes (Langen & Driessen, 2006). Langen and Driessen (2006) stated that educational settings often inadvertently perpetuate these stereotypes through biased curricula, teacher expectations, and peer interactions. For instance, Mesman et al. (2017) state that girls who are reminded of stereotypes before a maths test tend to perform worse than those not exposed to such reminders. This phenomenon, known as the stereotype threat, highlights the powerful influence of societal expectations on individual performance. Furthermore, Mesman et al. (2017) state that gender representation in schoolbooks can reinforce stereotypes, noting that women are underrepresented in professional intellectual and sporting roles in schoolbooks, which does not reflect societal realities.

3.1.2 Self-Confidence

Self-confidence plays a crucial role in motivating girls to pursue a technical education and career (Elfering et al., 2016; Van Aalderen-Smeets et al., 2018). Research has shown that stereotypes and biases significantly impact girls' self-efficacy in STEM fields, which in turn affects their educational choices (Elfering et al., 2016; Hand et al., 2017; Makarova et al., 2019; UNESCO, 2024). Huguet and Régner (2009) discuss the concept of stereotype threat, where girls' awareness of negative stereotypes about their abilities in technical subjects can lead to decreased self-efficacy and performance. This phenomenon can create a self-fulfilling prophecy where girls underperform due to lowered expectations, further discouraging them from pursuing technical education.

Van Tuijl and Walma Van Der Molen (2015) highlight that girls often do not consider technical education a viable option because they are unaware of potential career opportunities. This lack of awareness can create doubt about their skills and potential, reinforcing a cycle of not considering technical education a viable option, thereby impacting their overall self-confidence in pursuing STEM careers.

3.1.3 Female Role Models

Research has shown that secondary education students are more likely to opt for STEM subjects if their parents have a technical background, with a particularly strong influence from mothers who have completed a technical education (Statistics Netherlands, 2024). While parental influence is crucial, external role models also play a significant role in shaping aspirations, particularly for girls (Lockwood, 2006). Lockwood (2006) defines role models as individuals who influence others by serving as examples. She continues by stating that role models have a significant impact as they inspire imitation and demonstrate what is possible, thereby influencing aspirations and achievements. For this reason, role models are often seen as essential for personal and professional development (Torres-Ramos et al., 2021). They help individuals envision their future possibilities and motivate them to achieve their goals.

Role models are particularly important for underrepresented groups, as they provide a sense of belonging and possibility within a given field (Torres-Ramos et al., 2021).

Breda et al. (2023) investigated the impact of female role models on young women's aspirations and achievements, specifically in traditionally male-dominated fields (e.g., STEM careers). Their findings confirm that role models play a crucial role in shaping young women's ambitions and career paths. Milgram (2011) adds that showcasing successful female role models is essential for recruiting and retaining women in STEM.

According to Jansen and Derksen (2015), the scarcity of women in STEM roles reinforces the stereotype that these fields are not suitable for women, thereby perpetuating a cycle of underrepresentation and limited opportunity. In an interview with the American Association of University Women (AAUW), Aronson emphasised that exposing girls to female role models, not only counters stereotypes but also fosters a growth mindset, reinforcing the belief that abilities can develop through effort and perseverance (Hill et al., 2010).

3.1.4 Media Representation

As mentioned in the previous paragraph, positive portrayals of women in STEM can inspire and motivate more girls to follow similar paths. According to Brussino and McBrien (2022) and Santoniccolo et al. (2023), media representation plays a significant role in maintaining and propagating gender stereotypes. The influence of media on gender perceptions is particularly evident in how certain professions and social roles are depicted (Cheryan et al., 2013). Individuals in technical careers, particularly, are often depicted in a highly stereotypical manner: as male-dominant. The Women's Media Center (2021) reported that women comprised only 5% of experts in technical fields, as portrayed in the media. The absence of visible female role models in these areas makes girls less likely to consider technical education as a viable and empowering career path.

Moreover, the Annenberg Inclusion Initiative has examined the prevalence and portrayal of female-identified characters in fictional entertainment (Smith et al., 2017). In 2017, Smith et al. (2017) found a significant underrepresentation of women in media, particularly in roles associated with intelligence or authority. Their research found that only 12.2% of female characters in the media were depicted in professional or academic settings, which paints a skewed picture of women's capabilities and aspirations for young female viewers.

In addition, the portrayal of female characters in fictional media often adheres to narrow stereotypes (Smith et al., 2019). Smith et al. (2019) concluded that only 33.1% of all speaking or named characters in top-grossing films were female, and even within this group, their roles often conformed to traditional gender stereotypes, such as being nurturing or emotional.

Research by Mendick and Moreau (2013) highlights the persistence of gendered discourses in media representations, particularly in online portrayals, where traditional gender roles dominate. Women are frequently depicted in domestic or supportive roles, while men are shown in positions of power and authority, reinforcing societal expectations that men are more suited for leadership and professional success (Mendick & Moreau, 2013; Archana & Himani, 2015). This imbalance in representation is further entrenched by popular media, including movies, television series, and music videos, which often depict gender stereotypically, as exemplified by the early seasons of The Big Bang Theory, where female characters are primarily valued for their physical attractiveness (Cheryan et al., 2013; Nerdy Men and Hot Women: Sexism in the Big Bang Theory, 2013; Turker, 2014). Such portrayals reflect and perpetuate existing societal biases (Sagebiel et al., 2008). The continued prevalence of these stereotypes underscores the critical need for more balanced and diverse representations of gender in media to foster a more inclusive society (Archana & Himani, 2015). However, reversing this trend presents an opportunity to leverage the power of these media to stimulate and empower girls to pursue technical careers.

3.1.5 Social Dynamics

Many students base their decisions on feelings and vague ideas about their futures rather than well-considered plans (Elfering et al., 2016). The perception of technical work often carries a stigma of being dirty and laborious. This perception contributes to the stigma surrounding technical careers, particularly among girls.

Adolescents often feel a need to belong and connect with their peers (Elfering et al., 2016). Parents are seen as the primary influence on study choices, followed by professionals, teachers, friends, and classmates. As children grow older, their friends' interests and opinions become increasingly important. For girls, a technically oriented friend group can significantly influence their decisions regarding technical education.

Similarly, students often enjoy school for its social aspects, and their choices are frequently affected by factors like school proximity, religious beliefs, and peer pressure. Schools can further shape decisions by providing modern facilities and early career information (Elfering et al., 2016).

3.2 Case Study

3.2.1 Context

This study uses a qualitative research design to explore how (potential) female pre-vocational students can be motivated and inspired to engage in technical education. This study gathers qualitative data through a literature study along with a case study. The case study will involve semi-structured interviews with relevant stakeholders, teachers, girl coaches, a promotional team member, and female students.

The interviews with different stakeholders aim to provide a comprehensive understanding of the factors influencing female students' decisions to pursue technical education. Each group contributes a unique perspective: teachers discuss their observations of classroom dynamics and curriculum delivery; girl coaches elaborate on strategies to motivate and engage students in technical subjects, as

well as the support provided to female students by the school; the promotional team member shares insights into outreach practices; and students offer first-hand accounts of their motivations, experiences, and the barriers they face when considering technical education.

The information from the literature review was used during the interviews from the case study to reflect on the answers and guide follow-up questions. The case under investigation is a pre-vocational technical school in the Netherlands.

To gain insight into girls' motivation for technical education, semi-structured interviews using the perception poll strategy from McKenney and Reeves (2019) have been conducted with teachers, girls' coaches, and promotional team members. The perception poll strategy collects information on stakeholders' perceptions of the problem, their specific context, and their beliefs, attitudes, emotions, needs, and desires.

This approach combines structured questions with open-ended discussions, allowing for comparative analysis while providing flexibility to explore unforeseen aspects (Kallio et al., 2016). Semi-structured interviews are known for their ability to generate rich and detailed data (Harrell & Bradley, 2009).

3.2.2 Participants

All participants were selected from the same technical pre-vocational school through purposeful sampling, a non-probability sampling technique based on their gender and/or job description, to select participants who can provide rich, detailed insights into the research questions (Palinkas et al., 2013). Five teachers (two male and three female), two of whom are also girls' coaches, one is also a promotional team member and nine female students were interviewed between the ages of 12 and 16. The female students were interviewed in duos per the school's request. The teachers teach the following subjects: German, Dutch, general technology, and 3D drawing on the computer/installation

technology. Participants and the female student's parents/legal guardians provided their consent beforehand.

3.2.3 Interview Schemes

A semi-structured interview guide was created, with two versions tailored to the target groups: one for students and another for teachers (including the girl's coaches and a member of the promotional team). The questions were framed with the expectancy-value theory (Hulleman et al., 2016), social cognitive theory (Bembenutty et al., 2016; Bozack, 2011), stereotype threat theory (Shapiro & Williams, 2011), and social role theory (Newman & Newman, 2020; Ridgeway, 2001) in mind. Using these theories in developing interview questions ensured that the resulting data was nuanced, without bias, and provided theoretically grounded insights, leading to more comprehensive and valuable findings.

3.2.3.1 Student Interviews

The student interview scheme included five main questions designed to gather additional information to address the research questions, focusing on motivation and future aspirations related to technical education at their school. Each main question was supplemented by additional questions based on the students' responses, leading to a more in-depth understanding of their perspectives.

One of the main questions asked was: "Why did you choose technical education at this school?" This question aimed to uncover the initial motivations behind the students' choices. Another question focused on the student's future aspirations: “Do you want to stay in a technical field after you graduate from this school?” To delve deeper into this topic, a follow-up question was posed: “Do you know what job you want to have after you graduate?” This sequence of questions helped to assess not only the students' immediate motivations but also their long-term career aspirations.

3.2.3.2 Teacher Interviews

The teacher interview framework also included a series of questions designed to gather insights relevant to the research questions. It focused on the teachers' perspectives on student motivation, the impact of stereotypes, and the factors influencing girls' participation in technical education. Similar to the student interviews, follow-up questions were asked based on the teachers' answers, allowing for a deeper exploration of their perspectives.

One of the main questions posed was: "Why do you think the female students choose technical education at this school?" This question sought to understand the teachers' views on the factors influencing students' decisions. Another question asked was: “Do you have any tips related to how this school could approach promoting technical education differently?” This allowed teachers to share their insights on potential improvements in promotional strategies. A follow-up question, “What could your role be in this?” was designed to encourage teachers to reflect on their contributions to enhancing the appeal of technical education for female students.

3.2.4 Procedure

3.2.4.1 Student Interviews

The interviews with the students began by revisiting the consent form that they and their parents had previously signed. This step ensured that participants understood their rights and the purpose of the research. Once consent was confirmed, the first question was asked to start the discussion. Follow-up questions were used to delve deeper into their initial responses, allowing for clarification and a better understanding of their motivations. This interactive process continued until all questions were addressed. Each interview lasted approximately 30 minutes. At the end of each interview, the students were thanked for their participation and presented with a chocolate bar as a token of appreciation for their time and insights.

3.2.4.2 Teacher Interviews

The interviews with the teachers started with the signing of a consent form, ensuring that all participants were aware of the research objectives and their rights. The interviews followed a semi-structured format, with each participant being asked the same set of main questions, along with relevant follow-up questions based on their responses. Each interview lasted approximately 30 minutes, providing enough time for discussion. At the end of the interviews, participants were thanked for their time and cooperation.

3.2.5 Data Analysis

The interviews were transcribed using Amberscript and coded in ATLAS.ti. The data was coded using an open-coded scheme in two rounds: first, assigning codes, and second, summarising the findings. The first round resulted in ten codes, which were then categorised into four themes: 1) Motivation for Technical Education, 2) Previous Contact, 3) Media Representation and Role Models, and 4) Improvements.

The first theme explores the various factors that motivated female students to choose technical education. Additionally, it highlights insights into why the participants thought other female students decided not to pursue technical education, including the influence of gender stereotypes, the perception of a male-dominated environment, and discomfort with technical subjects.

The second theme discusses students' prior experiences with technical subjects.

The third theme examines the representation of women in media and the impact of role models on students' choices.

The fourth theme discusses the participants' recommendations for improving the curriculum and implementing changes to the promotional strategies to increase the enrolment of girls at the school.

The insights gained from these interviews will inform the design and construction phase of this study, where potential improvements and interventions will be explored to attract more female students to technical education.

3.2.6 Results

This section will be divided into two parts: the first part focuses on the analysis of the student interviews, while the second part examines the analyses of the teacher interviews. The interviews with female students provided valuable insights into their motivations for choosing technical education and their experiences with technical subjects. The interviews with teachers provided valuable insights into the challenges and opportunities for attracting female students to technical education. Several key themes emerged from the analysis.

3.2.6.1 Student Interviews

3.2.6.1.1 Motivation for Technical Education

A strong recurring theme was the desire for hands-on, practical work. More than half of the students (i.e., five) cited that they enjoyed working with their hands. This preference for practical learning was a key reason why the students chose technical education over more classroom-based environments. One student remarked, “I do not want to sit behind a book all day,” reflecting a common sentiment among the participants.

Additionally, students expressed a genuine interest in technical subjects close to their field of interest, such as those involving design and interior decoration. Other students mentioned their enjoyment of working with motor vehicles and aspired to careers as carpenters or truck drivers.

In this context, one of the primary reasons students chose this particular school over other schools was the greater number of hours dedicated to technical education. At this school, students could engage in technical subjects for a significant portion of their school time (eight to ten hours a week), in contrast to the limited two hours per week offered in the technical profiles at non-technical

schools. Additionally, the ability to specialise in their third and fourth years was a decisive factor in their school choice, allowing them to develop more skills and gain deeper experience in their areas of interest.

Moreover, one student appreciated the school's organised structure, stating that the school provided clear guidance rather than requiring her to figure it all out on her own.

The students also identified barriers that, in their opinion, discouraged others from pursuing technical education or attending a technical pre-vocational school. A common issue raised was the male-dominated environment, which made some female students hesitant. The perception of being a minority in technical subjects, coupled with discomfort around boys, was mentioned four times during the interviews.

On the other hand, three girls mentioned that, overall, girls are only interested in typical girly stuff: “Girls who wear makeup and dresses do not like technical subjects.” Another student stated, “They (the other girls from her primary school) found makeup important and always wore dresses, so they do not like technical subjects.” Additionally, some girls noted that their peers do not like to get dirty.

3.2.6.1.2 Previous Contact with Technical Subjects

All interviewed students had, to some extent, prior experience with technical subjects, though this experience rarely came from primary school education. Instead, most students mentioned working on technical projects at home with family members, such as helping their parents with renovations or working with a family member on building projects. These projects ranged from making a picture frame to assisting in the construction of a canopy.

3.2.6.1.3 Role Models and Media Representation

Another aspect discussed in the interviews was the participants’ role models and the representation of women in the media. Most participants came from families where at least one

member held a technical occupation, primarily fathers, uncles, or grandfathers. Four students mentioned having a role model or someone in a technical occupation whom they admired and thought, "I want to do that too." Among these, three students identified women as their role models. Two named their mothers; one noted, “She is always doing something technical around the house,” while the other mentioned, “My mom renovated the bathroom.” The third student shared a different perspective, stating, “A woman was working for the local fish shop that had a bright pink truck, and I wanted that too.”

The fourth student identified a male role model, recounting, “During a renovation, there was an electrician who was disabled; one of his legs was paralysed. I admired how he still managed to do everything himself, even working underground. He was still capable. It made me think that even though I find it very difficult, he could do it, so I should be able to as well.” This statement highlights the student’s self-confidence and downlights it at the same time; she believes that if a disabled man can accomplish such tasks, it shows that anyone can succeed, including herself as a girl.

Only one student commented on female representation in the media, remarking, “The only women I see on TV are either cooking or doing something else, but not really in technical careers.” This limited representation in media contributes to the perception that technical education and careers are not aligned with female interests.

3.2.6.1.4 Improvements

The female students provided several suggestions to improve the appeal of technical education at their school and increase the enrolment of girls. One of the most frequently mentioned suggestions by eight students was the importance of maintaining the girls’ common room, which they felt should not be made smaller when they move to a new building in January 2025. The girls also expressed a desire for (more) girls' bathrooms spread throughout the building (currently, they only have one situated on the ground floor).

Four students expressed a desire for creativity to be integrated into the projects within the technical curriculum. One student remarked, “Your brother once made a fence. That might be fun for the boys but not as much for the girls.”

Two students expressed that organising only one girls' open day in February is insufficient and too late in the year. One student mentioned that she was deciding between two schools and “would have loved to visit the school again to make sure I really liked it before applying.”

In addition to the open days, the students felt that it would be beneficial for female students to visit primary schools to show younger girls that there are girls at technical pre-vocational schools and to demonstrate what they are capable of in technical fields.

3.2.6.2 Teacher Interviews

3.2.6.2.1 Motivation for Technical Education

The teachers noted that many female students were motivated to choose technical education because of the opportunity to engage in hands-on, practical work. One teacher explained, “Girls who choose technical subjects tend to be very motivated. They have often set a goal for themselves and are determined to reach it.” Another teacher stated, “They like to work with their hands and want to do something practical rather than theoretical.”

Teachers explained that many female students chose the school because it is the only school in the region that offers specialisations in all technical profiles. In contrast, other schools either do not offer all profiles or do not allow for specialisation. One teacher remarked, “This school is unique because we offer more hours of technical education compared to other schools.” Additionally, another teacher noted, “We are the only school where you can still go in all directions with your technical education.”

Moreover, the reformed character of other schools in the area was a deciding factor for some students. One teacher stated, “There are other schools that offer technical education, but they have a strong religious character that does not suit many of our students.”

While some girls were motivated to pursue technical education, the teachers also discussed several barriers that made others hesitant. Two teachers noted parental influence, with one stating, “When girls come home from open days, their parents sometimes say, ‘No, this is not for you.’” Four teachers added that the male-dominated environment poses a considerable barrier for girls.

Three teachers identified deeply ingrained gender stereotypes and cultural norms as major obstacles. One teacher shared an example from visiting primary schools: “When we go to primary schools, girls often say, ‘Oh, I cannot do technical work,’ but by the end of the lesson, when we ask them how they found it, they say, ‘Oh, I did not know this was also considered technical work.’ They just have no idea what technical work really involves. They often think it is heavy, dirty work, but it offers so much more than that.”

Teachers also noted how girls' upbringing influences their interest in technical subjects. One teacher explained, “We still offer girls more 'girly' toys, while boys are given things like LEGO. Girls are just less encouraged to choose technical subjects. Moreover, for the girls we do get, we often notice resistance from their parents because they know the girls will need to have a thick skin in a male-dominated environment.” Another teacher further emphasised the deep-rooted nature of gender stereotypes, stating, “Boys are naturally more active, and people associate that with technical fields, especially in the workplace where there are far more men. Even though I can think of many technical jobs that girls could do just as well, we still see that girls are choosing other careers by nature.”

However, the stereotypes are not just ingrained in the students but also in the teachers. One teacher revealed his own biases when asked how to reduce the barriers for girls considering technical education, stating, “The question is whether we should want girls in technical fields if they prefer other things, as they have so many qualities that suit them for careers where they feel more comfortable.” He acknowledged that girls tend to perform better and are more precise when it comes to their projects but implied that not many girls are inclined toward technical subjects.

3.2.6.2.2 Previous Contact with Technical Subjects

Teachers expressed their concerns about how little exposure many students had to technical careers before joining the school. One teacher mentioned, “Girls often do not know what careers they can pursue with technical education before they come to this school.” However, efforts are made to counter this once the female students are at this school, with the girls' coaches noting, “We try to visit companies and have quests come in to talk about career options.”

3.2.6.2.3 Role Models and Media Representation

Teachers also stressed the importance of female role models in encouraging girls to pursue technical education. They highlighted examples of former female students who have succeeded in technical careers, such as the former student who now works for the TV program *Eigen Huis en Tuin*, a point of pride for the school. Social media was also mentioned as a potential tool for showcasing female role models. “With the rise of social media, students can now see women, for example, building camper vans on Instagram,” one teacher said, suggesting that increased visibility online could inspire girls to follow suit.

Despite these efforts, teachers acknowledged that traditional media still underrepresents women in technical fields, which continues to influence girls' perceptions. One teacher remarked, “The students do not see many women in technical careers on TV, and that reinforces the idea that it is not for them.”

3.2.6.2.4 Improvements

Teachers provided several suggestions for improving the appeal of technical education at their school and increasing female enrolment. One common recommendation from three teachers was to enhance the visibility of female role models within the school. They stressed the importance of hiring more female instructors in technical subjects to demonstrate to students that women can excel in these

fields. One teacher noted, “Girls need to see more women doing technical work, both in the classroom and in the media, to see that they can do it.”

Additionally, four teachers suggested adjusting the curriculum to include more creative and design-oriented projects that would resonate better with female students. For instance, one teacher mentioned, “If we let girls work on projects that involve interior design or similar areas, they might feel more engaged.” Another teacher added that, instead of making a miniature tractor or barbecue, students could create a makeup organiser or something else better linked to their interests.

Furthermore, two teachers highlighted the importance of engaging parents more during open days. One teacher stated, “We need to inform the parents about the opportunities for girls in technical education and careers to help them understand that it is a viable path for their daughters.”

Lastly, two teachers emphasised the need for early outreach programs to introduce technical education to girls at a younger age. One teacher remarked, “Starting workshops in primary schools would show girls that technical subjects are not just for boys and help them become familiar with these fields before they reach secondary education.”

3.3 Discussion of Results

3.3.1 Gender Stereotypes

The findings from both the literature review and the case study highlight the impact of gender stereotypes on girls' decisions to pursue technical education. The literature indicates that societal norms frame technical fields as male-dominated, discouraging female participation (De Blank et al., 2020; De Witte & Haan, 2013). Students also expressed internalised stereotypes, such as the belief that "girls who wear makeup and dresses do not like technical subjects." This reflects deeply ingrained societal norms that frame technical education as incompatible with traditionally feminine interests.

Teachers also acknowledged the role of gender stereotypes in shaping students' perceptions. They noted that ingrained societal norms lead girls to believe they are not suited for technical work. This

aligns with the students' sentiments and highlights the pervasive nature of these stereotypes in both educational settings and societal contexts. Overall, the case study supports the literature's assertion that such stereotypes create significant barriers, making it difficult for girls to see themselves in technical fields and choose a technical education and career.

3.3.2 Self-Confidence

Both the literature and case study findings emphasise the importance of self-confidence and stereotype threat in influencing girls' participation in technical education. The literature describes how stereotype threats can undermine girls' confidence and deter them from engaging in technical subjects (Huguet & Régner, 2009). Teachers corroborated this by indicating that many female students face self-doubt. One of the students also stated that she doubted her abilities, but when she saw that a man with a handicap could do it, she could, too.

Interestingly, students shared that their hands-on experiences at home, often informal, helped develop their interest and capabilities in technical work. This suggests that while initial confidence may be low, hands-on experiences can help build the self-efficacy needed to succeed in technical subjects. Early experiences can bolster self-confidence, but a lack of structured exposure prior to secondary education may hinder girls' initial interest in pursuing technical education.

The students’ technical experiences were often informal, rooted in home environments rather than structured educational opportunities. This highlights an area where educational systems, especially at the primary level, could do more to introduce girls to technical fields formally.

3.3.3 Role Models and Media Representation

The importance of female role models emerged as a critical theme in both the literature and the case study. The literature suggests that a lack of visibility of women in technical fields contributes to the perception that these careers are not for girls (Elfering et al., 2016). This was echoed in the case study, where students noted that they rarely see women in media portraying such careers. However, only one

student mentioned female representation in media, remarking that women are typically seen in domestic roles rather than technical careers. The students did not seem aware of the lack of female representation in the media.

Conversely, students identified personal role models, such as mothers and male family members who engage in technical work, as significant influences on their career aspirations. This duality indicates that while broader media representation is lacking, personal connections can serve as powerful motivators for girls considering technical education.

Teachers reinforced this point by discussing the importance of visible role models. They highlighted successful female alumni as examples to inspire current students. One teacher remarked, “Girls need to see more women doing technical work, both in the classroom and in the media, to see that they can do it.”

3.3.4 Social Dynamics

Social dynamics significantly influence career choices in technical education, as noted by Elfering et al. (2016). They highlight that the stigma surrounding technical work, perceived as dirty and laborious, deters many students, especially girls, from pursuing these fields. Another important factor is male dominance. At the school from the case study, only 3.7% of the student population is female. Students expressed discomfort about being part of a minority in a predominantly male environment, which contributed to their hesitation in selecting technical subjects. The lack of girls' bathrooms at this school further exacerbated this discomfort.

The female students who chose the technical pre-vocational school in this study said that the availability of a girls’ common room was a key selling point, indicating that supportive spaces can positively influence decision-making in a male-dominated setting. Overall, this aligns with Elfering et al.'s (2016) assertion that social context, peer relationships, and a supportive educational environment are crucial in shaping students' motivation and self-confidence in technical fields.

3.3.5 Career Perceptions

Teachers noted that girls often have misconceptions about technical work, believing it to be dirty or heavy. The students have no idea what technical work can involve. This lack of understanding underscores the need for educational efforts to clarify what technical careers entail.

The case study also revealed that when students were exposed to a diverse range of technical opportunities, their interest in pursuing technical education increased. This suggests that introducing diverse career paths within technical education could help shift perceptions and attract more female students. Teachers recognised this potential, suggesting that integrating more creative projects into the curriculum could engage female students more effectively. This points to a critical avenue for shifting perceptions and attracting more girls to technical fields. Notably, the case study also revealed that most of the interviewed students already had an idea of the types of jobs they wanted, with many aspiring to careers in technical areas.

3.3.6 Practical Learning and the Hands-On Approach

A critical insight from the case study was the strong preference among students for hands-on, practical learning. More than half of the participants expressed a desire to work with their hands, reflecting a key motivation for choosing technical education over traditional classroom-based learning. This finding resonates with teacher observations, noting that girls are often motivated by opportunities for practical engagement.

Both students and teachers pointed out that their school’s unique position in offering specialisations in all technical profiles and the number of hours dedicated to technical subjects further distinguishes it from other schools. This alignment between student preferences for practical work and teachers' recognition of its importance suggests that hands-on experiences are essential for engaging girls in technical education. By providing ample opportunities for practical learning, the school from this

study appears to create an environment conducive to attracting and retaining female students in technical fields.

4 Design & Construction

The design and construction phase aims to propose strategies for increasing female enrolment in existing pre-vocational technical education programmes, contributing to a more gender-balanced school environment. The interventions outlined are structured as general guidelines for application across educational pre-vocational institutions, with a specific case study focus on a technical pre-vocational school in the Netherlands. This case study allows these general strategies to be tailored to a real-world setting, providing a model that may also support other institutions working to achieve a more gender-inclusive environment in technical education.

This chapter will present eight targeted interventions derived from the results of the Analysis and Exploration phase. Some interventions are designed to produce immediate results, while others aim to shift attitudes, perceptions, and enrolment in technical programmes, taking more time to impact girls' choices regarding technical education fully. These interventions have been categorised into two types based on their expected timeframe for impact: immediate and long-term.

This focus on enduring change aligns closely with generalised strategies for similar educational settings, where interventions must address the root causes of gender imbalances, including stereotypes and lack of exposure. These broad principles can be extracted and tailored to suit other schools, illustrating how specific measures from the school in the case study provide a blueprint for wider application.

4.1 Improvement Strategy

4.1.1 Strategically Planned Open Days

Scheduling multiple recruitment events tailored specifically to female students is crucial for increasing enrolment (Elfering et al., 2016). Hosting these events at different times throughout the academic year, closely aligned with formal decision points in school schedules and curricula, allows female students to explore technical education and see themselves in these roles, fostering early

interest and engagement (Elfering et al., 2016; Jansen & Derksen, 2015; Van Tuijl & Walma Van Der Molen, 2015). This intervention is aimed at having an immediate impact on the number of girls attending the events and enrolling in a technical programme.

Studies show that early and repeated exposure to academic or career pathways increases enrolment rates (Van Tuijl & Walma Van Der Molen, 2015). When students attend events at varied times, they feel they have ample opportunity to consider their options thoughtfully. The case study found that students want to have more opportunities to visit a school to make a well-considered choice.

The school from the case study could offer a second girls' day earlier in the year, such as in the autumn term, providing prospective students with more time to reflect on their options before application deadlines. This additional event would cater to female students who need more interactions to consider technical education seriously and would provide an earlier touchpoint in the decision-making process.

4.1.2 Involving Parents

Research shows that parental support and endorsement are key factors in encouraging female students to enter non-traditional fields like technical education (Blumberg et al., 2023). Both the literature and the case study revealed that involving parents in the recruitment process allows schools to address misconceptions about technical fields and reassure them about their daughters' prospects and opportunities. The case study also highlighted that all the female students had hands-on experience with technical subjects through family members, indicating that family influence plays a significant role in shaping students' perceptions of technical areas.

Therefore, engaging parents actively in the recruitment process is beneficial, as family members significantly influence students' educational decisions (Brussino & McBrien, 2022; Elfering et al., 2016; Phillips, 2024). Inviting parents to open days or informational sessions helps dispel concerns about

technical education for girls and can positively influence their support for technical career pathways, with an immediate impact on girls' enrolment in technical programmes.

The school from the case study could invite parents of prospective female students to join open days alongside their daughters. Including female professionals as guest speakers to share their own career experiences would provide parents with tangible examples of what their daughters might achieve in technical fields, fostering greater parental support and enthusiasm.

4.1.3 Female-Specific Amenities

As the literature (Elfering et al., 2016; Hill et al., 2010) and case study demonstrate, creating inclusive and supportive spaces for female students is essential in male-dominated educational settings. Gender-specific amenities, such as dedicated common rooms or restrooms, can foster a sense of comfort, security, and belonging. These features help female students feel valued and respected within their environment, contributing to a more welcoming experience. In an unbalanced educational setting, these facilities provide a 'safe haven,' aiming for an immediate impact on girls' enrolment in technical programmes.

This recommendation is based on findings from the case study indicating that female students often feel outnumbered and overwhelmed in a male-dominated environment. Furthermore, the literature states that the school environment and classmates have a big influence on the student's choice of schools (Elfering et al., 2016). A well-considered and personalised school environment can have a positive effect on students.

At the school from the case study, this strategy can be applied by expanding the number of bathrooms for female students and maintaining the girls' common room as a dedicated space for social interaction, also in the new building setup. This specific action shows the school's commitment to recognising and addressing the unique needs of its female students.

4.1.4 Wider Variety of Projects

The case study revealed that technical education settings should emphasise the diversity of existing technical projects to appeal to a broader range of female students. Female students felt there was a lack of projects incorporating design and creative aspects beyond purely 'hard' technical skills, or at least these elements were not visible. Literature (Jansen & Derksen, 2015; Langen & Driessen, 2006; Smith et al., 2017) also suggests that women are often drawn to work where they can use their creativity. Highlighting existing design-oriented projects appeals to female students and provides a broader view of what technical fields can offer, helping dispel the stereotype that technical work is solely “hard” labour. A balanced presentation can attract a wider range of female students who may have interests beyond traditional technical tasks, creating immediate interest and engagement in technical education.

Beyond showcasing existing projects, it is vital to extend the programme to include more opportunities for creative expression. Research (Jansen & Derksen, 2015; Langen & Driessen, 2006; Smith et al., 2017) and the case study reveal that female students have a strong desire to express their creativity in their education. By incorporating more creative projects or design assignments into the curriculum, educators can enhance engagement among female students in technical subjects (Brussino & McBrien, 2022).

Women are often drawn to work where they can use their creativity (Jansen & Derksen, 2015; Langen & Driessen, 2006; Smith et al., 2017). Providing opportunities for creative expression allows female students to connect more personally with the material, making learning more relevant and enjoyable. This approach can help create a more inclusive environment where all students resonate with the material, which can have a long-term impact on girls’ choice for technical education.

The case study found that when a school plans to implement changes for the upcoming academic year, it is crucial to communicate these changes to potential students. Highlighting such developments can increase interest and encourage new students to apply.

During open days or girls' days, the school from the case study could showcase existing projects that involve both creative and practical skills, such as interior design, environmental technology, or product development. This balanced approach is likely to attract a broader demographic, appealing to female students who have interests beyond traditional technical tasks.

Incorporating creative, hands-on projects into the school's curriculum will enhance female students' participation and engagement in technical subjects and make them feel more welcome and valued. The school's initiative to introduce a new learning pathway focusing on design should be promoted through various channels, including social media, brochures, and open days. This proactive approach will help create excitement and encourage students to consider enrolling in the programme.

4.1.5 Diverse Educator Team

Female teachers in technical fields provide visible examples of success, helping students envision similar career paths for themselves (Breda et al., 2023; Guenaga et al., 2022; Hill et al., 2010; Lockwood, 2006; Torres-Ramos et al., 2021). Hiring female teachers to teach technical subjects is an effective strategy for inspiring and mentoring female students, with a potential immediate impact on their choice for technical education.

Research shows the positive impact of role models on female students, particularly in fields where women are underrepresented (Breda et al., 2023; Guenaga et al., 2022; Hill et al., 2010; Lockwood, 2006; Torres-Ramos et al., 2021). The case study further supports this. Female teachers provide relatable figures and mentorship, helping students see themselves as capable within these environments and overcoming barriers related to gender perceptions.

The school from the case study could prioritise hiring at least one female technical teacher to increase the visibility of women in technical roles within the school. This approach signals to female students that technical careers are attainable and fulfilling for women, potentially boosting interest and enrolment in technical subjects.

4.1.6 Female Role Models in Early Education

When girls engage with technical subjects before secondary school, they are more likely to pursue them when the time comes, leading to a long-term impact (Guenaga et al., 2022). Introducing girls to technical subjects and engaging them with female role models during their primary school years can help develop an early interest in technical fields. Girls who are exposed to these areas early on are more likely to feel confident about technical education and career paths, helping to counteract gender stereotypes (Hill et al., 2010; Huguet & Régner, 2009; Jolles, 2010; Lockwood, 2006). Research (Blumberg et al., 2023; Brussino & McBrien, 2022; Elfering et al., 2016) and the case study show that educating parents and teachers about the full scope of technical education, while also highlighting the achievements of women in these fields, can help establish technical education and careers as viable options for girls. Since parents and teachers significantly influence students' choices, involving them early can help highlight the opportunities that technical education can provide for girls (Brussino & McBrien, 2022).

The school from the case study could partner with local primary schools to organise workshops led by female students and teachers. These workshops would introduce girls to technical skills and provide relatable role models, fostering early interest and helping to dispel the notion that technical fields are solely for boys.

4.1.7 Gender-Inclusive Teaching Practices

Literature (Blumberg et al., 2023; Elfering et al., 2016) and the case study showed that training teachers in gender-sensitive approaches is essential for creating an inclusive classroom environment

that supports female students. While this intervention can yield some immediate benefits, changing the school environment takes time. Educators trained in these practices are more equipped to foster a supportive environment for girls in technical subjects.

Research shows that teachers play a key role in shaping students' confidence and interest (Blumberg et al., 2023; Brussino & McBrien, 2022; Elfering et al., 2016). Teacher training helps educators understand the specific challenges female students may face in technical subjects compared to male students. It will also provide them with tools to mitigate stereotype effects (Blumberg et al., 2023). The case study illustrated that teachers could benefit from training focused on the obstacles female students face and how they can effectively support them.

From the case study at the school, providing regular gender-inclusive training for teachers could enhance support for female students, ensuring they feel engaged, comfortable, and confident in pursuing technical subjects.

4.1.8 Industry Engagement

The teachers in the case study noted that facilitating visits to workplaces, particularly those where women are employed in technical roles, can strengthen career aspirations among female students and challenge stereotypes by presenting real-world role models. Companies can also come to the school to interact with students, further enhancing their understanding of potential career paths. While this intervention can yield some immediate benefits, changing perceptions takes time. The case study demonstrated that both teachers and students desire to visit workplaces or invite women to come to the students.

Studies show that exposure to female professionals in technical settings boosts girls' interest and helps them envision future career paths (Milgram, 2011). By interacting with industry professionals, students gain insight into the practical applications of their education and are encouraged to pursue similar roles (Torres-Ramos et al., 2021).

The school from the case study could organise visits to local companies featuring, preferably female, professionals in technical roles or invite representatives from these companies to the school. This would give students firsthand experience and help establish a tangible connection to their potential career paths.

4.2 Conclusion of the Design and Construction Phase

This chapter has focused on how to improve the influx of female students into technical education and highlights the school from the case study's potential efforts to address this issue. Based on a combination of literature review and case study findings, nine targeted interventions were identified. These range from short-term solutions aimed at creating a more welcoming and supportive environment for female students to long-term strategies designed to challenge stereotypes and shift perceptions about technical education.

In the short term, the recommendations focus on creating immediate improvements, strategically planned recruitment events tailored to girls, involving parents in the recruitment process, sufficient female-specific amenities, showcasing a wide variety of projects, and a diverse educating team. These interventions are designed to foster a sense of belonging and increase initial interest in technical education.

For the school from the case study, this means organising an additional Girls' Day and actively approaching girls' parents, arranging for more toilets for girls and maintaining their common room in the new building, including and showcasing projects aligned with girls' interests, and hiring more female technical educators.

In the long term, sustained efforts such as incorporating technical subjects at an earlier stage in girls' education, providing teacher training on gender-inclusive teaching methods, and facilitating exposure to female professionals in technical fields are crucial for ensuring that interest in technical

education continues to grow. These interventions aim to change attitudes towards technical careers and help girls see the long-term potential of pursuing technical education.

For the school from the case study, this means partnering with primary schools, incorporating creative, hands-on projects and actively informing potential students about those, organising gender-inclusive training for teachers, and partnering with companies in the region.

Ultimately, the recommendations presented in this chapter aim to create a pathway that will not only increase the number of female students enrolling in technical programmes to fulfil the societal need for skilled technical professionals. The proposed changes focus on both immediate improvements and systemic, long-lasting shifts in perceptions and attitudes, recognising that real progress requires a multi-faceted approach.

5 Discussion & Future Research

5.1 Discussion

This research aimed to explore how female pre-vocational students can be motivated to engage in technical education, addressing the significant gender imbalance in this field. The Educational Design Research model was used as the framework for this research. A literature review of relevant reasons behind female underrepresentation in the technical field and identified opportunities for improvement through targeted interventions. A case study provided practical insights and areas for improvement specific to that situation, which could also be applicable to other educational institutions and serve as a general blueprint. The findings from both the literature review and the case study were aligned accordingly, as they identified the same critical factors limiting female participation in technical education. In the case study, both teachers and female students mentioned the same factors overall, indicating a strong alignment between the stakeholders' insights and the literature. The only, but notable, difference was that the students did not mention the influence of gender stereotypes, cultural norms, and media, suggesting they may either be unaware of this influence or that it simply did not arise during the interviews. By becoming aware of these external influences, students may be less impacted by them, better equipped to counteract their effects, and more confident in pursuing technical paths without internalising doubts or limitations imposed by societal norms.

The case study revealed an important aspect regarding female amenities that was not fully addressed in the literature review. While the girls greatly appreciate their dedicated room, they also face a significant drawback: there is only one female toilet throughout the entire school, located on the ground floor. This highlights the need for dedicated facilities to create a positive and welcoming environment for female students, which will benefit not only this school but also other educational institutes in their pursuit of more female students.

The slight difference between the findings from the case study and the literature review suggests that the identified interventions do not serve as a definitive blueprint for other institutions. Instead, the unique insights gained from the case study are integrated into the general strategy for educational institutes, helping to address the factors influencing female participation in technical education.

5.1.1 Practical Implications

This research provides a strategy for stakeholders in technical education institutes to increase the female influx in technical education. Early outreach is essential, as both the case study findings and literature (Van Tuijl & Walma Van Der Molen, 2015; Elfering et al., 2016) suggest that introducing technical subjects in primary schools and involving female professionals as role models could shift perceptions before gender stereotypes become deeply ingrained. Engaging parents and teachers in this outreach process will be crucial, as both this study and prior research (Blumberg et al., 2023) indicate that when parents view technical careers as viable options for female students, they are more likely to support these paths.

Additionally, this research highlights the media's role in perpetuating gender stereotypes around technical careers (Jansen & Derksen, 2015). All stakeholders can play a role in addressing media representations to counter these stereotypes effectively.

The findings also underscore the importance of early and hands-on learning, as observed in the case study and literature (Huguet & Régner, 2009). Students with practical exposure to technical work expressed greater confidence in their abilities, which suggests that primary and secondary schools should expand technical learning time and incorporate creative, design-oriented projects to make technical education more appealing to female students (Van Tuijl & Walma Van Der Molen, 2015).

Creating a supportive school environment is another key factor in attracting more female students. Schools can benefit from ensuring that female-specific facilities, such as common rooms and

bathrooms, are maintained and even expanded to create a more inclusive atmosphere. This implication is drawn primarily from the case study findings, which highlighted the importance of these physical spaces in helping female students feel comfortable in a male-dominated setting.

Finally, the importance of female role models—both as instructors and integrated into the curriculum—can not be understated, as the findings from this study and supporting literature (Elfering et al., 2016; Jansen & Derksen, 2015) suggest. Visible female figures in technical roles help dismantle the perception that technical work is solely for men, making technical careers feel more accessible and attainable for young women.

5.1.2 Theoretical Implications

This study reinforces the Stereotype Threat theory (Huguet & Régner, 2009) as a robust framework for understanding the educational choices of pre-vocational female students. Indeed, the notion that gender stereotypes, self-confidence issues, and the lack of female role models discourage girls from pursuing technical fields.

While the study largely corroborates previous methods and theories, it also introduces a nuanced perspective by suggesting that hands-on, creative approaches in technical education curricula may serve as a unique mechanism, making technical education more appealing to female students. This finding suggests that practical, skill-based education can simultaneously act as an engagement tool and a means to challenge stereotypes.

The study further contributes to the field by revealing that institutional support tailored to gender inclusivity—such as facilities and activities that make technical spaces more welcoming to girls—can be instrumental in reshaping gender perceptions in traditionally male-dominated fields. Additionally, engaging parents and teachers in this process will be crucial to demonstrating the value technical education and careers can bring to girls.

5.1.3 Limitations

Several limitations must be considered when interpreting these findings. The literature review was complemented by a case study. Time constraints limited the case study to one pre-vocational school with a 100% dedicated technical profile. The findings may not be generalisable to other pre-vocational schools and in different regions of the Netherlands. Conducting similar studies in a broader range of pre-vocational schools and in different regions could offer a more comprehensive picture of whether and how institutions address the gender gap in technical education.

Furthermore, the study focused on female students who chose technical education. It would have also been beneficial to interview students who did not choose technical education or a technical profile. Their perspectives could have offered valuable insights into the barriers that prevent girls from entering technical fields in the first place. Including students who chose technical profiles but did not pursue technical education would also have provided additional context for understanding decision-making.

Lastly, the case study revealed that female students are not aware of the influence of cultural norms and gender stereotypes on their decisions. However, this study did not explore this issue. Additional research could help in understanding how increased awareness of these influences might affect students.

5.2 Future Research

Future research should aim to address the limitations mentioned above by conducting studies across multiple schools and regions in the Netherlands to provide a more generalisable understanding of gender disparities in technical education. Including the perspectives of students who chose not to pursue technical education would offer further insights into the barriers that prevent girls from engaging with technical subjects.

The percentage of female students graduating with technical profiles at a pre-vocational level is significantly lower than the proportions for Higher General Secondary Education and Preparatory Scientific Education (the Dutch HAVO and VWO), 28% and 50%, respectively (Kaiser & Vossensteyn, 2019). Research into the Higher General Secondary Education and Preparatory Scientific Education tracks could, therefore, be valuable. These students may face different challenges and motivations when considering technical subjects. Understanding how gender stereotypes and self-confidence issues affect students across various educational levels would provide a more comprehensive understanding of how to address the gender imbalance in technical education.

More research is needed on the impact of increasing girls' awareness of external influences on their career decisions, such as gender stereotypes, cultural norms, and media. This could empower them to make choices based on their true interests and abilities rather than societal expectations, potentially helping them overcome doubts and confidently pursue technical paths.

Longitudinal studies following female students throughout their education could help track the long-term effects of interventions designed to increase female participation in technical subjects. Additionally, it provides insight into strategies that encourage them to remain in technical fields.

Finally, future research could investigate the impact of media representation on female students' career aspirations, evaluating how changes in media portrayals of women in technical fields might influence their interest in pursuing these careers.

Additionally, a clear outline of stakeholder roles in addressing the gender imbalance in pre-vocational technical education would help each group understand how they can contribute.

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7 Appendices

During the preparation of this work, I used Copilot and ChatGPT to develop a list of relevant researchers during the orientation phase of this thesis. After using this tool/service, I thoroughly reviewed and edited the content as needed, taking full responsibility for the final outcome.

7.1 Appendix I: Instrument and Codebook Analysis & Exploration Phase

Table 1

Code scheme student interviews

Category	Code	Description	Example
Career Perceptions	CP	Statements about how girls perceive the career opportunities and advancement potential in technical fields influence their decision-making.	“My uncle has a carpentry company, so I know that is an option.”
Cultural Norms	CN	Statements about the influence of cultural or societal expectations on the roles of women and men, shaping girls' decisions to pursue or avoid STEM.	
Female Role Models	FRM	Statements regarding the presence (or lack) of female role models in technical fields and how this affects girls’ interest and motivation.	"A woman was working for the local fish shop that had a bright pink truck, and I wanted that too."
Future Aspirations	FA	Statements about the student's future aspirations.	"I want to design and make camper vans." "I want to be a truck driver."
Gender Stereotypes	GS	Statements referring to biases and expectations about what girls or women should do or can achieve, specifically in relation to technical subjects.	"They found makeup important and wore a lot of dresses, so they do not like technical subjects."
Media Representation	MR	Statements referring to how media portrays women in technology or technical fields and its impact on girls' perceptions of these careers.	“The only women I see on TV are either cooking or doing something else, but not really in technical careers.”
Motivation	MN	Statement that represents why they chose this school.	“I really like technical subjects.”, “I want to work with my hands.”, “I am not good at sitting still all day.”

Social Dynamics	SD	Statements about the social dynamics within technical classrooms, particularly how male-dominated environments might discourage female participation.	"I do not mind walking past boys or having a chat with them every now and then, but a lot of boys tend to be a bit rough-and-tumble, and I would rather not have that.", “I am glad I am not in a class with just boys because I do not think I could handle that.”
Previous Contact	PC	Statements referring to previous contact with technical subjects and/or influence from their environment.	"Working with my dad in the shed to make a wooden picture frame.", “Renovating my room and helping my parents renovate theirs.”
Self-Confidence	SC	Statements about girls' confidence (or lack thereof) in their ability to succeed in technical subjects are often influenced by stereotypes or feedback.	“During a renovation, there was an electrician who was disabled; one of his legs was paralysed. I admired how he still managed to do everything himself, even working underground. He was still capable. It made me think that even though I find it very difficult, he could do it, so I should be able to as well.”

Table 2

Code scheme teacher interviews

Category	Code	Description	Example
Career Perceptions	CP	Statements about how girls perceive the career opportunities and advancement potential in technical fields influence their decision-making.	“I think that the students who did not choose for this school have no idea about the opportunities.”
Cultural Norms	CN	Statements about the influence of cultural or societal expectations on the roles of women and men, shaping girls' decisions to pursue or avoid STEM.	“I think the ideas that students have about technical education come from their culture and their parents.”
Female Role Models	FRM	Statements regarding the presence (or lack) of female role models in technical fields and how this affects girls’ interest and motivation.	“I think it is important for the students to have female role models so they can get an idea of what the possibilities are in technical fields.”
Future Aspirations	FA	Statements about the student's future aspirations.	“The students that choose for technical education already

			have a clear idea of what they want to do in the future."
Gender Stereotypes	GS	Statements referring to biases and expectations about what girls or women should do or can achieve, specifically in relation to technical subjects.	"Guys, they are naturally more agile and are much more quickly associated with technical subjects."
Media Representation	MR	Statements referring to how media portrays women in technology or technical fields and its impact on girls' perceptions of these careers.	"I think social media helps to get the girls interested in technical education. The students see women build camper vans, for example, on Instagram."
Motivation	MN	Statement that represents why they chose this school.	"I think they chose us because we have the largest technical education offering here in the region."
Social Dynamics	SD	Statements about the social dynamics within technical classrooms, particularly how male-dominated environments might discourage female participation.	"The environment is important; we have lost some female students due to the fact that there are way more boys at this school than girls."
Previous Contact	PC	Statements referring to previous contact with technical subjects and/or influence from their environment.	
Self-Confidence	SC	Statements about girls' confidence (or lack thereof) in their ability to succeed in technical subjects are often influenced by stereotypes or feedback.	