In whose eyes am I technical?

Exploring the ‘problem’ of the (non)technical girl

Ulrika Sultan

FACULTY OF EDUCATIONAL SCIENCES

Linköping Studies in Science and Technology Education

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Department of Behavioural Sciences and Learning, Division of Learning, Aesthetics, Natural Science, TekNaD.

Linköping University

SC-581 83 Linköping, Sweden

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TekNaD, Technology and Science Education Research, is a research environment at the Department of Behavioural Sciences and Learning (IBL), Campus Norrköping, Linköping University. TekNaD comprises some thirty senior researchers, postdocs, and doctoral students in science and technology education, and also hosts FontD, the Swedish National Graduate School in Science and Technology Education. Research at TekNaD focuses, for example, on the history of school subjects; teaching content; conceptual understanding; analogies, models and representations; multimodality; digital tools; teacher and student attitudes; gender issues; and assessment. TekNaD and FontD jointly publish doctoral and licentiate theses in the series Studies in Science and Technology Education (ISSN 1652-5051).
Abstract

In Sweden, girls’ non-interest in technology education and technological careers has been a topic of focus for many years, both in general and in politics, and it has influenced how the subject has been taught in schools. The thesis aims to critically examine the ‘problem’ of the (non)technical girl. This is done through four different studies. The first explores girls’ (age 10-17) engagement and interest in technology, according to international scientific literature (Study I). It is followed by studies of girls’ (age 9-14) activities, self-image and performativity in technology education, both in and out of school (Studies II, III). Lastly, the theory and empirical findings on gender, technology, and the technical girl and their implications for technology and STEM education from the first three studies were applied in Study IV. The thesis uses a theoretical framework based on concepts from the philosophy of technology and gender theory, primarily the three gender levels: the symbolic, the structural, and the individual. Data collection includes participant observation and focus group interviews with girls who have participated in technology education and camp activities, and data analysis is carried out using thematic analysis and qualitative content analysis. The findings from the first study confirm the general pattern of girls’ lesser interest in technology and call for the need to add a gender perspective. In contrast, studies II and III highlight the complex interaction between girls’ activities and self-image in technology. Although girls in study II confirm prevailing gender norms around technology, the results also show ambiguity and resistance to stereotypes, primarily when they work together and engage in their tasks in technology. Study III shows ambivalence about the “girlification” of technology to suit girls, and emphasises that girls’ interest in technology extends beyond gendered activities. Study IV reveals’ implications for technology and STEM education, pointing to potential gender pitfalls and stereotypical responses. The discussion contributes new insights into girls’ perceptions of themselves as technical. It advocates for a gender perspective in technology education research to uncover social barriers hindering girls from embracing their technical abilities. The emphasis lies in questioning established ‘problems,’ challenging gender norms, promoting inclusivity, and recognising diverse interests and skills in technology.

Keywords: technology education, girls’ interest in technology, gender, technical, STEM
Sammanfattning


Nyckelord: teknikdidaktik, flickors teknikintresse, genus, teknisk, STEM
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Nora, in March 2024

Ulrika Sultan
List of Studies


My contributions to the co-authored research studies

My supervisors and I have designed three studies using various research methods to answer my research questions and conducted three rounds of data collection, resulting in three articles and the final study, in addition to a book chapter, which was single-authored by myself. Below is an illustration of my contributions to each of the co-authored studies in the dissertation (Sw. Kappa).


In this study, I have been the principal investigator when it came to planning and formulating the research idea, purpose, and research questions and in conducting the review. Together with the other authors, I have also taken responsibility for carrying out the analysis of the literature included in this review.


In this second study, I was the principal investigator responsible for planning and formulating the study’s research idea, purpose, and research questions. I was also the researcher who carried out the data collection, but I shared the responsibility for analysing and interpreting the data and writing the article with the project’s supervisors/co-authors.


In this third study, I was the principal investigator responsible for planning and formulating the study’s main focus, aim, and research questions. I also carried out the data collection, but I shared the responsibility for analysing and interpreting the resulting data and writing the article with the project’s supervisors/co-authors.
In summary, my key contributions to the co-authored articles have been acting as principal investigator, consisting of planning the studies, gaining access to the research settings, carrying out data collection, infusing theoretical perspectives, and writing the articles/chapter and the kappa in a gender-sensitive style with implications for the research field and teaching practice. When revising the articles, I also assumed primary responsibility and oversaw the administrative aspects of publishing.
Related work

Conference papers


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Preface

Technology must be understood as part of the social fabric that holds society together; it is never merely technical or social. Rather, technology is always a sociomaterial product—a seamless web or network combining artefacts, people, organisations, cultural meanings, and knowledge. (Wajcman, 2004, p.106)

In any society, one fundamental expression of gender occurs through technology (Bray, 2007). Women and girls represent half of the world’s population and half its potential (Global Goals, n.d.) however, much of the discourse on increasing women’s presence in technology overlooks the impact of their underrepresentation in shaping the world (Wajcman, 2004). In 2015, all United Nations Member States adopted the 2030 Agenda for Sustainable Development. At its heart are the 17 Sustainable Development Goals (SDGs). The global goals “seek to end poverty and hunger, realise the human rights of all, achieve gender equality and the empowerment of all women and girls, and ensure the lasting protection of the planet and its natural resources” (The Global Goals and the 2030 Agenda for Sustainable Development, 2018).

Linköping University, LiU, conducts research and knowledge dissemination relevant to all of the sustainable development goals (Agenda 2030 at Linköping University, n.d.). As a strategic process, doctoral students “who graduate from LiU have knowledge, ability and a mindset that enables them to contribute to sustainable development” (Strategic Process, High-Priority Choices, Goals and Indicators, n.d.). The Higher Education Ordinance (1993:100) states that for the doctoral degree, the doctoral student “[...] shall demonstrate the capacity to contribute to social development and support the learning of others both through research and education and in some other qualified professional capacity” Higher Education Ordinance (1993:100, Annex 2). This thesis, a result of my doctoral studies, is written in the spirit of goal 4—Quality Education—a goal meant to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. Within the goals are specific targets meant to inspire action to ensure quality education.
I have focused my work on target 4.3; “By 2030, ensure equal access for all women and men to affordable and quality technical, vocational, and tertiary education, including university”. The choice to focus on goal 4 and target 4.3 was easy. I am a trained instructor in technology education. I have met plenty of girls and women in my courses, and if I—in anyway—can contribute to enabling all girls’ equal opportunity to enjoy high-quality education, to achieve at equal levels, and to enjoy equal benefits from education I would be proud to do so. Target 4.3 is addressed through knowledge contributing to reducing barriers to skills development and technical and vocational education and training—calling for gender equality.

However, as Harding (1995) points out in the UN-commissioned policy proposals for national science and technology programs—we cannot just add women and stir. Harding suggests that simply including women in ongoing science and technology development projects would not contribute to the improvement of women's conditions or the promotion of sustainable human development. The principle of equality is much more than “adding women and stirring”. It dictates that everyone should have the same opportunities, including studying and working in the field of their choice. The LiU Vision and Strategy (Linköping University, Vision and Strategy, n.b) highlight that we, as LiU members, must work to adopt global perspectives, protect diversity, foster gender equality and work for equal opportunities. This includes an inclusive attitude, and through my work I wish to contribute to girl’s inclusiveness and to ensure girls are given an opportunity to shape the future of technology and society. In the UNESCO (2017) report, the participation of women increases the quality of outcomes in STEM (Science, Technology, Engineering and Mathematics) fields by fostering diverse perspectives, which, in turn, stimulates creativity, reduces potential gender biases, and facilitates the development of more sustainable knowledge and solutions. They emphasise the importance of ensuring that girls and women have equal opportunities in STEM education and careers, viewing it as a necessity in terms of human rights and scientific progress.

Reading guide to the rest of the text

This kappa is part of a compilation dissertation; it is a text that aims to connect the dissertation project and its four contributions. The articles
examine—from different perspectives—how girls enact, express, and experience technology, and how adults, researchers, teachers, and other stakeholders close to girls talk about technology and about girls as being technical or not. The book chapter is aimed at pre-service students and teachers and provides implications derived from studies of teaching technology. In the kappa, I deepen the descriptions of how the work was conducted, what theoretical and methodological choices I made, and the research that is the basis for the study.

Chapter 1 introduces a historical context to the problem of this thesis, the ‘problem’ of the (non)technical girl. Chapter 2 presents the problem, aim and objective of the research. It also presents the research questions. Chapter 3 describes what the literature says about girls regarding technology, STEAM and technology education. Chapter 4 connects the key concept of value in reading and understanding the text. Chapter 5 presents the theoretical lenses employed when examining the data. Chapter 6 presents the method used to access the data used in the studies. Chapter 7 responds to the research questions and presents the results. Chapter 8 connects the research questions to Bacchi’s WPR analysis. Chapter 9 discusses what all this might mean, and chapter 10 concludes what has been learned. Chapter 11 is an epilogue, and chapter 12 is a Swedish summary.

The thesis ends with a summary in Swedish. The summary in Swedish is more of a popular scientific text summarising the why, what, and how in terms of results and implications, making the main conclusions of the thesis accessible without needing to read the English articles.
Ulrika Sultan
Chapter 1

Introduction

This dissertation aims to problematise the ‘problem’ of the (non)technical girl. This chapter is an attempt to provide historical context to the problem of this thesis—the ‘problem’ of the (non)technical girl - and how it is still affecting current efforts to promote gender equality in STEM fields; for example, the 2023 aims for a STEM strategy to increasing women’s participation in engineering programs and data on its success.

In Sweden, girls’ participation in technology education, in schools, in higher education, and in technological careers has been a topic of focus for many years, both in general and in politics, and it has influenced how subjects are taught in schools. This chapter explores the historical context of gender and technology, reviewing how societal views influenced access to education and professions. It traces the evolution of government policies to address gender disparities in technology education, highlighting changes in curricula and ongoing initiatives. The text examines persistent narratives around girls and technology, encouraging us to confront persistent stereotypes, which is necessary in unpacking the ‘problem’ concerning girls’ participation in technology and in STEM more broadly.

Why are we here?

Western scholarly thinking, which dominated the 18th and 19th centuries, understood women and men as fundamental opposites (e.g., Kerber, 1988; Myrebøe et al., 2023). Women were considered unsuitable for technological thinking and official professional life (Berner, 1997, 2003; Bjurulf, 2011). So, it was no surprise that when the first technical schools in higher education were founded in Sweden, they were only intended for men. Engineering was not considered suitable for a woman. A study carried out at the Royal Institute of Technology (KTH) in the
1890s concluded that the more hands-on programmes, such as civil engineering, mechanical engineering, and mining science were unsuitable for women because they were expected not to have the same endurance as men, and would probably become overworked during their studies (Berner, 1982; Karlqvist, 1997).

In 1938, a Swedish Government report officially stated for the first time that Swedish women could, would, and should be able to work with technology. Of course, women have always been engaged with technology and engineering in the forms of textile work, mining, manufacturing, logging, charcoal-making, or other industrial or construction work (Marçal, 2021; Oldenziel, 1999: SOU 1938:13). For example, in 1921 at Swedish KTH (Royal Institute of Technology) women were permitted to enrol for a degree in engineering; their first women students enrolled in 1897. Still, the goal in 1938 was for women to enter organised and industrial engineering and technology fields. During the 1940s and 1950s, women began to work in these professions, primarily as low-skilled workers but not to the extent needed by employers (Berner, 1999). The need for practical knowledge surged, and as the industrial sector grew in the 1960s, pupils in school years 7 and 8 (ages 13–14) could choose to participate in technology or technical orientation (as it was then called). Approximately 1% of these pupils were girls (Elgström & Riis, 1990). According to Hedlin (2011), in the early 1960s, expectations surrounding the potential to enrol young women in workshop training and make them commit to careers in engineering mechanics were noticeable. These expectations coincided with a period of economic growth in Sweden. The imagined outcome included cultivating a cohort of women engineers to address the demands of the growing industrial landscape and contribute to national economic development. At the same time, the field of computing, according to Van Oost (2000) exhibited a strong association with masculinity, at least in the Netherlands.

In the 1970s, new and active government-funded efforts emerged to encourage and increase the number of girls and women interested in pursuing technology-related fields (Hedlin, 2013; Skoog, 2001). The total number of women studying at universities and colleges in Sweden has, since 1977, been higher than the number of men. Still, they were not studying the degrees needed in industry. Governmental funding originated mainly from a significant need in the manufacturing industry, which faced a shortage of employees (Lövheim, 2010). Funding addressed the underrepresentation of women in technology and engineering roles. This contributed to government efforts to increase the
While examining the restructuring of compulsory school technology in Sweden, Lövheim (2010) noted a rhetorical correlation in politics at the time between technology and higher education recruitment. Recruitment discourse envisioned equal access to school technology not merely as an educational benefit for the learners but as a potent means of reshaping girls’ attitudes; particularly regarding engineering and science. According to Lövheim (2010), politics saw a kinship between science and technology in that they shared a recruitment challenge which, therefore, merited the same solution: girls.

Staberg (1992) noted that as we moved into the 1980s, state-led public campaigns promoted education and careers in technology, specifically targeting women and encouraging them to make non-traditional educational and vocational choices. However, the reasons behind why girls did not want to make these choices in the first place were seldom addressed (Staberg, 1992). The societal movement can be seen as reflected in school in the Lgr80\(^1\) curriculum and the fact that technology became mandatory for pupils in school years 1–9 (ages 7–15). According to Skogh (2001), there are different explanations as to why technology education became compulsory at this time. Reasons include the ambition to increase the recruitment base for future studies in technology, the need for new teaching methods, and the need for equality. Riis (2013) concluded by making technology education compulsory for all pupils, the ambition was also to increase the likelihood of girls choosing engineering and technology as a future career.

The Swedish government continuously supported interventions and initiatives in the 1980s to bridge the gap between women and technology during this period. Then Minister of Education Lena Hjelm-Wallén stressed that governmental funding was significant for girls, because it could enable girls from an early age to engage in technology (Lindblad, 1985). The 1985 budget bill proposed that special funds—totalling SEK 2.7 million—be set aside for summer courses in technology for girls. The purpose of the courses would be to increase girls’ interest

\(^1\) Lgr 80 (Läroplan för grundskolan 1980) appeared in 1980 and was a Swedish primary school curriculum.
in scientific and technical education and to strengthen their self-confidence in this field (The Swedish National Agency for Education, 2004). In the late 1980s, out-of-school projects aimed to bring girls into future technological careers by providing them with role models (Hedlin, 2011). These women role models came from the technology industry and higher education (Chaib, 1988, 1989). Role models were meant to change girls’ attitudes to technology. The reasoning behind the use of women role models was that direct contact with girls is the easiest way to affect girls’ opinions (Lövheim, 2016). A not uncommon ‘women fixing the issue of the lack of women’ solution still prevails. At this time, women and men had, at least in theory, equal access to the education system and labour market. However, most educational programmes and professions were and are still designed by and for men, demanding women adapt to existing structures and conditions (Berner, 2003; Lövheim, 2016; Nordvall, 2023). It was clear to girls that they were being asked to enter a masculine world, and they would only fit in if they changed; reinventing themselves as “tech girls” (Lövheim, 2016). Girls were and are seen as an unexploited resource, and the need to exploit them is in line with industry demands.

In the early 1990s, the Swedish newspaper Svenska Dagbladet (SvD) published a debate about girls’ interest in technology initiated by Dr Annmarie Israelsson (SvD, 1993). She debated girls’ interest in technology and how it was presented—and suggested that we should stop talking about girls as not being interested in technology itself. Discussions were centred around the upcoming 1994 curriculum in technology education launched in Sweden at the time. Israelsson (1993), argued that it was time to change the curriculum to better suit girls. She suggested lesson content containing discussions and exploration of environmental issues. In addition, she expressed ideas about allowing technology be more connected to a technical understanding of how technology impacts society and changes lives. With the 1994 curriculum, Lpo94, technology became a subject with its own curriculum, aims, and knowledge content. Lpo94 stands out, since the curriculum stated that teachers should organise their teaching to stimulate girls’ and boys’ interest in technology.

In 2009, the Swedish National Agency for Education announced a governmental initiative inviting educational institutions to apply for funding to organise technology courses or camps explicitly designed for girls to engage with during their summer break. This mission draws parallels with the efforts made in the mid-1980s. The primary aims of the 2009 initiative courses or camps were to create and support girls’
interest in science and technology while fostering self-efficacy within these domains (SOU 2004:43).

When the Lgr11 curriculum was introduced in 2011, the statement pertaining to the differences between girls and boys was gone and has not reappeared since. Instead, it stated that:

[-] teaching should give pupils the precondition to develop confidence in their ability to assess technical solutions and relate these to questions concerning aesthetics, ethics, gender roles, the economy, and sustainable development.

(Skolverket 2018, p.296)

When they introduced Lgr11, they also introduced the technology program in upper secondary school during the same year. The Lgr11 curriculum was the current policy document when data for this project was collected. The latest curriculum, Lgr22, was introduced on July 1, 2022. One of the curriculum changes compared to Lgr11 is that ethics, gender roles, and the economy are now expressed only in terms of sustainable development.

Today, we can see the continuing implementation of various initiatives to promote gender equality and diversity in technology education. For instance, in the form of specific political funding, schools, and organisations, workshops, events, and coding camps are explicitly targeted toward girls to encourage them to choose STEM and become technical. Being seen as ‘not technical’ can be viewed through the lens of gender, as interventions can be seen focusing on girls and women regarding technology. In such a context, it may suggest that an individual is subject to notions or societal expectations that associate technical ability with masculinity (Fröberg, 2010). This can contribute to women being seen as not technical (enough) in domains typically considered to require technical skills or one which are male-dominated. Linking technology to men and masculinity, Fröberg (2010) said, tends to exclude women from technology while simultaneously affecting women’s relationship to being ‘technical’. Wajcman (1991, 2000) points to technology and technical competence as fundamental parts of what it means to be ‘male’ and ‘masculine’, and it results in constructing femininity and women as constructs inherently bad at technology.

In autumn of 2023, the Swedish government presented in the 2024 Budget Bill (Prop. 2023/24:1), an aim to create a STEM (Science,
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Technology, Engineering and Mathematics) strategy to solve the recruitment problem and to continue the work to ensure that Sweden continues to be a nation at the forefront of technology innovation. Even though girls are not mentioned explicitly in connection to the STEM strategy, in the Budget Bill for 2024, girls and women are highlighted under section 3.5.4 regarding initiatives aimed to increase interest in science and technology subjects, not least among girls. The Minister of Education, Mats Persson, has also publicly and repeatedly called for the need to get more girls and women into STEM. What “more girls and women in STEM” means, exactly, is unclear, but a complex picture can be drawn if we examine engineering degrees. It is misleading to state that the proportion of women participating in engineering programs is low. For example, even though Swedish women engineers are a minority, the gender distribution in education has become more equal. Over the last ten years, the proportion of women engineering graduates has increased from 27.4% to 35.4% in civil engineering alone (Swedish Higher Education Authority, 2023). There are varying degrees of enrolment in the different programs. The ratio of women who graduated in 2021/22 is higher in areas such as chemical engineering (53%), biotechnology (60%), architecture (64%), and climate/energy (62%) (Swedish Higher Education Authority, 2023). Furthermore, women engineering/technologists as a group drop out of their education to a lesser degree than men, and more likely to graduate in most higher education programs, including engineering (The Royal Swedish Academy of Engineering Sciences, 2019; Swedish Higher Education Authority, 2023).
Chapter 2

The ‘problem’

As the introduction describes, the persistent ‘problem’ discourse surrounding girls and technology within educational and political contexts has been a recurrent and often uncritically retold theme (Hedlin, 2011). “The so-called ‘woman problem’, meaning the exclusion of women in science and engineering, has been thoroughly investigated in gender and technology studies.” (Mellström, 2009, p.886).

Notably, the Ministry of Education, in a report from the 1990s (Dir 1994:98), labelled girls and technology as a symbolic focal point for gender equality. Hedlin (2011) goes as far as saying, “in addition, girls’ choices were associated with tradition and an outmoded society. The female mechanic or industrial worker came to be seen as a symbol of modern Sweden” (p. 447). This resonates across various epochs and underscores its significance in educational, governmental, and sustainable dialogues. Thus, the ‘problem’ of the (non)technical girl is both an apt and an inaccurate description, depending on the point in time and the context. However, Mellström (2009) raised questions about the idea that a universally dominant masculine culture in science and engineering persists across different times and geographical contexts. Still, in this dissertation, I will specifically focus on how the ‘problem’ plays out in and affects technology education. To identify the ‘problem’ you can use a “What’s The Problem Represented To Be?” (WPR) analysis (Bacchi, 2012). I will take a moment and describe WPR before coming back to the problem I am unpacking in this dissertation.

Analysing the ‘problem’

Conducting a WPR analysis involves employing a set of six questions and applying these to one’s own problem representations. These questions are:
1. What’s the ‘problem’ represented to be in a specific policy or policy proposal?
2. What presuppositions or assumptions underpin this representation of the ‘problem’?
3. How has this representation of the ‘problem’ come about?
4. What is left unproblematic in this problem representation? Where are the silences? Can the ‘problem’ be conceptualised differently?
5. What effects are produced by this representation of the ‘problem’?
6. How/where has this representation of the ‘problem’ been produced, disseminated, and defended? How has it been (or could it be) questioned, disrupted, and replaced?

(Bacchi, 2012, p. 21).

What Bacchi (2009) suggests with these questions is how to identify implicit issues, such as problem representations, with problem-questioning more than problem-solving being key to understanding and change. Within WPR, knowledge is viewed as a cultural product—not an absolute truth, but rather the content within the framework of ‘the truth’. The concepts of knowledge and culture articulate what is perceived as truth within a specific practice at a particular moment. Regarding the ‘problem’ of the technical girl, little research has been conducted regarding what girls themselves see as technology or how they engage with it. Focusing my research only on girls and using the WPR approach as inspiration will enable a critical examination of the ‘problem’s formulations. It provides a framework for critical analysis of the mechanisms behind the underrepresentation of girls in technology and girls’ lack of interest in technology, unveiling the effects and consequences for those subjected to be seen as a problem. Feminist scholars such as Harding (1986), Cockburn and Ormrod (1993), and Wajcman (1991) argue that traditional images of science, technology, and gender fuel negative norms of what technological agency is and what belonging in a technical world means.

The table below is a representation and introduction of the results of using Bacchi’s (2009, 2012) questions and applying them to the dissertation and the connected studies. Bacchi’s questions will be readdressed more thoroughly in the discussion chapter.
What is the ‘problem’ represented to be?

To unpack the societal ‘problem’ of the (non)technical girl described above, I have turned to Bacchi’s method of “What’s The Problem Represented To Be?” (WPR) as inspiration. The overarching objective of this method is to discern, reconstruct, and systematically study problematisations inherent in policies, decisions, and stakeholders’ activities (Bacchi, 2009, 2012). Mufic (2024) states, “There is also a connection between power and policy within the approach. Policies involve power relations as they are productive in the way they produce problems as specific kinds of problems” (p. 114). Bacchi and Goodwin (2016) present the WPR approach as a method to identify, reconstruct, and systematically make it possible to study problem formulations. The WPR suggests that we are governed not merely by policy but through problematisations. The focus is on studying problematisations by analysing the problem representations they contain rather than the problems themselves. The WPR approach centres on understanding how
issues are shaped, making implicit problems explicit for critical examination. The WRP approach advocates for problematising problematisations and emphasises “problem-questioning” over “problem-solving” (Bacchi, 2009, 2012; Bacchi & Goodwin, 2016).

Researching the ‘problem’ of the (non)technical girl can provide valuable insights into the factors influencing their engagement and participation in technology-related domains. By examining girls’ unique experiences, interests, and challenges in relation to technology, researchers can gain a nuanced understanding of their specific needs and preferences (e.g., Sultan et al., 2020, 2023). WPR has allowed me to examine my research findings in the articles from a helicopter perspective and can help identify common research findings, and, by extension, effective educational strategies and interventions. This focus contributes to expanding the knowledge base, offering insights regarding girls’ interest in technology. However, based on earlier research, we still seem to know very little about what girls themselves see as technology or how they engage in and with it. This is especially true for girls ages 9–12 and for girls self-identifying as ‘technical’ (Sultan et al., 2019). By focusing research on girls and not comparing boys’ and girls’ interests, we can add to the knowledge pool. This knowledge production can be helpful in educational settings, as it can support girls’ engagement with technology and be of use in, for example, politics, as it can challenge the perspective of girls’ interests in technology.

The research questions

This dissertation aims to problematise the ‘problem’ of the (non)technical girl. To reach this aim, I have used different perspectives and methods to gain as much knowledge as possible to contribute to understanding the technical girl and the ‘creation’ of the ‘non-technical’ girl. This purpose can be reformulated into the following research questions:

- According to international published scientific literature, what is the nature of girls’ engagement with and interest in technology education and technological careers? (Study I)

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2 Nature here meaning type or main characteristic of something (Cambridge English Dictionary: Meanings & Definitions, 2024)
• What is the nature of girls’ technological activities, self-image, and performativity when participating in technology education inside and outside of school? (Studies II, III)

• What are some implications for technology education specifically and STEM education more broadly given empirical findings about the ‘problem’ of the (non)technical girl? (Study IV)

The research studies

The first study, a scoping literature review, shaped my research by identifying gaps and emphasising the need for closer engagement with research on girls. The second article, pulled from the exploration of a technology-based classroom, revealed contrasting technical confidence between younger and older girls. Motivated by these findings, the third contribution was set at a summer camp focused on girls’ self-identification as ‘technical’. The final contribution offers up diverse gender perspectives for technology education educators, aiming to foster a more inclusive teaching approach.

The original articles for each study will be provided as appendices at the end of the thesis. The three empirical studies have specific aims and research questions, but all explore the overall objective of the thesis, which also holds true for the fourth study, with an additional discussion about implications. An introductory summary of the studies in the thesis follows below, and the section ends with a discussion of my contribution.


In the scoping literature review, we investigated girls’ participation in technology education, shedding light on prevalent research themes of girls’ engagement, technological activities, and overall relationship with technology. The analysis consists of 20 articles and sheds light on a pattern of girls exhibiting lower interest, linked with more negative
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attitudes toward technology than boys, and a decreased likelihood of pursuing technology or STEM-related careers compared to boys. Cultural factors emerge as contributors to the observed gender disparity and are often raised in the reviewed papers as potential explanations for the evident differences in girls’ engagement. The scoping literature review shows a tendency for studies about girls’ interactions with technology to centre around more neutral or stereotypically male applications. The findings highlight the need for additional research and studies dedicated to unravelling the complexities of girls in technology. One of the conclusions drawn from this review stresses the need for additional exploration into the root causes of girls’ reduced interest in technology and why we need to study girls—not just in comparison with boys—to come closer to an answer and to be able to provide more inclusive and effective educational strategies.


In this study, we observed 9- to 12-year-old girls during lessons in technology education. Using a methodological blend of participant observations and a focus group interview combined with Harding’s three-levelled gender framework (symbolic, structural, and individual) we sought to untangle the complexities surrounding girls’ engagement in technology-related activities expressed in Study I. Despite the gender-neutral activities offered by the educator, the study uncovered a notable trend—girls often aligned themselves with prevailing male norms of technology. These norms could be tied to cultural perceptions of what gets to be deemed ‘technology’ and the social construct of what it means to be ‘technical’. Nevertheless, a noteworthy finding emerged within this conformity—examples of girls actively performing being not technical. This became clear during collaborative efforts and when girls assumed ownership of their technology-related tasks. The study suggests that such moments reveal a multifaceted interplay of gender within girls’ engagement in technology education, showcasing a narrative of girls negotiating and occasionally subverting traditional norms within technology. The research highlights the need for a more nuanced understanding of girls in technology education, emphasising the
potential for transformative educational strategies that consider and address gender levels.


Continuing the exploration of the complexities of girls’ involvement in technology, we, in this study, turned our attention to a three-day STEM camp in Sweden. A camp designed to spark, sustain, and educate girls’ interest in technology professions. With a blend of participant observations, a focus group interview, and the framework of Harding, this Study examines the technological activities and perceptions of technology that unfolded during the camp. Findings indicate the camp is introducing uncertain perspectives on technology as it tries to make traditionally male-dominated technology more inviting to girls. However, the efficacy of this approach can be questioned, given the interest in technology already being demonstrated by the girls. Despite this uncertainty, the camp emerges as a space that provides girls with a sense of being ‘technical’ and a feeling of belonging. We conclude that promoting hands-on and practical work and embracing improvisational design work—all while steering clear of excessive gender stereotyping—might enhance girls’ engagement but can also broaden their understanding of technology.


The chapter is part of a book aimed at students in teaching programmes and practising technology teachers and debates how gender is demonstrated and expressed in the aims, objectives, and subject content of design and technology education. It moves beyond the conventional discussions about the enrolment patterns of girls and boys. Instead, it looks into how gender manifests in design and technology education’s aims, objectives, and subject content. The chapter debates pupils’ attitudes and the educational task of supplying them with the knowledge necessary to navigate our technological world. The chapter discussion explores gendering technology and probes into the
perceptions that certain kinds of content may be more aligned with girls while others might resonate better with boys. As the chapter draws to a close, I address potential gender pitfalls and stereotypical responses to subject content and offer practical suggestions on nurturing an inclusive educational environment.
Limitations

In undertaking this research, I am aware of the boundaries and challenges inherent in the discourse surrounding girls and technology within educational and political contexts. Recognising the recurrent and often uncritically retold theme of the ‘problem’ of the (non)technical girl, I acknowledge the responsibility to validate the integrity and transparency of my work. This awareness forms the foundation for the significance of my research and its potential impact on educational, governmental, and sustainability discourses.

In defining the original contribution of my research, I aim to problematise the ‘problem’ of the (non)technical girl using a multifaceted approach. The research strives to provide a comprehensive understanding that can challenge, inform, and support educational settings and the broader academic community. While the WPR approach has allowed me to analyse research findings from a holistic perspective, it is crucial to note that there is still limited insight into how girls perceive technology, especially among those aged 0-9 and older girls self-identifying as technical. By narrowing the focus on girls and avoiding direct comparison with boys, my research can be seen as both a contribution and a limitation. Ottemo (2015) suggested we stop questioning girls’ choices in studying technology. Instead, attention should be on understanding the environment in which girls live. I would argue that focusing on girls’ unique experiences and challenges can offer a nuanced understanding of their needs and preferences and the notion of being technical. Researching the ‘problem’ of the (non)technical girl might shed light on the factors influencing girls’ engagement in technology-related domains.
Chapter 3 - Literature review

Girls in technology and STEM education: state of the art

In constructing this literature review, I have selected references from a rich tapestry of research on gender and technology education. The diverse perspectives covered below pay specific attention to studies addressing gender differences in technology education. Research spanning early childhood to adolescence explores factors influencing pupils’ attitudes and engagement. No doubt there has been research on gender and technology education from various perspectives: for example, concerning early childhood education (Hallström et al., 2015; Turja et al., 2009); Pupils’ Attitudes Towards Technology (PATT) studies (Ardies et al., 2014; Van Rensburg, et al., 1999; Svenningsson et al., 2018; 2022); interest and engagement (Mim, 2019; Kim et al., 2018; Klapwijk & Rommes, 2009; Matson et al., 2004; Niiranen & Niiranen, 2015; Sander, 2005); and gender specifically (Klapwijk & Rommes, 2009; Virtanen et al., 2015). Many of these studies focus on girls as less technical or less interested in technology or STEM compared to boys (Adenstedt, 2018; Fox et al., 2024; Kelly et al., 1984; Kessel, 2024; Murphy & Whitelegg, 2006; Sultan et al., 2019; Tellhed, 2017).

The objective of this literature review is to highlight the knowledge of societal perceptions and early socialisation in shaping girls’ attitudes regarding technology and hope to shed light on the challenges girls face. The literature is meant to offer insights into the factors influencing girls’ engagement with technology and STEM subjects and help understand the ‘problem’ later discussed in chapter 8 (discussion).

Girls’ interest—Nature or Nurture?

Studies have also been conducted to find genetic, biological, or cognitive explanations for girls’ lack of interest but so far, none have revealed any correlation with gender alone (e.g., Di Battista, 2024; Ferrari & Mahalingman, 1998; Kollmayer et al., 2018; Moss-Racusin et al., 2012; Sáez et al., 2016; Schermer & MacDonald, 2024; Solbes-Canales et al., 2020). People seem to choose STEM based on their interests and abilities (Su et al., 2009) and how much science capital a person has (Archer et al., 2020). Noteworthy is the paradigm shift Heldin (2011)
noted in research during the 1980s that started to emphasise the need for a pedagogical approach that can be summarised as ‘girl-friendly’. At that time, research began calling for increasing or boosting girls’ interest in technology (Heldin, 2011).

An important aspect of this is that children define themselves as masculine or feminine from an early age, as young as three (Ruble et al., 2006). The children know that particular behaviours and interests are connected to the specific gender (Puck & Welty, 2001). For example, as found in Niiranen (2016), young girls are directed toward certain types of play and provided with certain toys, which offer fewer opportunities for girls to develop technical knowledge and skills, which was also recognised in Adler et al. (1992) and Francis (2010). Hallström et al. (2015) found that preschool girls often have a particular purpose when building something they need in play; boys, on the other hand, more often see the construction process itself as the primary purpose of the play.

This can be connected to how children form their identities and perceptions of others as they socialise and encounter each other’s gendered behaviours (Martin et al., 2013). The primary school years seem to be when girls’ interest and engagement in technology education drop and seldom recover (Ardies et al., 2015; UNESCO, 2021). At the age of 10–12, girls often start being described as uninterested in technology, seen as uninterested, and self-report as not being interested in technology (Caleb, 2000; Jackson, 2021; Mammes, 2001; Rahm et al., 2021, Sultan et al., 2019). Sjøberg et al. (1983) studied 11-year-old pupils in Norway and showed that girls and boys had clear conceptions as to what were regarded as ‘boy’ and ‘girl’ activities. For example, girls were seen as more likely than boys to “be afraid of electricity”, by both the boys and the girls. The researchers concluded that the girls in school year five had accepted that science and technology were better for boys than girls. During science class, Ditchfield and Scott (1987) asked English girls’ what content or activities they missed from lessons. The girls wanted more practical, hands-on experiences and opportunities to try their own ideas and organise their work. The researchers pointed to this as a strong indication that girls like practical work and are suited for technical and experimental work, similar to the results in Sultan et al. (2023). Andersson (1989) expressed concern regarding society’s communication to girls that they are less suited for science and technology than boys, while Jönsson (1986) called for girls and women not to fall blindly into traditional women’s careers and instead take the lead when it comes to being part of the world of technology.
Girls’ interest across continents

The 2017 Microsoft Europe-focused study found that young girls gain interest in STEM subjects at age 11 and then lose interest again by age 15. The study spanned over 12 European countries, surveying 11,500 girls aged 11–18, asking for their views on science, technology, engineering, and math-related subjects. The results, like those found in the two global ROSE (2005, 2010, 2019) and ROSES (Jidesjö et al., 2021) studies on 15 year olds in 50 different countries, pointed to a difference in the global Eastern, Western, Northern, and Southern countries. The Microsoft study saw how girls from Eastern Europe leaned more toward a positive view of STEM than their Western European peers. The ROSE project (2005, 2010, 2019) showed that in the wealthiest countries (Northern Europe, Japan), young people were more ambivalent in their interests, and they could see a growing gender difference, with girls, particularly those in the wealthiest countries, expressing more negativity than boys regarding a future career in science or technology.

However, in several African countries, there is either equal interest between girls and boys in technology or a higher level of interest among girls (Ankiewicz, 2017). PISA 2015 (OECD, 2016) countries in western and northern Europe show considerable differences in interest in science between boys and girls, where boys are more interested. However, girls can have various interests in STEM, just like people of any gender. Mendick et al. (2017) critiqued what is often talked about as a “pipeline” to STEM careers. They stated that it is crucial to analyse how the pipeline model neglects to address the intersections of gender, ethnicity, social class, and nationality. Both the Microsoft and ROSE(S) studies put a finger on differences in gender and nationality. STEM is a field that involves applying scientific and mathematical principles to design, build, and innovate various systems, products, and structures. Some girls may be drawn to it because they enjoy problem-solving, creativity, and innovation and want to make a difference for themselves, society, and the environment. The research and report above are a reminder that the issue of girls not engaging in STEM or technology is not a global phenomenon. It is therefore likely that different cultures talk about girls’ engagement with technology in different ways.
Being ‘good’ at technology

The American Association of University Women’s (AAUW) 2000 report on how to educate girls to become tech-savvy women highlighted that the girls showed minimal interest in the technical aspects of computers but were enthusiastic about exploring technology’s potential applications. The path forward to get girls into computing, they concluded, was overcoming girls’ resistance to engaging with the machine directly. This conclusion can be seen as an example of what it can mean to be ‘good’ at technology. Here it seems to mean to relate to technology in a certain way. Being a user and an enthusiast of technology is not enough—to be tech-savvy you need to “understand basic principles of programming and other computer science fundamentals” (AAUW, 2000, p. x).

Rhetoric and norms surrounding girls’ way of being technical, or doing, making, and using technology might lead to implicit exclusions from the subject (Ottemo, 2015). If the concept of technology is coded as a male construct, which has been and often still is the case, this may be problematic (Sanders, 2005; Turja et al., 2009). de Vries (2006) concludes that girls are less confident than boys when handling so-called ‘hard’ technology: computers, electronics, and similar artefacts. The greater people-centeredness of what is described as ‘soft’ technology, such as household technology, is more often linked to girls (e.g., Berner 1993; Kimbell et al., 1996). Sjögren (2015) describes some technology that is not acknowledged as technology at all, such as lace-making. This distinction between hard and soft technology has caused an issue, since ‘hard’ has become synonymous with ‘real’ technology. This lack of confidence extends to encounters with and using what is identified as ‘hard’ technology in schools (Kimbell et al., 1996). Sadker and Sadker (1994) elaborate upon teaching methods by showing that teachers may inadvertently favour boys, especially regarding technology.

Skogh (2001) took another perspective and explored the issue of how girls themselves interpret their technical abilities—how they learn that they ‘can’ or ‘cannot’ deal with technology.

Results show that the girls in the study, with few exceptions, express great interest in technology and technical tasks. Results also emphasise the significance of how the girls...
define the concept of technology and the technical experience they may have had. Here technical education at school is shown to be an effective way to offer girls the opportunity to build up a “technical identity”. (Skogh, 2001, p.7)

Skogh (2001) highlighted the importance of a well-functioning technology education to maintain girls’ engagement and technical confidence. When technology and education about technology are constructed as male domains, including ’male’ attributes such as logic and technical knowledge, girls tend to internalise the negative stereotypes surrounding them (Cheryan et al., 2015, 2016; Sanders, 2005; Turja et al., 2009; Smith & Hung, 2008). Girls are also more likely to be subjected to negative stereotyping in settings where being technical or tech-savvy is seen as something you are born with. In these settings, girls are often expected to be less able and less confident and are seen as not wanting to gain experience in the area (Emerson & Murphy, 2015; Smith & Hung, 2008). Furthermore, since girls tend to encounter technology less often, acquiring fewer skills and therefore less knowledge about technology (Klapwijk & Rommes, 2009), girls are more likely to adopt an identity as not being technically capable. This adoption can come with a sense of non-belonging, which should be a reason for concern, as Naukkarinen and Bairoh (2020) discussed. Furthermore, once they have lost their interest, it is challenging to get it back (Lindahl, 2003).

Autio and Soobik (2017) assert that spatial skills and reasoning predict success in male-dominated fields such as STEM. They argue that technological knowledge is essential, especially in spatial reasoning, impacting girls’ motivation to learn about technology. A meta-analysis investigating gender differences in spatial reasoning by Lauer et al. (2019) involving over 30,000 children and adolescents aged 3–18 revealed no discernible gender distinction in mental rotation skills among pre-schoolers. However, a slight advantage for males became apparent in children aged 6–8. While disparities in verbal and mathematical abilities between men and women are generally minimal or absent, a notable gender difference was observed in mental rotation as the ages of the researched children increased. According to Lauer et al. (2019), mental rotation is a critical aspect of spatial reasoning and involves envisioning how distinct objects can rotate to align with each other.
Girls’ lack of interest in technology and STEM

It can be helpful to dig into the reasons behind girls’ lack of interest in technology. Below, I navigate a maze of socialisation, stereotypes, and support systems influencing girls’ attitudes toward STEM from an early age. By untangling these complexities, my goal is to shed light on the challenges that might lead girls to not being technical.

**Early socialisation factors**

Factors contributing to girls’ lack of interest include socialisation from an early age, including the belief that technology and STEM fields are ‘for boys’ (Ardies, 2015; Dakers et al., 2009; De Souza Vieira et al., 2024; Godec et al., 2020; Knopke, 2015; Mim, 2019). Other studies (Master & Meltzoff, 2016) report that girls are interested in technology at around age ten, but from then on, their interest begins to decline. According to some studies, girls generally tend to be more negative toward technology (Ardies et al., 2015; Björkholm, 2010; Brown, 2009; de Vries, 2005; Shoffner et al., 2015; Sullivan & Bers, 2019; Sultan et al., 2019). This can happen through various means, such as gendered toys, books, media; messages from parents, teachers, and peers; and giving girls less access to technological language (e.g., European Parliament, 2022/C 67/18; Niiranen & Niiranen, 2015). At the same time, the idea that technology is not gender-neutral has been brought forth in a wealth of research, and girls may even lose interest before being fully exposed to the subject (cf., Berner, 2009; Lindqvist 1987).

**Deconstructing stereotypes**

One of these contributing factors to girls’ lack of interest can be traditional gender roles and societal stereotypes that can discourage girls from pursuing technology. Researchers such as Mammes (2004), Autio and Soobik (2017), Andréucci and Chatoney (2015), Chatoney and Andréucci (2009), and Autio et al. (2017) conclude that the low level of interest among girls is traceable to their socialisation, the different social
expectations placed on boys and girls, and to the fact that girls are not exposed to technology as often as boys. Girls’ lack of interest is thus seen as a social construction, while other studies find that girls are just as interested in or engaged with technology as boys (Dakers et al., 2009; Master et al., 2021). The cultural image of what technology is and its role in influencing what it means to be a girl or woman in STEM have also been explored (e.g., Blackburn, 2017; Heybach & Pickup, 2017; González-Pérez et al., 2020). Furthermore, girls will be more motivated and engaged when invested in participating in learning technology on their terms and when they receive positive feedback (Chatoney & Andréucci, 2009; Virtanen et al., 2015).

Support systems impacting girls

Lack of support at home and in the classroom can also explain why few girls pursue STEM careers (Archer et al., 2017; Cheryan et al., 2017; Merayo, & Lanchares, 2022). Tellhed et al. (2017) focuses more on the teachers’ role as gatekeepers of subjects and professions relatively unknown to the pupils. Teaching methods, curriculum design, and classroom dynamics can affect girls’ interest and participation in STEM education. Andersson’s (1989) literature review demonstrated that girls possess equal knowledge and the ability to acquire the necessary skills for technology and engineering studies. And girls are, on average, more successful at school (Archer, 2020; Blickenstaff, 2005; Storms, 2019).

Sometimes, it is argued that girls’ decreased interest in technology is linked to lower interest and lower self-confidence in mathematics, a key part of many engineering programs. However, on average, girls, with grades according to the objectives and skills-based grading system in grade 6 and 9, in Sweden have received higher grades in STEM subjects than boys (Skolverket, 2020, 2023).

Complexities of social constructs

Jónasdóttir (1985) highlights that within women’s research studies, the concept of interest has been a well-known but seldom investigated discourse. On the contrary, research in technology education, where interest in the subject has been frequently discussed, can be seen as its own vein of research within the field (Pappa et al., 2023). However, it
could be worth mentioning how women’s research has been exploring the idea of interest. Jónasdóttir (1985) explains that the term ‘interest’ varies from context to context, such as expressing an interest in something or the need for someone to become interested. Is interest interesting, one may ask, and women’s studies would answer “yes”. Jónasdóttir (1985) point to researchers who have asked questions such as: she is “interested in”, she is “interested”, and “it is in the interest of women”. Nordvall (2023) explored the development of how engineering education managed equity policy and found results that can be seen to be connected to the questions asked in women’s studies. Nordvall highlighted three common solutions in international policies for STEM diversity—“fixing the number of women, fixing the institutions and fixing the knowledge” (p. 196).

Early influences and motivations

Studies (Lane et al., 2022; Nguyen et al., 2022) indicate a link between early engagement in STEM activities and an increase in the number of girls becoming women in STEM in the future. Motivations behind girls’ interests in STEM can be girls who enjoy studying its subjects, such as innovation. For example, Moë (2018) showed that women with STEM degrees preferred spatial toys which challenge mental rotations in childhood more than women with non-STEM degrees. Moote et al. (2020) pointed to evidence that these career choices begin to form at the elementary school age. Early positive attitudes can be influenced by factors such as teacher and familial support, argue Ing and Nylund-Gibson (2013), but are not a sure sign of future careers in STEM. Research conducted during school years 7–12 indicates that positive attitudes concerning these subjects are one indicator an individual may be considering careers in engineering (Edmonds et al., 2022). However, Naukkarinen and Bairoch (2020), after researching gendered differences among science and engineering applicants in Finland, concluded simply encouraging more girls to study STEM is not enough. They argued instead for the need for young people to better understand what engineering can be if we want more girls in STEM.
Teaching to boost girls in technology and STEM

Within technology and STEM education, there is an increasing awareness of the challenges girls may meet during their early engagement in these fields (Lockwood, 2020). By exploring studies on the broader perspectives that girls contribute to technology, this section aims to provide insights into inclusivity in STEM education.

If girls have a slight disadvantage early on in technology and STEM education, Mammes’ 2004 findings, suggesting that teachers can encourage girls to be interested in science and technology through how they teach are encouraging. This is also noted in Autio and Soobrik (2017). Lauer et al. (2019) conclude that teachers should be aware of the differences in development between boys and girls. Weber and Custer (2005) concluded that girls and boys engage in technology education with preconceived notions of activities. They conclude it might be challenging to alter cultural and gender-related stereotypes, but carefully designed activities could spark girls’ interest in them less-engaging subjects.

Gender and girls’ experiences

Andersson et al. (2009) saw how introducing gender theory might alter teachers’ awareness of gender issues to challenge these cultural and gender-related stereotypes, whilst Knopke (2019) showed how teachers found to believe in gender-neutral teaching can at the same time be unaware of their language bias and instructional delivery.

The results of Svenningsson et al. (2022) imply that for girls the ability to broadly describe technology is positively related to career aspirations, and in general, they have a broader view of technology than boys. According to Murphy (2007), several studies have observed that girls prefer collaborative work. Descriptively, girls are portrayed as facilitators who offer substantial support to others during discussions on the strengths and weaknesses of designs. This, she continues, is evident
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even when girls work on individual projects, as they frequently verbalise their problems and potential solutions, actively monitoring both their own and others’ designs and product-related issues. This can be interpreted as girls being more sensitive to the ‘what’ (context or artefact-specific) content and ‘how’ (hands-on or theoretical) they approach it, as well as ‘what’ they are working with regarding technology in the classroom.

Niiranen (2019) points out how less experience in hands-on activities girls have (compared to boys) can influence their aspirations towards studying technology. Makrakis (1992), however, when studying Swedish and Japanese pupils in year nine and their attitudes towards computers, concluded the influence of culture and societal norms played a more significant role in shaping one’s attitudes toward computers compared to factors such as owning a computer. Mammes (2004) saw how girls show greater imagination and inventiveness and take more risks than boys with technological concepts they are familiar with. Niiranen (2019) points to how gender-sensitive education can support girls while simultaneously creating learning experiences that acknowledge and appreciate the distinct interests of both girls and boys.

Early interventions and fostering belonging

In her doctoral dissertation, Lockwood (2020) followed an online STEAM (Science, Technology, Engineering, Arts and Mathematics) Program for young girls aged 7–10. In her literature review mostly covering STEM, she noticed a pattern of young girls initially participating less and less in STEM subjects in elementary school. However, the impact of early interventions was successful. Most especially, informing STEM educators focused on elementary-aged learners in an informal educational setting and creating a sense of belonging both fostered participation (Eccles, 2015; Veldman et al., 2021). Belonging, in this case, is about emotional attachment and feeling “at home” (Yuval-Davis, 2006; Rainey et al., 2017). Abe and Chikoko (2020) explored the factors influencing girls’ career decisions. Their results showed how doing creative, experimental, and situation-based projects made STEM more attractive for girls and increased girls’ self-esteem. In Sultan et al, (2023), girls expressed confidence and saw themselves as technical, which meant STEM did not have to become more attractive; it was already attractive to girls. Jeanpierre and Hallett-Njuguna (2014), who performed their study in grades 6 and 8, found that
minority girls provided a bright spot in their responses regarding positive attitudes, which had not been commonly reported in the research literature. Girls from minority backgrounds were more interested in STEM than nonminority girls.

Recognising diversity of doing and being in STEM

Jackson et al. (2021) stress that when developing a STEM experience, whether within a school or in an out-of-school setting, the STEM experience should be considered as disrupting systems of oppression and privilege. Finally, Kiernan et al. (2023) conclude that the key factor which influences low STEM subject uptake among pupils in the third and sixth year at an Irish post-primary all-girls’ school is the lack of access to these subjects in lower grades, where discrimination in providing equal access to STEM for all is still very apparent.

Kim et al. (2018) explored how aspects of the social environment influence girls’ STEM identity development. Findings indicate that young women experience challenges to their participation and inclusion in STEM settings. They concluded that intervention and educational programs could change perceptions regarding who is part of the ingroup or outgroup of STEM fields. Zuga (1999), on the other hand, pushed the notion of women as technologists:

Every woman has been a technological being, using and often inventing tools, materials, and processes in order to adapt and modify her world. Their contributions have been either focused on the traditional homemaking roles of females, or they have been diminished in the records of industrial and economic spheres (Zuga, 1999. p.57).

Zuga (1999) stresses the value of women’s ways of knowing. Researching girls in the culture and context of technology and technology education can be important in many ways. Feminist scholars have long and repeatedly argued that everyday encounters with technology are rarely recognised (Berg & Lie, 1995; Berner, 1996; Faulkner, 2000). Daily encounters could include solving technical problems with your mobile phone, your bicycle, your clothes, at breakfast at home when the toaster does not work as expected, or in school when trying to open a locker that will not open (Cockburn, 1996). All these examples are activities where
you feel safe and secure when solving technical problems and navigating STEM.

Girls’ identifying as being good at technology: obstacles and opportunities

Identifying as ‘belonging’ in technology can be multifaceted. It could be seen as situated conduct, as Brickhouse and Potter (2001) argue, in that a person’s actions are influenced by their identity, making those actions a reflection of that identity. Identity includes an understanding of who one is in relation to one’s past and potential future. An identity—being something—has overlapping layers (Brickhouse et al., 2000). Although developing an individual’s identity is a personal journey, the process is set in society (Brickhouse, 2001). Godec et al. (2020) noted, while studying young women in a STEM coding club, that the girls mostly used their tablets for selfies, which they concluded was more of a social performance than a performance of a ‘tech’ identity.

Butler (1990) emphasises that gender is a crucial component of a person’s identity. Elwood (2006) says, “girls and boys experience different, gendered forms of life and learn through a gendered mediating of the wider communities to which they belong” (p. 273). Francis (2006) and Gullberg et al. (2018) emphasise that young children form their gender identity under the influence of family, mass media, and various social institutions, including schools. In the educational setting, gender shapes classroom culture, imposing gender differences. This leads individuals to construct their gender identity based on what aligns with the norm, as the deviation is often perceived as an anomaly. Hsu et al.’s (2011) survey of 192 elementary teachers showed teachers exhibited bias against girls’ capacity to grasp design, engineering, and technology concepts. In earlier research, these biases are linked with being handy, objective, rational, and non-emotional (Brickhouse, 2001). In stereotypical settings like the ones above, girls are likelier to disengage and adopt a self-image of not being technical (Kim et al., 2018). Ardies et al. (2015) stated that elementary school is a critical period for girls to develop their gender identities, particularly concerning their attitudes regarding technology. During this time, they question their societal roles and attempt to meet the expectations set by their environment. To engage with technology, girls must establish a relationship between
technology and their identity, cultivating a sense of being ‘technical’ (Brickhouse et al., 2000; Brotman & Moore, 2007). In this section, we can understand that developing an identity can be complex, especially during puberty, when girls simultaneously form new identities as women. During puberty, girls are performing their situated identities as women; identities as women who usually do not express themselves as having a technically interested side and conforming to societal expectations that may not align with any intrinsic technical interest.

Recruiting for the future

Both international and national research have explored how girls’ technical self-confidence and attitudes towards technology affect girls’ technical self-understanding and engagement in future studies or work in technology, as expressed earlier. Virtanen et al. (2015) pointed to how these topics can discourage girls from pursuing tech-related interests or careers, while girls may not have the same access to technology education and resources as boys. Nevertheless, the pipeline model remains in policy and educational initiatives (Mendick et al., 2017). The pipeline model describes a linear sequence of steps to becoming a person engaged in STEM-related fields. The idea of a pipeline goes against what research has learned about how limited exposure to STEM opportunities and insufficient encouragement from parents, teachers, and peers can play a role in the underrepresentation of girls. For example, Virtanen et al. (2015) and Riegle-Crumb and Morton (2017) suggest this can be due to the national school system, upbringing, and several other factors limiting exposure and skill-building in these fields. Early exposure to STEM fields and encouragement to pursue these subjects can help spark interest and build confidence. (Kokot, 2009; Lockwood, 2020). Corrigan and Aikens (2020) highlight the importance of understanding girls’ negative self-identity in STEM and how it may be disrupted before it shapes their future careers. Recruitment efforts to involve girls and women in technology remain sparse, lacking assessments of their impact, as Corneliussen (2022) highlighted in her expert paper for UN Women. One reason could be the lack of agreement regarding what kind of interest among girls should be modified. Wright et al. (2008) studied 381 survey-completing stakeholders in technology education, including, for example, classroom teachers, school leaders, directors of career and technical education, and university educators specialising in technology. When summarising their work, they pointed to a confusion and absence of agreement regarding what should be the ideal or sought-after identity of technology (education).
Corneliussen et al. (2021) assessed an IT campaign targeting girls in school year nine and concluded that for girls lacking support from family or school in exploring technology, the campaign filled that void, leading to shifts in educational choices. Additionally, for girls already interested in technology, exposure to women role models shaped their ability to envision a future in the field. This result is recognisable in Grande’s (2023) study of role modelling in computing and engineering education. Despite these positive effects, the Seddighi and Corneliussen (2021) results indicated a tendency for schools to send only those girls already perceived as interested in technology to such initiatives, potentially limiting the broader impact of the campaign. Something also noted by Sultan et al. (2023) is that girls who were already interested were the ones who attended the initiative.

Using role models as a tool to diversify participation in STEM fields faces mixed empirical evidence. Despite its cost-effectiveness and adaptability, the impact of role models on motivating pupils and students to STEM education and careers is complex (Gladstone & Cimpian, 2021). Grande (2023) concludes that “role modelling should not be limited to individual educators but rather permeate all levels of the education system” (p.114). They also point to the problem of how we seldom define what a role model is. These different interpretations can lead to misunderstandings among different actors. Grande (2023) shows that the term ‘role model’ is used inconsistently and points to various ways of thinking about the term—one as representing a certain role, e.g., engineer, and the other as someone who positively and negatively shapes another person’s motivation by acting as an example. There are also close and distant role models (Gibson, 2004). Teachers can be seen as a close role model, as they can play a key role in dismantling gendered practices and renewing the image of technology education (Murphy, 2007).

Competent female teachers show that women can overcome these stereotypes and succeed in STEM [-] and they may signal to girls that their teachers will be less likely to endorse negative stereotypes about them (Master et al., 2014, p. 81).

The existence of women teachers and girl classmates is also important for improving girls’ engagement and could thus lead to a positive effect.
regarding interest and engagement in STEM (Stevanovic, 2013; Rasinen et al., 2009). On the other hand, Bamberger (2014), revealed that after a woman scientist had visited classes, there was a notable adverse shift in perceptions regarding the capabilities of women in the fields of science and engineering, their ability to handle STEM subjects, and their choices in STEM careers. In two experiments, Master et al. (2014) examined how gender and stereotype threat cues affected adolescents’ self-reported concerns about being negatively stereotyped in computer science courses. Results show that girls are less concerned with negative stereotypes when they have a woman teacher. This positive impact of a woman teacher can also be found in the Swedish study by Lindahl (2003). Lindahl (2003), in her thesis work, followed a group of pupils from age twelve until they left lower secondary school at sixteen to describe and analyse the factors influencing their choice of upper secondary school. The teacher was one of the important factors. This could also be seen in the scoping review by Sultan et al. (2019). However, in other situations, studies such as the ones from Master et al. (2014) and Martin and Marsh (2005) have found that a teacher’s gender has little effect on high-school girls’ motivation and achievement in STEM.

In role modelling, there is not necessarily an interaction between the role model and the one observing the model. It is more about the observer wanting to become like the role model in some way. The role model should present attainable aspects (Lockwood & Kunda, 1997); e.g., skills or bits of knowledge or achievements (Grande, 2023), such as a desirable way of engaging with a discipline (Grande et al., 2018). Girls expressing interest in technology seem to enjoy great parental support (Microsoft, 2017; Whittock, 2018). Parents, especially those employed in a profession related to technology and those who have children’s technical toys at home, positively influence their children’s attitudes when young (Ardies et al., 2015). The caregivers’ influence can also be seen as girls go into higher education in engineering or STEM, as the choice to go into engineering studies is often a result of experience; e.g., having a parent working as an engineer (Engström, 2018; Carrasquilla et al., 2022; Yazilitas et al., 2013). UNESCO’s (2017) report addressed how dads engage their daughters in everyday technology, such as car maintenance, showing them an everyday STEM world by asking girls to watch, try, and learn.

Research on mothers and their relationship to technology and how that affects girls concludes that mothers may have a negative impact on girls’ technical confidence. This could be seen as negative role modelling,
but role modelling is complex, as addressed earlier. Negative role modelling involves refraining from imitating the role model’s behaviour. However, the scenario depicted could also be seen as positive role modelling, where the girls imitate their mothers in expressing what could be interpreted as incompetence. If mothers express themselves as not technically able, their girls are more likely to do the same (Adya & Kaiser, 2005; Chisolm & Du Bois-Reymond, 1993). Having relatable and close role models can influence girls’ interest and confidence in pursuing STEM education (González-Pérez et al., 2020). It is also indicated that girls are more likely to pursue a degree in science, technology, engineering, and/or mathematics if they have access to an attainable role model such as a parent employed in a STEM field (AAUW, 1998, 2010, ; Heaverlo, 2011). We should keep in mind that “it is the person observing, making the decision on how to act based on their observations and values, that makes someone a role model (or not)” (Grande, 2023, p.30). A role model is someone we can think we can become, but we cannot expect/guarantee/ensure that we are role models ourselves if this perception is the eye of the beholder. Enthusiasm for role models has continued to grow, even though empirical support remains limited (Gladstone, 2021). For instance, despite little measured effect, Sweden, for at least 40 years, has actively used aspects and achievements of role modelling as positive propaganda to increase girls’ participation in technology (Lövheim, 2016).

Summary
Most fields of technology are still associated with boys and men, and gender stereotypes produce many barriers to girls’ and women’s participation in technology. Male dominance in contexts of technology negatively affects girls’ and women’s choices, making it more difficult for young women to see themselves as fitting into contexts heavy on technology (Corneliussen, 2020). Girls can have a range of interests in STEM, just like anyone else. Some girls may be drawn to STEM because of their passion for science and mathematics, a desire to make a difference, creativity and innovation, or women role models in the field. Whatever the reason, girls who are interested in STEM have the potential to make essential contributions to the field and to society. However, girls need to feel they belong. Girls should receive support and encouragement to make non-gendered educational choices; family and school are central in this respect (Eccles, 2015).
Murphy (2007) points to the importance of recognising assumptions about what children can and want to do to break gender gaps. As mentioned earlier, there is often a comparison of girls’ and boys’ interests to be found in the research. Earlier research regarding learners’ interest in technology has given valuable knowledge about gender differences. However, we still do not know very much about what girls themselves see as technology or how they engage in it. By focusing research on girls and not comparing boys’ and girls’ interests, we can add to the knowledge pool. However, it is crucial to understand what kind of technology girls see as not being interesting. Therefore, exploring and describing how girls identify and interact with technology education is vital, especially during primary school education. It is about understanding the processes by which the concept of the technical girl is shaped and reshaped and what significance the context has for her technical self. I do this by focusing on how young girls engage with technology in educational contexts as described in three perspectives: the girls’ own voices; other researchers’ descriptions; and stakeholders within technology, for example, camp organisers. The cultural images’ role in accepting how technology influences what it means to be a girl or woman in STEM has also been explored (e.g., Blackburn, 2017; González-Pérez et al., 2020; Heybach & Pickup, 2017). Therefore, we need more understanding as to how the notions of technology and ‘being technical’ affect one’s interest in technology, and the image of oneself in relation to technology.

Limitations of the review

The above review reflects the complexity of the issue of girls’ engagement with technology and STEM education, so although it is the result of a systematic reading of relevant literature, it is by no means exhaustive. The research was found in databases but also in books and articles recommended by other researchers and in courses, in article and book reference lists, as tips on social media, and at conferences. The chosen literature should be seen representing the richness and diversity of gender-related research within technology and STEM education.

The literature review has certain limitations that should be acknowledged to maintain research transparency. Recognising these limitations is key for a comprehensive understanding of the challenges involved. The limitations include restricted access to information, difficulties in studying longitudinal effects, potential cultural biases, and
the time constraints associated with the research process. While the selected references offer a broad exploration of gender regarding technology education, it is good to note that the literature may not cover every perspective or demographic within this complex field. Focusing on factors such as pupils' attitudes and engagement may lead to gaps in addressing other relevant aspects of gender dynamics in technology education. A notable limitation stems from the commonness of suggesting that girls are less inclined towards technology. This perspective may oversimplify the intricate web of societal attitudes, early socialisation practices, and individual differences contributing to girls' technology engagement. The review recognises the need for a more nuanced understanding of these factors.

Additionally, the examination of genetic, biological, and cognitive explanations for perceived gender differences may overlook other sociocultural influences that shape attitudes towards STEM subjects. While valuable, the emphasis on early interventions may only partially encompass the myriad of factors impacting girls' interest in technology, leading to a potential oversimplification of the issue. The review's global perspective acknowledges cultural variations but may not capture the full diversity of experiences within specific cultural contexts. The challenge lies in addressing the complex interplay of cultural nuances that influence girls' engagement with technology on a global scale. The discussion of girls' self-identification and the impact of societal constructs recognises these intricacies. Still, it may not go deep enough into the contextual factors contributing to negative self-identity. The limitations in this area underscore the need for a more granular analysis of how cultural, socioeconomic, and regional factors interact to shape girls' perceptions of technology.
Chapter 4—Key Concepts

Key concepts

Before continuing, I want to introduce key concepts and discuss how they are used in the thesis. Each concept begins with a summarised description followed by its use in this context.

What is technology?

Technology is often a definition used daily without clear boundaries and with various meanings. Technology can be described as the actions necessary for the constructed world of technology; for example, art, craft, or engineering, to create something (Agar, 2019; Schatzberg, 2018). Technology is not solely confined to theoretical knowledge but includes tangible items, artefacts, and objects used daily. According to Norström (2014), it could also mean technology can be described as knowledge of the actions through which humans transform the artefacts of nature to satisfy their needs. Meijers (2009) noted that the terms ‘technology’ and ‘engineering’ are rooted in words aimed at a practical form of knowledge. Ginner and Mattsson (1996) characterise technology as the means by which individuals create a barrier between themselves and their environment to meet their needs. They articulate the definition of technology as standing in for humanity’s methods for controlling their physical environment, constituting humanity’s techniques for fulfilling needs by using physical objects. Additionally, Kline (2003) talks about technology as sociotechnical systems for making and for using and adds that artefacts are distinct from natural objects. Donna Haraway further notes:

“Technology is not neutral. We’re inside what we make, and it’s inside us. We’re living in a world of connections—and it matters which ones get made and unmade.” Donna Haraway, interviewed by Kunzru (1997)

With these perspectives, technology can hold various actions through which humans seek to manipulate their surroundings. For instance, the house, corridor, and office I am currently in could qualify as ‘technology’, as does the computer I am using to compose this text. Because of its multifaceted nature, it can be of value to define technology (cf., Dusek, 2006) and give more explicit boundaries to the word to make it
understandable. However, it is essential not to narrow the definition too much, so that it becomes unproductive (cf., Idhe, 1993).

**How technology is defined and used in this study**

In the studies, we have chosen to use various definitions of technology. This was a conscious choice, since we wanted to explore what technology could be for participants in different contexts, and due to the complexity of what technology is, we needed definitions of technology to interact and intra-act to understand what the data was telling us. When I say ‘intra-action’, I am referring to how different definitions blend and influence each other. Unlike ‘interaction’, this suggests that definitions exist independently before coming into contact. Intra-action challenges the idea of complete separation and indicates that the tools used for measurement (data) and the person using them are crucial parts of the process (for example, as described by Barard, 2007). Think of the definitions in this dissertation as intertwined.

The various definitions set the complex stage for the study’s exploration of the ‘problem’ in the context of girls’ engagement with technology and STEM educational settings. By broadening these definitions, we could give girls’ views on doing and making technology a clearer voice. However, the definitions have been more for us than those participating in the studies, and they are mainly an analytical tool. As such, they serve the purpose of improving the scientific understanding of girls’ (and other actors’) conceptions of technology and of being technical. As Dusek (2006) highlighted, by defining technology we also learn about its characterisation.

The first article used each scoped literature’s definition. The second article uses Ihde’s (1993) three dimensions of technology: technology must have a concrete component, enter some set of praxes, and have a relationship with humans. This definition presents a responsive spectrum of human—technology relationships, which became useful when studying gender issues within technology. The third article uses DiGironimo’s (2010) definition of technology as Technology as Artefacts, Technology as a Creation Process, and Technology as a Human Practice.
STEM

STEM and research about STEM education is gaining attention worldwide. STEM is commonly used in Sweden in research and some out-of-school educational settings more than in-school practices. However, critics have raised concerns within research about STEM teaching, highlighting a potential bias toward prioritising Science (S) over other STEM subjects (Hallström & Ankiewicz, 2019; Kristensen et al., 2022; Larsen et al., 2022).

Even though this thesis is mainly about educational settings within the realms of technology, there are relationships to STEM in Studies III and IV. One rationale for using STEM in my work is the amount of research about girls’ engagement, interest, and belonging in the fields that is now being done internationally. Furthermore, the choice was made because engineering and technology education can mean similar but different things depending on where we are in the world. STEM educational research relates to transdisciplinary and interdisciplinary pedagogical approaches to education, aiming to understand concepts often recognisable in Swedish as technology education. Nevertheless, it is crucial to question what contributions STEM offers to the pedagogy or didactics of teaching technology.

Being technical

Being technical is being knowledgeable or skilled in technology; in the praxes, design, construction and/or use of technology (Idhe, 1993). In Studies II and III, ‘technical’ is defined in relation to human technological activity, according to the definition of technology mentioned earlier. I am using the term ‘technical’ to describe the girls’ skills in regard to technology, such as creating, using, and discussing technological content, understanding oneself as technical, and feeling safe and secure when solving technical problems, exploring, and thinking about technology. Also included in ‘being technical’ are interest and engagement. In addition, being technical is being a part of technology culture (Sultan et al., 2023).
What is a girl?
Exploring the problem with the technical girl not only brings with it the importance of defining what technology can be/is but it is also useful to define what a ‘girl’ is since she can also be seen as constructed.

A girl is a person with a biological narrative alongside historical and cultural narratives. A girl is a body with a biological sex that is female. However, said body has been conceptualised and theorised as a natural object and as a social construct (Butler, 1990). It has been influenced by biological determinism and social discourses (Haraway, 1992). A body is a physical structure, including a person’s bones, flesh, and organs. Where it starts and ends, and its boundaries are unclear (Spivak, 1989), but what it is extends outside the skin of the person. Butler (1990) argues that the sexed body repeats the gender performances that it has learned, and as female is socially constructed as weaker and more fragile and have historically been seen as rationality questionable, this presents issues (Grosz, 1994; Haslanger 2012; Hearn, 2012). Therefore, the word ‘female’ in the thesis will only be used when referencing other authors to stay true to their work.

Instead of female, the term ‘girls’ or ‘women’ will be used, since I am not interested in bodies in their biological, reproductive form. Biology is the natural science of studying life and living organisms, including their physical structure. I am interested in gender—more precisely, the gender performances of girls and women. In this study, the girls in Studies I and II were identified and sorted by others as girls. In study three, the girls self-identified as girls. In Study IV (chapter), I use ‘women’ and ‘girls’ as inclusive concepts, meaning anyone identifying as such, is.

I will return to a few of these concepts in the next chapter – theoretical lenses.

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3 “Others”, in this case, are schools, teachers, and researchers.
Chapter 5—Theoretical framework

Theoretical perspectives

To identify the implicit issue in the ‘problem’ of the (non)technical girl, it has been necessary to research girls only. The decision to exclude boys is due to gender, and we need to talk about gender. We also need to talk about technology, as gender and technology can both be seen as socially constructed.

The intersection of gender and technology is particularly evident in technology education and STEM education (e.g., Wajcman, 2000), which frames the essence of my research. To understand how girls become non-technical girls, we need lenses to understand and analyse how girls and technology are constructed. We need tools to explain the ‘construction of’. As Faulkner (2001) puts it: “from early on, feminists in this tradition framed their concerns in terms of ‘gender and technology’ rather than ‘women and technology’, signalling (among other things) an insistence that both technology and gender be understood as socially shaped and so potentially reshapeable.” (Faulkner, 2001. p.80). Faulkner (2001) emphasises the usefulness of distinguishing between gender in technology and gender of technology. However, let us explore these concepts by themselves before we connect them.

Gender

Gender is produced by the context of a person and is not something you are born with. It is not biological sex. Gender relates to biological gender but highlights the values, attitudes, and experiences of being human and existing in society (Butler, 1990).

The social construction of gender

Social and cultural gender are the perceptions and notions in our society about what is feminine and masculine (Sjögren, 2015). We create gender constantly, every day, every minute. Gender can be performed differently, given different circumstances. Gender is continuously constructed and created based on our values, attitudes, and experiences (Butler, 1988; 1990). Therefore, individuals do not inherently embody
gender roles but construct their gender identities through repetitive, performative actions and behaviours (Ton, 2018). These actions include movements, interests, and roles that shape how others perceive them as gender-specific subjects (Hedlin, 2009). For example, individuals might be perceived as more or less technical based on their actions, interactions, and treatment by others.

The social process of doing gender

“Doing gender” goes beyond the ongoing creation of gender meanings; it involves bringing gender into existence through human interactions; essentially a gender display. According to West and Zimmerman (1987), this display projects gender as if it were ‘natural’ and examines how it is enacted through interactions. Gender, they argue, is a culturally scripted performance reflecting societal ideals of femininity and masculinity. This performance occurs in specific settings, much like theatrical productions, serving as introductions or interludes within more significant activities. According to Goffman (1976), gender is a socially scripted performance of culture’s expectations of how to be feminine and masculine. Studies II, III, and IV reflect these scripts and consider what is involved when doing gender in a culture of technology education.

The concept of ‘doing gender’ creates distinctions between girls and boys, women and men which are not natural or biologically determined but socially constructed (West and Zimmerman, 1987). Once established, these distinctions reinforce perceived gender qualities (Grzelec, 2022). Any social interaction can serve the purpose of ‘doing gender’, turning a person’s gender into an active engagement, not just a facet of identity. This process involves assimilating gender ideals, viewing them as proper ways of existence and behaviour, and developing personal, upheld gender identities (Rooke, 2013). Women and men are a product of society itself (Butler, 1993). Those not affected by gender exclusions and gender discrimination will not notice the built-in structures of a non-functional system—e.g., of a technology or STEM community. Instead, those affected will be forced to become aware of the biases directed against them (Dusek, 2006). Understanding how gender is constructed in social contexts provides valuable insights into the intricacies of societal norms and expectations.
Technology as social construction

Technology is not only constructed by technical aspects but is also profoundly influenced by social, cultural, political, and economic factors, subsequently impacting society (Björkman, 2002). The social construction of technology implies that its technical dimensions are not the sole determinants of technological knowledge. (Faulkner 2014; Trojer, 2014). Technological knowledge is situated within broader social contexts (Pinch & Bijker, 1984; Schieberger, 2014). They, in turn, are intertwined with societal values, norms, and power dynamics (Klein & Kleinman, 2002; Sismondo, 2011; Sayes, 2014). The materiality and design of technological artefacts and systems reveal how they embody specific forms of knowledge, assumptions, biases, and values.

Wajcman (1991, 2000) suggests that gender and technology co-construct. From this perspective, technology is shaped by the social circumstances within which it takes place, combining artefacts, people, cultural meanings, and knowledge—a sociotechnical product. Wajcman (1991), as Faulkner (2006, 2014) addresses the ways in which gender–technology relationships manifest not only in gender structures but also in gender symbols and performance—combining technology, gender, their impacts on society, and social construction. This approach means that many actors, concepts, and artefacts are co-creators of technology: actions, language, gender, culture, physical environment, things, emotions, epistemological discourses, and influences from media and politics, among others (Faulkner, 2007).

The technical person as a social construct

In a societal context, someone is generally considered ‘technical’ if they possess knowledge, skills, or expertise in a specific technical field or subject matter (e.g. Sjögren, 2015; Sultan, 2023). This could include professionals such as engineers, scientists, computer programmers, data analysts, and others who have a deep understanding and practical know-how in their respective technical domains (Berner, 1999; Faulkner, 2009; Nguyen et al., 2022; Sultan et al., 2023). The term “technical” often implies a level of specialised knowledge and the ability to apply that knowledge to solve complex problems or tasks. These individuals usually have and are believed to have the technical skills and knowledge necessary to design, develop, troubleshoot, and maintain various technological systems and solutions (Faulkner, 2009; Sultan, 2023).
How we as actors define technology will influence what and who we see as part of it. According to Nye (2007), “technology is not merely a system of machines with certain functions; rather, it is an expression of a social world” (Nye, 2007, p.47). Defining technology has many dimensions and is, as mentioned earlier, a word of many worlds entangled with society and gender. When exploring this thesis’ three research questions, the aim was to keep the definitions as open and multidimensional as possible, so as to not ignore girls’ and other participants’ experiences of these worlds. At the same time, the definitions had to be precise enough to capture what emerged from the data. As written above, Ihde (1993) and DiGironimo (2010) provided reasonably broad definitions of technology, to which the notion of ‘being technical’ could be related.

Technology is not solely defined by its physical properties but also involves sociotechnical aspects and connection to human activity (Ihde, 1993). One should remember that technological knowledge comes in various forms, including sociotechnical understanding, technical know-how, technical skills, and socio-ethical technical understanding (Norström, 2014). These different knowledge types might shape individuals’ views of technology (Wajcman, 1991). The perspectives on technological knowledge can influence individuals’ thoughts and mental pictures of technology. These views, in turn, might affect how individuals—especially girls—engage with technology and perceive themselves as being technical.

A technical girl as socially constructed

To understand how a technical girl is constructed, we can intertwine the social construct of gender and technology and use it as an analytical tool to unveil girls’ distinct understandings and perspectives regarding technology. The interaction between gender and technology goes beyond structural gender roles and extends into gender symbols and identities (Wajcman, 2004). Technological knowledge can play a role in shaping perceptions of what it means to be technical, which can have implications for gender-related aspects of technology education (Sultan, 2023). This includes exploring what can be involved in producing (non)technical girls. “Gender stereotypes are a culture’s shared beliefs about the roles, behaviours, and personality traits of males and females” (Hyde et al., 2007, p. 26). Steele (1997) suggests a stereotype threat is a situational threat. If threats are repeated and thus sustained, these threats can cause girls to disidentify with, for example, technology and invite other girls to disconnect themselves from this part of their self-
identity (Steele, 1997). Tabassum and Nayak (2021) concluded that women find it challenging to see themselves as fitting into occupations that are stereotypically associated with masculinity.

Cockburn (1983) and Wajcman (1991) demonstrated ways in which gender structures—but also gender symbols—manifest. This manifestation can happen directly. For example, a child tells another child that a particular interest is inappropriate for one gender or the other; for example, “makeup is for girls”, or “only boys like math”. Alternatively, it can happen indirectly. For example, the more time children spend with peers, the more similar they become to one another in their interests, behaviours, and interactional styles (Martin et al., 2013). Girls also fear that even excessive intelligence or talent for male-coded subjects will discourage boys’ interest in them. Pomerantz and Raby (2017) interviewed 57 girls and 17 boys to learn more about what being smart looks like for girls. The research revealed that girls dumb down or stay quiet in class to gain friends and attract boys by conforming to accepted femininity. Girls shared the need to look attractive, noting that boys “go for pretty [over smart].” (p.68) They also communicated the need to be seen as pleasant rather than outspoken in the classroom. In one sense, the girls learn to be a girl “the right way” and then perform in the “right way”.

The theoretical rays

It may seem like there are many different perspectives for reflection and analysis in this dissertation. However, they have many similarities and focal points, although they also point to slightly different understandings of becoming or being technical. I like to think of these perspectives as being rays, passing through a lens. While various scholars’ rays are mentioned, the primary focus is on Bacchi’s (2009, 2012) Harding’s (1986) theory, which is used extensively in the analysis of technology education contexts and throughout this dissertation.

Figure 1. Summary the theoretical rays and theoretical lenses used to reflect upon and analyse who is considered ‘technical’. The lenses established by Harding (1986) and Bacchi’s (2009, 2012) help reflect and refract the rays of theory as they pass through and can be used to focus in on a bigger picture—in this case, who is seen as technical.
These lenses of knowledge, particularly in the context of technology and gender, have been chosen as tools to explore the research questions. They emphasise the importance of considering gender as a socially shaped concept in knowledge production (cf., Harding and Hintikka, 1983). They are socially constructed beings (Mellström, 2004), and by performing in specific ways, such as how we speak, move, and have interests and roles, we are perceived as women or men, making ourselves gender-specific subjects. Bacchi’s and Harding’s work and scholars such as Berner (1993, 1996, 1999, 2003, 2009) and Wajman (1991; 2000) helped me pursue the idea that we become technical—or not—in different contexts.

We can become more or less technical depending on how we act, are treated, and interact with others. In one context, a girl will not even be considered as possibly being technical; in another, she is unquestionably so. One could always be speaking of girls as not being technical or as girls being asked repeatedly by others to explain why they like technology, thus constructing girls as non-technical. Harding (1986) further underscores the connection with the ‘what’ and ‘why’ of our research endeavours. This awareness is where I begin.
Using the rays to look through the lens

The presented lenses are used from a macro to a micro perspective. The apparatus used most often in this examination is one authored by Harding, whose work is repeatedly used in the studies. In Harding (1986), gender is described as an ordering principle by which every society and all social relationships are organised. She has addressed the feminist issues in science and technology and criticised theories and practices of science and technology using a gender lens (cf. Andersson, 2009; Harding, 1995, 2011a, 2011b).

Harding’s (1986) theory suggests that gender is constituted on three societal levels: structural, symbolic, and individual. The structural level refers to how the division of labour—based on gender—looks in society. In all cultures, there is a division of labour where women and men perform separate tasks. Women in one culture may have the same chores as men in another, but duties are (often) strictly divided within the same culture. Most people who work with STEM, especially high up in the academic hierarchy, are men. Therefore, the structural gender of STEM subjects can be said to be male, according to Harding’s definition. Symbolic gender refers to how gender is constructed through language by, for example, maintaining dichotomies where the pairs of opposites are given a feminine and masculine meaning; e.g., feeling–reason, subjectivity–objectivity, nature–culture. In short, the implications are that different groups of people attribute what they see as either feminine or masculine. It can be expressed in perceptions of how women and men should act and study. By individual gender, Harding (1986) means the socialisation of individual people into a gender identity where both structural and symbolic gender are of importance in that process. The understanding of femininity and masculinity within the three levels changes from culture to culture and over time, but within a culture, the three forms of gender are intrarelated. Even if these were not initially used for gaining knowledge within technology, they have been frequently used in a STEM context and are valuable tools for unpacking data.

The levels used in this study are as follows: the symbolic level, concerning cultural norms, ideas, and linguistic
expressions/dichotomies to recognise what gender and technology are and what it means to be technical; the structural level, which in this case pertains to gender in relation to the teaching organisation; and the individual level, used to connect to girls’ self-image or view of their identity in regard to technology and technology education. The analysis of articles one, two, and three builds on Harding’s conception of the three levels of the gender system (1986), and as a fourth contribution, I use the theory as a tool for teaching practice.

Reflecting on my theoretical lens

Throughout history, men and women have had different experiences due to cultural influences, which have led to separate social construction processes. Despite gaining equal access to education and the labour market in the 20th century, many education programs and professions are still designed by and for men (Faulkner, 2003; Mellström, 2003; Salminen-Karlsson, 2003). This forces women to conform to existing structures and conditions (Berner, 2003; Lövheim, 2016). Feminist scholars of the realms of technology (Harding, 1986; Cockburn & Ormrod, 1993; Wajcman, 1991) have explored the issue from women’s perspectives only and argue that images of technology culture affect gender norms in negative ways. Norms fuel ideas as to what technological agency is and what belonging in a technical world means. These discourses can threaten girls’ interactions and interest in STEM (Archer et al., 2012). However, we experience ourselves and are experienced by others as more or less technical in different situations and contexts.

The choice to incorporate Harding’s (1986) framework to the studies incorporated in the dissertation stemmed from what I saw as its practicality in a classroom setting. As a budding researcher, I noted a lack of theoretical tools to explain the differences between girls’ and boys’ interests in technology. I did not want to repeat what I saw as an issue within our research field. At the same time, I was neither a gender nor a feminist theorist. I needed a tool that a novice could understand and use. The three levels of gender Harding articulated provided a structured approach, allowing me to step into the realms of gender research. This straightforward method facilitated gender analysis and contributed to my understanding of research possibilities.
The implications of being inspired by feminist theories in research and discourse vary depending on the context. These theories offered me a theoretical foundation to challenge gender roles and reassess expectations. As they stem from questioning established scientific and societal ‘truths’, feminist theories can, much like Bacchi’s ‘problem’ provide a valuable perspective to examine the perceived disinterest of girls in technology. In our research, these theories brought attention to social structures within groups of girls and illuminated the individual and structural dimensions they navigate. Using Harding’s (1986) three levels of gender played a pivotal role in achieving these insights. Incorporating feminist theories into the research design also influenced how studies were conducted. Each study guided the next, yet the flexibility of the research was maintained to address diverse perspectives and research questions in unique settings. Despite, or maybe because of, the complexity of the analytical tools I chose, they enriched my exploration of technology education. Careful consideration was given to each layer of these ‘rays’, ensuring their relevance to the research.

Criticism against using feminist theories is often connected to how they challenge traditional values, structures, and ‘truths’ (Mies, 1991; Riger, 1992), and one of these critical voices is Harding (1987) herself, who questioned whether there is something called a ‘feminist method’. Their thought-provoking insights were the perspectives I needed to challenge my thoughts about girls’ interest in technology. I found it crucial to understand why conventional comparisons of girls versus boys might not be fruitful and how a feminist discourse could provide a more nuanced understanding. Another criticism involves the potential generalisation of experiences, as summarised by Wigginton and Lafrance (2019). While the amount of data is relatively modest in terms of its potential for generalisation, it is of a qualitative nature but contextualised within a broader framework, as reflected in our articles and in the chapter. The aim has been directed toward demonstrating the intricacies of the research findings rather than making sweeping generalisations.

All research theories have both advantages and disadvantages, possibilities and challenges, but I believe the ones I have chosen are the best analytical tools for my research objective. By highlighting what technology is and who is considered technical and relating it to gender, we can come closer to better understanding the discourses and practices that construct the (non)technical girl.
Possible limitations

The study’s exploration of gender, technology, and social constructions provides a foundation for understanding the complexities of the research domain. However, it is crucial to acknowledge and address certain limitations and potential challenges associated with the study. The study relies on a feminist lens, which, while offering valuable insights, might be criticised for possible bias or for overlooking alternative perspectives. I have acknowledged and discussed how the lens shapes the interpretation of findings when reflecting on my theoretical lens. The study recognises the social construction of technology. It is crucial to recognise that the study might not capture the perspectives of all participants, and remember the study does not claim to do this but is focused on girls alone. As such, the chosen theoretical perspectives achieve what they intend to, in relation to the research objective.
Chapter 6—Method

Methods

Art critic John Berger has said, “we only see what we look at. To look is an act of choice. As a result of this act, what we see is brought within reach—though not necessarily within arm’s reach.” (Berger 1973, p.8). In my view, Berger’s quote captures the essence of choosing one’s research methods; for me, they have been an act of choice. In this chapter, I aim to present and explain the method behind knowledge production, results, and conclusions. My theoretical lenses can be summarised as inspired by Science and Technology Studies (STS), and many methods are used in data collection in Studies I–III. However, Bacchi’s (2009) method, What’s The Problem Represented To Be? (WPR) has been essential in addressing the overall ‘problem’ explored in the thesis.

Study design

The foundations for the thesis are three unique sets of data collection and a didactical application. Therefore, the work described in this thesis can be seen as continuing along the same paths as earlier multidisciplinary methodological traditions found in technology educational research. I have implemented four separate studies, each dealing with issues related to girls in technology-oriented fields.

Table 1. Overview of the specific research questions, the data, and the analyses used in the studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Title of original article</th>
<th>Research aim/questions</th>
<th>Empirical data</th>
<th>Analysis method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Article I</td>
<td>Girls’ engagement with technology education: A scoping review of the literature</td>
<td>To identify the most common descriptions of girls’ engagement with technology education, girls’ technological activities, and the relationship between girls and technology.</td>
<td>20 articles from the field of technology education, focusing on ages 9–17, were identified and included in the study</td>
<td>Content analysis</td>
</tr>
</tbody>
</table>
Collecting data

Data were collected through various methods, including a scoping literature review, empirical data, observations, and focus group interviews. Studies II and III are ethnographically inspired. According to Beach and Vigo-Arrazol (2021), there are both empirical and analytical reasons to do an ethnographically inspired study; most notably, the research site needs to be experienced first-hand to understand it fully. In addition, the researchers’ experiences will be a lens through which they view the world and, subsequently, their research: “common human experiences of people as they negotiate social structures, power relations and interactive encounters are easily compared and interpreted through ethnographic methodology” (Beach et al., 2004, p. 534). Choosing an ethnographically inspired study meant the possibility of understanding the research questions asked in Studies II and III. The two studies built on the results in Study I, which led me to the need to be where the girls experienced learning about technology
and performed being technical. As a researcher, this meant stepping into the classroom and participating in summer camp. Participating in the studies themselves was also something I interpreted as necessary. I asked myself whether we can actually know what girls do and say if we are not situated in their contexts.

Scoping literature review

A scoping literature review is a “type of review [that] provides a preliminary assessment of the potential size and scope of available research literature. It aims to identify the nature and extent of research evidence” (Grant & Booth, 2009, p. 101). A systematic literature review involves identifying, evaluating, and interpreting all relevant research on a specific research question, topic area, or phenomenon (Kitchenham, 2004). Performing systematic reviews serves various purposes; the most common of which being summarising existing empirical data, identifying gaps in current research, or providing a background to appropriately position new research activities (Kitchenham, 2004). A scoping literature review shares similarities with a systematic review in attempting to be methodical and transparent. However, it is less systematised and rigorous because it aims to establish the extent of existing evidence and the requirements for further research (Grant & Booth, 2009).

Participant observation

The purpose of participant observations was to get inside the social and cultural context of the settings. The observer moved from being a non-participant to becoming a participant in to produce qualitative observation data (Kawulich, 2012). Audio recordings, photos, and field notes were used to document observations. The audio recordings were transcribed. Photos were taken to better remember the settings. Fieldnotes were taken continuously on a check sheet and in the field notes booklet. After each round of data collection, notes and observations were written up as soon as possible after the sessions.
Focus group interviews

A focus group is a group of individuals discussing a specific topic within a limited timeframe (Morgan, 1996). Typically, a moderator introduces the topic, often initiated by stimulus material, such as recounting earlier observations. Group members then engage in a free discussion, with minimal intervention from the moderator (cf. Krueger & Casey, 2000). A focus group interview allows researchers to gain insights into events or phenomena observed during previous investigations.

In Studies II and III, semi-structured interview formats were employed. The questions were derived partly from the researcher’s experiences and knowledge in the technology education field, acquired during the PhD project. The interview guide was also informed by the outcomes of the previous scoping literature review on girls’ interest in technology (Sultan et al., 2019). Combining semi-structured and structured elements facilitates exploration through questions and comments. By encouraging participant discussion and interaction, researchers can glean insights into the language and cultural dynamics surrounding technology (e.g., Harding, 1995, 1996).

Ethical considerations

The ethical principles for research were followed by informing all the participants in Studies II and III about the purpose of the observations and the focus group interviews and their right to consent and to discontinue their participation should they wish to do so. Consent was obtained from the participating pupils and their legal guardians. All participants were also informed that their participation was confidential and that the data would not be used for anything other than research purposes (Swedish Research Council, 2020).

Linköping University serves as the data controller for all activities conducted within this project’s framework. The project supervisors have diligently ensured that the research adheres to ethical standards and aligns with Sweden’s Act, which contains supplementary provisions to the EU General Data Protection Regulation, GDPR (SFS 2018:218). The lawful basis for processing personal data is individual consent. Measures
have been implemented to maintain data security and confidentiality. A comprehensive risk and vulnerability assessment has been conducted concerning personal data processing. It is important to note that none of the studies involve sensitive personal data. All project data have been securely stored on an external hard drive, while fieldnotes are kept in a locked drawer accessible only by a single key. This drawer is located within a locked room, which, in turn, is located in a secure corridor.

The potential power dynamics between the researcher and participants, especially in the school setting and the camp, need to be addressed as an ethical concern. There is a possible impact of the researcher’s presence on participants’ behaviour; however, these dynamics have been taken into account and have impacted the choice of methods and the time spent gathering data.

Gaining access

In studies, different gatekeepers opened their worlds for us to study. Without these people, teachers, and organisers, gaining close access to the girls would have been potentially more challenging. There is a potential concern when using gatekeepers from one’s formal and informal network, since there could be a loyalty issue. In my case, the people involved have not been persons I have worked with or who are in any way dependent on me. I also ensured that they were not in focus when using gatekeepers. Either girls or views about a topic remained in focus.

Studying only girls as a method

As mentioned, studying girls only is both a method and a theoretical position. Below, I present the study of only girls as a method. Researching girls only as a theoretical stance is presented in the theoretical chapter.

I have chosen to study girls only because studying girls as a group could also provide insights into girls as individuals. The approach sprung mainly from Study I, which resulted in the need to focus solely
The results of the first study stressed the importance of going beyond simple gender comparisons. As Hussénius et al. (2013) argue, too many studies are restricted to comparing female and male students. As I chose to study only girls, the approach entailed putting their technical self in the foreground. As in Skogh (2001), I intended to give value to their experiences without the constrictions of having to be compared with another gender.

Researching only girls can provide valuable insights into the factors influencing their engagement and participation in technology-related domains. By examining their unique experiences, interests, and challenges in relation to technology, researchers can gain a nuanced understanding of their specific needs and preferences. Understanding oneself as technical and feeling safe and secure when solving technical problems, and discussing and thinking about technology is therefore not a given or static but is understood in this study as something that changes in different contexts and environments, which become different in different group constellations. Therefore, it is useful study only girls to see what kinds of findings can be teased out when girls are not being compared to boys.

Methods used in each study

Below is a summary of the tools we used to collect data and why.

Study I employed a scoping literature review method to understand the methods and perspectives in researching girls in technology education. Content analysis was used for data analysis. Data were collected in January 2018 from the ERIC database, focusing on full texts in international peer-reviewed journals published between January 1, 2000, and December 31, 2017. Search criteria included terms such as ‘girl’, ‘interest’, ‘technology’, and ‘education’. Inclusion criteria involved research on girls’ engagement with technology education, while exclusion criteria covered aspects like after school activities and age spans outside 10–17 years.

Study II used ethnographic-inspired methods, including participant observations over two weeks in technology education classes and a focus group interview with five girls aged 9–12. Insights from a previous study informed the observations. Fieldnotes were collected without predefined checklists or coding schemes, focusing on
conversations, the tools used, and expressions related to technology. The analysis followed qualitative content analysis in a hermeneutic tradition.

For Study III, ethnographic-inspired methods, including participant observations, audio recordings, field notes, and a focus group interview were employed. The focus group session involved nine girls discussing themes like ‘belonging’ and attitudes toward technology education. A semi-structured interview guide was based on the scoping literature review results.

Overall, the choice to perform three rounds of data collection and to choose various methods was aimed at testing and refining the research aim. Adaptations were made based on the lessons learned from each study. For example, actively using Harding (1986) came directly from finalising Study I, since we could see its potential as a tool for understanding what was expressed in the article by others in our field of research. The desire to be closer to girls’ experiences influenced the choice to collect qualitative data. The studies provided insights into different perspectives related to girls’ interactions in technology-oriented fields.

The four studies

Each of these studies approaches the main research aim from a different point of view. In each study, various data and analysis methods were used. It was decided that they would depend on each study’s aim and focus and be led by the results of previous studies. This way, I could explore my overarching thesis research questions from different perspectives and discover new knowledge. The methods are presented in more detail above and in the original studies (Studies I–IV); however, in the following sections, I briefly summarise these studies and their research questions, data, and analysis methods (see Table 1).
Summary of point of view studied

Figure 2. Visual explanation of whose voices are in focus of each study. Study 1—research views on girls in technology. Study 2—girls’ activities regarding technology education. Study 3—girls’ activities and conceptions at a technology camp. Study 4—a chapter debating how gender influences technology education and suggesting change.

Methods used to analyse the data

In study I, content analysis was used. The content analysis was inductive, exploratory, and open-ended concerning the research objectives and questions in the context of a scoping review (Sultan et al., 2019). Our analysis of the data on girls’ participation in technology education faced challenges due to the limited amount of information available from the articles in the review (please see Study I, Table 1 for details). Nevertheless, the content analysis allowed us to uncover recurring themes, such as engagement, activities and relationships pertaining to gender and technology. To some degree, this research reflects a traditional perspective on technology—one that sees technology primarily through a lens of male-associated and male-coded aspects. For
instance, survey questionnaires occasionally featured prompts such as, “spends a lot of time with engineering-related hobby activities” (Autio et al., 2017, p. 98), which can be viewed as a portrayal of technology biased toward male-oriented domains. Such framing could potentially lead to misleading responses from girls, who may not identify their involvement in technology as being strictly tied to engineering. The analysis revealed the disparity between the perception of girls as disengaged from technology and the expectation of girls as actively involved. The analysis helped us understand gender dynamics, even within the research discourse.

Study II used a systematic process aligned with Elo and Kyngäs’s (2008) three primary phases—preparation, organisation, and reporting—and was correlated with the three gender levels as proposed by Harding (1986). Using Harding (1986) for our analysis, we learned that the girls validate the existing norms and perceptions associated with the nature of technology and the concept of ‘being technical’. Even within girls-only groups, the young individuals continually reinforced prevailing societal norms. Notably, the active–passive dichotomy becomes apparent as the girls tend to assume that boys possess superior technological skills, such as computer proficiency. Consequently, they frequently seek assistance from boys, even when the boys themselves express uncertainty about solving a particular problem.

In Study III, we used a thematic analysis method. Thematic analysis is a systematic approach that identifies and explores common or shared experiences among participants by creating descriptive themes (Braun & Clarke, 2006). As we progressed toward completing the analysis, the emerged themes were connected deductively to the theoretical framework presented by Harding (1986), which defines three levels of gender influence. In addition, the study identified a fourth level, the social level, as important for the girls in the study. Harding’s framework therefore served as a valuable tool in evaluating the technological activities and perceptions of the girls in relation to varying levels of gender influence.

Study IV, which was a review, did not use an analysis process like the other three studies.
Reading Beach (2014) and Beach and Vigo-Arrazola (2021) and Harding (1986) expanded my methodological world. Beach (2014) Beach et al. (2004) and Beach and Vigo-Arrazola (2021) and Harding’s (1986) methods are similar in how they understand and explain the world by stressing being in the world under study. Beach also references Harding in their work (Beach, 2014). Both Harding (1986) and Beach (2014) address the lack of objectivity as not being wrong. It can provide researchers with stories about the social and natural world in ways that are different from or additional to traditional science based on men’s views and experiences. Harding (1993, 2015) argues that the ideal of value-neutrality is self-deceptive. When scientists represent themselves as neutral, this blocks their ability to recognise how their values have shaped their inquiry, thereby evading critical scrutiny of these values. Instead, research is valid if it remains open to the researcher’s experiences and the knowledge that is our lens: “common human experiences of people as they negotiate social structures, power relations and interactive encounters are easily compared and interpreted through the ethnographic methodology.” (Beach et al., 2004, p. 534). First-hand knowledge of the social and material conditions and interests of those being researched establishes and strengthens objectivity (Harding, 1995). My shaped objectivity in this research project brought a perspective as important as any—a perspective shaped by being a Swedish woman and self-identifying as being technical.

**Strong objectivity and reflexivity**

According to Harding (1993, 2001, 2015), objectivity is enhanced through reflexivity, which involves researchers placing themselves on the same causal plane as the object of knowledge. It is about being aware of what you in your choices of method and analysis are sensitive and insensitive to as a researcher. By ‘sensitive’, I mean what traditions of research in your field have you negotiated and are okay with. Reflexivity is used in different research traditions, such as political science, but has been, to my knowledge, most prominent as a research tool in gender-
related research. This could be because most of my reading has been in this field.

According to Bacchi (2011) and Bero and Grundy (2016), reflexivity is when you acknowledge your potential influence on the research during the research process. Influence is more than simply reflecting on data. It is about examining one’s beliefs, biases, and choices during the process. Acknowledging oneself as not neutral is not negative for me; it has been a humbling process, yet, at the same time, liberating, since it encourages discussions about the when, how, what, and how of the research process. It is challenging since it has meant and continues to mean a constant negotiation of different knowledges but rewarding, since it has allowed me better to understand myself and my role in the research. Reflexivity enables one to pilot one’s biases and has helped me understand how my work is situated. Harding’s “strong objectivity” includes reflexivity, a key feature of more objective inquiry processes.

Potential limitations of the PhD project include variations in research methods and timing. The field I am exploring has developed over the years. Additionally, the referenced theories and studies originate from Western contexts and researchers. This makes sense, since Studies II–IV were conducted in a Swedish context, and Study I was undertaken in a Western setting. Even though reasonable choices, the researched girls represent different cultures, and I wonder what I have missed by having the perspectives I have and have accordingly used and drawn conclusions from. Findings from the ROSE project (Sjøberg & Schreiner, 2010) underscored that girls in countries such as Uganda, Ghana, Lesotho, Swaziland, Zimbabwe, and Botswana show notably positive attitudes toward technology and technology-related careers. Since we have a global classroom, it could have been interesting to have known more about the girls’ backgrounds to find out whether their mothers or fathers had positive attitudes toward technology/STEM. This warrants further investigation and is a potential avenue for further research. Examining data and conducting analyses from a cross-cultural perspective could offer valuable insights into discussions and conclusions about gender structures, gender symbols, and identities.
Method discussion

Implications for further approaches to a research project is the ‘how’ of collecting data. Performing a study on only girls in a mixed setting was interesting. The research methods presented in the text have their strengths, but acknowledging their limitations is also important. They also had their methodological and practical challenges. For example, the classroom in Study II is a room that can be seen as both a possibility and a challenge. The girls were familiar with the room and visited it at least once a week. For them, it represented a recognisable environment. However, rooms within rooms also make data collection an endless choice. Given that they do not know what they will experience, the researcher needs to be open to choosing different methods when collecting the data required to answer the research question(s). We used an ethnographic-inspired approach in Studies II and III in order to keep the data collection method open and changeable/modifiable if necessary. However, this was demanding since observing, taking fieldnotes, and being an observer are skills and knowledges in the own rights. This is not just a thing you do; it is something that requires training and a plan.

Limitations

Each study employs different methods, and the variety of data collection techniques could pose challenges regarding comparability and consistency. In the discussion, I address how these methodological choices impact the coherence of the research project. The studies span several years, and technology education and societal attitudes may have evolved during this period. I acknowledge a temporal aspect and potential changes in the field over time.

Looking inside myself

Acknowledging the limitations of the research conducted intends to demonstrate awareness of the boundaries and challenges associated with the research while simultaneously validating the integrity and transparency of the researcher. I will now actively look for my boundaries and challenges.
The journey

Embarking on the journey from being a technology teacher to a gender-curious technology education researcher brought about consequences, and reshaped and continues to reshape my epistemological perspectives. It is a continuous process of ‘de-learning’ and ‘re-learning’. This transformation extends to theory and methodology, which were often different from the principles instilled during my teacher training and professional experience. I trained in technology and science education and have always seen myself as having a pure ‘science brain’, where facts are facts. Gender research introduced me to a not-so black-and-white world of knowledge. Another notable difference arises in the traditions of writing articles and the use of discourse. The studies compiled in the thesis tell the story of initial challenges in reading thinking tools and articles authored by gender researchers and applies them to something I could use as an analytical tool. By trying and trying again to join the two worlds and with the support of supervisors, reviewers, and the research community, a path began to open up to me.

Crossing disciplines

Crossing disciplinary boundaries and adopting other knowledge paradigms demands a constant need to explain oneself, explaining the essence of what I believe gender research to be to others and justifying its relevance within technology education. But during the journey, this also meant clarifying my perspective as a technology educationalist to gender researchers as we met in different settings during my journey towards earning a PhD. Nevertheless, the challenges have been fun. I have embraced the idea that crossing disciplinary boundaries also unlock opportunities.

Both technology education and gender research, in addition to being fields of knowledge and research, represent distinct modes of viewing the world, even if they also share philosophical questions. Introducing new approaches into any discipline presents challenges for the receiving discipline. Gender research is not new to our field of technology education. Therefore, the challenges were not about gatekeeping, but they posed questions about the acceptability of my research within the two disciplines and the possibilities of communicating the two different languages of each discipline simultaneously and doing so in my second language. As a visitor in the world of gender research and with a beginner’s conversational booklet in
my hand, would I be accepted? I had learned from literature and courses that gender research is interdisciplinary, and its integration into technology could prove immensely valuable; however, questions regarding openness and communicability persisted. Could I write for two different audiences and then translate what I learned for third audience—the educational community? I made a choice and decided to focus on and engage with the research and teaching community of technology education, which in itself is an interdisciplinary field, and, for me, has always been an open community, in that technology education aspires to continue contributing to research on girls. In that case, we should allow ourselves to exist in friction and within negotiations concerning the nature of knowledge, whose perspectives we maintain and whose voices we listen to.

Reflexivity—obstacles and solutions

Gulbrandsen (1995) argues that we must acknowledge that, as researchers, we are not just part of the solution but also contributors to the problem by describing it too narrowly. Here, it is relevant to reflect on the relationship of the researcher, what is researched, and what is learnt.

Revisiting methods in Study I

Reflecting on my thesis, I recognise the significance of keywords such as ‘girl’, ‘interest’, ‘technology’, and ‘education’. These keywords not only shape our search parameters but also define what we perceived. The scoping literature review revealed the existence of non-technical girls when the focus is on ‘hard’ and male-coded technology. There seemed to be a need for these girls to cultivate interest in specific types of technology, as indicated by our results. Moreover, it brought to light the stereotyping of boys as naturally interested and technical.

The scoping literature review led to a realisation that earlier data primarily relied on surveys, and a shift toward gaining first-hand experience could be fruitful to explore. To identify and address knowledge gaps more effectively, I needed a methodology that explored how girls engage with technology. Crafting the right research questions proved challenging without a clear understanding of girls’ interactions with and perceptions of technology.
Revisiting methods in Study II

To bridge the methods gap found in Study 1, I adopted an approach that involved observing, listening to, and understanding girls' activities and thoughts, allowing them to express their perspectives. However, after reflecting on the method, I wish I had stayed longer, dug deeper, and visited more times to learn more about similarities and differences in how girls express themselves as technical—asking more about the tools they use and their views of technology. Framing the teacher as a gatekeeper helped identify when, where, and how to perform the study. The teacher's knowledge about obtaining parental consent proved valuable. However, a potential negative was the risk that pupils may feel obliged to participate due to their loyalty to the teacher. To tend to this challenge, efforts were made to establish an open relationship with the pupils through casual conversations and shared moments, considering their similar socioeconomic backgrounds. Additionally, concerns about ensuring legal guardians' comprehension of the consent process led to discussions with the teacher on simplifying consent letters, incorporating insights from the teacher's input. This collaborative approach might be seen as improving the transparency and accessibility of future consent letters for a diverse receiver, including those not well-versed in academia or those for whom Swedish is a second language.

Revisiting methods in Study III

The implication for future approaches in the thesis work was the role of the researcher. I had a plan for how to collect data, and I held onto that plan. I was there to explore interested and technical girls and the technological context of a camp. However, being a participant observer was not planned from the beginning. This happened as I entered the camp. This surprised me since I had pre-knowledge of the setting, the location, and aims as a former employee and co-organiser. I did not know any of the girls or any of the group leaders. Nevertheless, I believed I knew what I was getting myself into, but being in a new role as an outsider was quite different. I felt as if my researcher's glasses were on. I distanced myself in a way I did not think I would. I was distant because I looked through my feminist looking glass; a role which was entirely new to me.
The fourth study (IV) included in this thesis was a review and did not use a ‘method’ in the ways revisited above. However, this journey towards earning a Ph.D. has been a learning process, emphasising the importance of diverse perspectives. I also acknowledge that each method and tool opens unique doors to understanding, providing insights into distinct ‘worlds’. This realisation is humbling.
Chapter 7—Results

Results

In this chapter, before presenting the results, findings, and highlights, I will provide a summary of the studies as a reminder of the connected work. I will then present the results from the different studies included in the dissertation, followed by findings and some similarities and differences between the studies. I will end the chapter by answering the results of the research questions in the thesis and summarising the results using Bacchi’s (2009, 2012) construct before discussing them later.

This dissertation seeks to examine the challenges associated with the ‘problem’ of the (non)technical girl. To achieve this objective, various perspectives and methods have been employed to accumulate comprehensive knowledge and contribute to the comprehension of the technical girl and the ‘problem’ of the (non)technical girl.

All four studies concern girls’ engagement with technology education and their relationship with technology. The articles can be seen presenting two focal points—structure-centred and individual-centred gender issues. Structure-centred is defined as pertaining to external influences, such as governmental efforts and societal expectations, and individual-centred is defined as a problem centred on the girls themselves. Cultural factors and gender norms are mentioned in the studies as potential explanations for the gender gap in technology engagement. The studies emphasise the importance of understanding girls’ perceptions, attitudes, and self-images in the context of technology education. They also highlight the need for more inclusive approaches to technology education which consider gender interactions and diverse perspectives. Worth emphasising is that Harding’s framework is used in all four studies; however, feminist thinking such as Harding’s is also used in all four studies.

Study I is a literature review summarising existing research on girls’ engagement with technology education, while Studies II and III are
empirical studies involving observations and interviews. Study I focuses on girls’ overall attitudes and concerns girls’ career choices in technology, while Studies II and III examine girls’ self-image and engagement during technology lessons and in a technology-centred summer camp. Study II uses Harding’s three gender levels as a framework for analysis. At the same time, Study III also incorporates Harding’s framework and proposes another level but explores it in the context of a technology camp. Study IV suggests teaching strategies, didactic capital, which address challenges such as girls’ lack of identification with the subject content, low self-confidence, and teachers’ subject knowledge. It advocates for inclusivity by valuing the technology process and product, understanding diverse perspectives, and fostering gender-aware environments. The thesis’ results are connected to those in the studies I will present.

Result of the studies

This section summarises each article’s results under their own sub-headlines.

Results; Study I

The aim of this study was to review internationally published scientific literature on the subject of girls’ engagement in technology education, in order to identify the most common descriptions of girls’ engagement with technology education, girls’ technological activities, and the relationship between girls and technology. The study’s results were described under two main tracks. The first is “girls’ engagement with technology education”, and the second is “girls’ technological activities and the relationship between girls and technology”.

When examining girls’ engagement with technology education, most studies reveal that girls are often underrepresented or reluctant to participate in technology, science, or STEM fields. They generally exhibit less interest or a more negative attitude toward technology compared to boys. It was reported that girls were less interested in and had lower ambitions than boys regarding technology (Chang et al., 2009; Jennings et al., 2015; Shoffner et al., 2015; Villas-Boas, 2010). Several studies (Ardies et al., 2015; Master & Meltzoff, 2016; Rasin et al., 2009) indicated that girls typically express interest in certain technological
subjects around the age of 10; however, their interest tends to decline after that. They were showing a negative trend in developing their attitudes towards the subject of technology. Nevertheless, as argued by Master and Meltzoff (2016), girls’ underrepresentation is not due to a lack of interest or ability. Some studies highlight that girls can be positive towards STEM, especially compared to technology alone (Ardies et al., 2015).

Scholars such as Mammes (2004), Autio and Soobik (2017), Andréucci and Chatoney (2015), Chatoney and Andréucci (2009), and Autio et al. (2016) concluded that the low level of interest in technology among girls is due to different social expectations. Stevanovic (2014) and Master and Meltzoff (2016) point to societal norms and expectations, such as socialisation patterns, cultural stereotypes, and educational policies as influencing girls’ choices. However, research by Chatoney and Andréucci (2009) and Virtanen et al. (2015) showed how girls would be more motivated and engaged when allowed to participate on their own terms.

Girls reported lower interest and self-confidence than boys in STEM in most studied countries (e.g., Chang et al., 2009; Dakers et al., 2009; Fensham, 2009; Osagie & Alutu, 2016) and even when the girl’s demonstrated talent in pursuing science and technology careers, they were discouraged from doing so. Chang et al. (2009) concluded that girls did not feel interested in learning about STEM, whilst Virtanen et al. (2015) pointed out that girls were interested in studying environment-related issues. In contrast, Dakers et al. (2009) and Voyles et al. (2008) found girls to be just as interested in and engaged with technology as boys. Regarding girls’ technological activities, the relationship between girls and technology was seen as more challenging to uncover in the selected studies. Regarding girls’ technological activities, few studies define the types of technology involved, but some categorise certain technologies as either neutral or male-oriented.

The technological activities described in the reviewed articles included creating a bag using electrical circuits (Sheffield et al., 2017), designing an electrical Christmas tree, designing and making a nesting box (Mammes, 2004); product development of a model football cage and a jewellery box (Chatoney & Andréucci, 2009); and using Lego Mindstorms robots (Master & Meltzoff, 2016). Autio and Soobik (2017) highlighted that technological knowledge has an impact on girls’ engagement in technology, especially in spatial reasoning, while Ardies
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el al. (2015) pointed to the fact that gender differences in technology may correlate with the lack of technological toys and the amount of actual play with such toys girls get as they grow up (cf. Ankiewicz, 2018).

In educational settings (Voyles et al., 2008; Virtanen et al., 2015), girls were likelier than boys to initiate teacher interaction. Mammes (2004) showed how girls also displayed greater imagination and inventiveness and took more risks than boys on topics with which they were familiar. Although less explored, girls’ relationships with technology show potential for improvement by adapting the social context of teaching to better suit girls’ preferences. Mammes (2004) implied that teachers can encourage girls to be interested in science and technology through how they teach.

The need for more information in the reviewed articles posed challenges for analysis. The research often reflects a traditional view of technology as male-coded, and there is a mismatch between the perception of girls’ disengagement in technology and the expectation for their engagement (e.g., Harding, 1986). We saw potential limitations in research methodologies and called for further empirical research adding knowledge from gender studies to unravel the complex and conflicting gendering within the discourse.

The reviewed studies indicate that girls generally exhibit lower interest and less positive attitudes toward technology than boys. Explanations often point to cultural factors, and defining the type of technology involved reveals a tendency to associate certain technologies with masculinity. The potential limitations of this study include methodological considerations in the reviewed studies, and further research should focus specifically on girls and technology, as well as on exploring interdisciplinary perspectives for a more comprehensive understanding of gender dynamics in technology engagement.

Results; Study II

The aim of this study was to examine the self-image of girls aged 9–12 when participating in primary technology education, by using Harding’s (1986) three gender levels: the symbolic, the structural, and the individual. The study can be seen as following the results of Study 1, where interdisciplinary perspectives were highlighted—plus girls aged
10–12 were highlighted as an interesting group meriting study. Studies such as Kim et al. (2018), Sultan et al. (2019), Ardies et al. (2015), and the Swedish Schools Inspectorate (2014) stressed the lack of research in technology education focusing on girls in younger years. The results build on Harding (1986) highlighted the interplay of gender and technology among girls in technology education, focusing on symbolic, individual, and structural aspects. Symbolic gender, deeply ingrained in culture, manifests through language and dichotomies, as observed in girls' conformation to prevailing norms related to technology. In gender-homogeneous work groups, girls conformed to existing norms and, at the same time, supported each other’s technical abilities. Symbolic gender was evident in group discussions about robot chores and material preferences, reinforcing traditional gender dichotomies. Despite this conformation to and confirmation of norms, a duality emerged, as the girls expressed dissatisfaction. They sought help from boys but also desired more autonomy. This duality was linked to the individual level of gender, reflecting socially constructed identities in technology education. Girls often needed to be more specific about their technical competence, expressing uncertainty about what constitutes technology and associating it with solving tasks and choosing tools. This uncertainty reflected both symbolic and individual aspects of gender. Structural gender, as per Harding (1986), was observed in the teacher’s efforts to avoid reinforcing stereotypes, as suggested by Rooke (2013). However, clear divisions emerged in the groups during lessons, with girls often working exclusively with girls, contributing to reinforcing stereotypical structural images similar to what is seen in Kim et al. (2018) and Virtanen et al. (2015). The preference for "feminine-coded" tools and sections of the room and the expression (cf. Turja et al., 2009) of dissatisfaction with technology also played a role in reinforcing gender stereotypes at the structural level.

The results revealed the intricate dynamics of gender and technology among girls in education as also mentioned by Rooke (2013), showcasing in how symbolic, individual, and structural aspects interact to shape perceptions and behaviours, one could see a social construction of (not) being technical. The findings emphasise the need for a comprehensive approach to address gender biases and stereotypes in technology education.
Results; Study III

The study investigated girls’ technological activities and conceptions when taking part in an all-girl technology camp.

The girls were immersed in various technological activities, shaping their engagement, interactions, and perceptions. The main themes included construction, joining and separating, rules of thumb, digital making, and improvisational design. While the girls were exposed to traditionally male-dominated activities like puncture welding, most engagements were with feminine-coded activities such as making earrings and handbags. The activities provided contexts for the girls' continued involvement with each other, the teachers, and with diverse technological artefacts. The examples provided from three observations revealed how peers and mentors guided girls in a traditionally male domain. At the same time, metaphors were used to boost confidence and create a positive identity in relation to technology. The second observation highlighted cooperative building and learning through skateboards, demonstrating the appropriation of traditionally male activities like drilling. The third observation emphasised improvisational designs with steel, where freedom of activity resonated most with the girls, surpassing concerns about gender-coded materials.

Thematic analysis from focus group interviews and observations identified three themes: technology as making, being technical in others’ eyes, and school technology education as an impetus. Girls preferred hands-on, practical technology activities, regardless of gender coding. The symbolic level reflected cultural norms associating technology with action, while structural and individual levels emphasised the importance of doing and making in shaping their technical identity. Regarding being technical in others’ eyes, girls often downplayed their own capabilities, comparing themselves to boys due to societal expectations. Despite this, they exhibited a strong technical identity, even in the case of traditionally male-coded technology. Their criticisms of school technology education included a desire for more practical work, competent teachers, and a focus on knowing and doing. A sense of belonging and identity in relation to technology was highlighted as crucial for participation.

The study showcased how girls navigate and engage with technology through various activities, emphasising hands-on experiences and challenging traditional gender norms. The findings
underscore the importance of fostering positive identities and creating inclusive technology education environments for girls.

Study IV, implications

Since Study IV is a chapter with implications for teaching and guidance for educators, it does not have empirical results to communicate as has been the case for Studies I–III. Nevertheless, Study 4 synthesises some of the results from the previous empirical studies and offers implications for teachers, which will be developed further below.
Answering the research questions

In this section of the chapter, I will answer the research questions. First I offer a reminder about the thesis’ overall research question and following, I provide the answer.

**According to international published scientific literature, what is the nature of girls’ engagement with and interest in technology education and technological careers? (Study I)**

The international published scientific literature uncovers multifaceted insights into girls’ interests, activities, and challenges. The studies note that girls, in general, express less interest in technology compared to boys. Their attitudes tend to be more negative, particularly around and after age 10–11, contributing to their underrepresentation in STEM fields. Girls actively participate in diverse technological activities; however, the decline in girls’ interest is linked to socialisation, distinct social expectations, and limited exposure to technology. Girls’ disinterest is viewed as a social construct shaped by cultural norms and biased feedback from an early age. Some studies suggest lower overall interest among girls, while others highlight instances where girls are equally engaged compared to boys. Girls may express interest in specific technological areas, challenging the notion of a general lack of interest. Girls’ underrepresentation is attributed to societal perceptions and stereotypes rather than an intrinsic lack of interest or ability.

The research discourse is complex, including a mismatch between the perception of girls’ engagement in technology and societal expectations. Recognising that the gendering of technology is complex and conflicting, this research also highlights the need for more detailed empirical explorations close to the girls. The literature also highlights that efforts are needed to address the underrepresentation of girls and women in STEM. Women hold a disproportionately lower share of STEM degrees, impacting their likelihood of working in STEM occupations. Girls’ motivation and engagement flourish when encouraged to participate on their own terms and when they receive positive feedback. Establishing environments where girls feel motivated and confident in pursuing STEM activities is crucial, and teachers, especially women teachers, play a role in encouraging girls’ interest in technology through supportive teaching methods.

While challenges persist in girls’ engagement with and interest in technology education and technological careers, the research
underscores the potential for improvement through inclusive teaching methods, addressing societal norms, and comprehensive empirical investigations in the intricacies of girls’ engagement with technology education and careers.

What is the nature of girls’ activities, self-image, and performativity when participating in technology education, inside and outside of school? (Studies II, III)

It Studies II and III we could see that girls’ involvement in technology education, both within and outside of school, was shaped by intricate dynamics involving their activities, self-image, and performativity. Our studies revealed the interplay of individual, symbolic, and structural dimensions of gender (Harding, 1986) and a social level, added by ourselves.

Cultural norms embedded the symbolic gender, evident in the language and dichotomies that influenced girls’ perceptions of technological competence. Even in gender-homogeneous settings, girls unconsciously conformed to prevailing norms, reinforcing stereotypes. Dichotomies, like active–passive, surfaced as girls in Study II sought help from boys, contributing to the stereotypical image of boys as technologically competent handymen. “These girls frequently expressed that they do not like technology, or that they are not good at technology, in contrast to the boys who were seen by the girls as being technical—despite one of the boys protesting about being labelled as ‘good at computers” (Sultan et al., 2020, p.188)

Symbolic gender was further reflected in girls’ preferences for traditionally feminine tools and activities, sustaining established norms. On an individual level, in Study II, girls expressed a duality in their engagement. While confirming stereotypes by seeking help from boys and expressing uncertainty about their own technical abilities, they simultaneously voiced dissatisfaction and a need for more autonomy. “Even here, however, we identified a duality or ambiguity because we also noticed that the girls’ view of being technical was closely linked to being able to use a certain technology without having to ask for help from someone else; i.e., from boys. In addition, as we have seen, the girls sometimes did just that” (Sultan et al 2020, p.188) This complex interplay suggested a socially constructed identity, revealing the complex nature of girls’ self-image in the realms of technology.
When examining the structural gender level, it unveiled efforts to counter stereotypical notions through gender-neutral assignments and teacher support. Despite these attempts, a division emerged in the classroom, with girls often segregating themselves and performing what we could interpret as their version of a technical self. Girls, in what I interpret as unconscious contributions, contributed to stereotyped structural images linked to technology, which were also observed in girls’ preferences for traditionally feminine-coded tools and avoidance of specific room sections.

Also, at the all-girl technology camp in Study III, we used Harding’s three levels of gender—symbolic, structural, and individual—as tools for understanding. The camp’s ‘girlification’ attempts sought to attract girls to STEM by transforming traditionally male-coded activities into more feminine-coded ones. However, questions arose about the effectiveness of such approaches, particularly in influencing girls who already self-identified as being technical. The camp’s limitations included focusing on traditionally male-dominated activities, but at the same time also labelled some of them as feminine by ‘girlifying’ them, thereby potentially reinforcing gender norms.

Study III proposed an additional level of gender—the social level, underlining the crucial role of the social context. A proposed fourth level, the social dimension, underscored the critical role of the social context in shaping girls’ perceptions of themselves as technical beings. This level was used to explore how girls perceived themselves as technical within a supportive social environment, most notably new friends at the camp but also their women camp teachers. The organisation of the camp influenced girls’ technical self-perception, highlighting the need to consider the interplay between symbolic, structural, and individual dimensions in a social context.

There seems to be an intricate nature of girls’ engagement with technology education. The interplay of symbolic, individual, and structural dimensions, augmented by the proposed social level, underscored the challenges and opportunities in fostering a genuinely inclusive and empowering environment for girls in technology education. One of the results that emerged from the study was the girls’ wish for technology education to be more a practical subject, where pupils learn how things work and can gain knowledge which they have a practical everyday use for (cf. Sultan et al., 2023). When comparing Studies II and III, there is a shift in the results found in a classroom setting and at camp. In the classroom, all pupils attend, no matter how
interested they are in the subject and its content, while at the camp, girls self-identify as being interested in technology.

Harding’s analytical lens can be seen as revealing the complex dynamics that shape girls’ activities, self-image, and performativity. The fourth social level points to the stereotypical conceptions prevalent at the camp, in that girls were primarily seen as interested in the social aspects of technology. On the other hand, the perhaps most enduring facet of the camp which strengthened the idea of girls as knowledgeable in all forms of technology—and therefore in fact as being technical—was meeting new, likeminded friends who engaged in a broad array of technologies.

What are some implications for technology education specifically and STEM education more broadly of the empirical findings about the ‘problem’ of the (non)technical girl? (Study IV)

The empirical findings on the ‘problem’ of the (non)technical girl have implications for technology education, especially within the broader context of STEM education. Traditionally, ‘being technical’ has been associated more with boys, contributing to the prevailing perception of technology as a male-dominated space; however, gender research emphasises that interests in technology are socially constructed and shaped by societal expectations and recurring situations.

The chapter highlights the importance of challenging traditional notions of technological interest, masculinity, and femininity. This early divergence is influenced by factors like a lack of identification with the subject, low self-confidence, external influences, and teachers’ subject knowledge. To address these challenges that threaten becoming a ‘technical girl’, teaching strategies which challenge gender stereotypes are suggested. Educators can reshape pupils’ perceptions of masculinity and femininity in STEM by presenting diverse views, behaviours, products, professions, and knowledge suitable for all their pupils. Also, recognising variations within groups and acknowledging intersections between them is crucial. There is not only a single version of being a ‘girl’. The implications underscore the role of gender stereotypes in shaping attitudes, emphasising the need for early interventions to challenge these stereotypes.

The challenges of teaching technology education lie in its broadness and the diverse interpretations of the curriculum. The chapter raises questions about how teachers interpret a subject and what
knowledge they possess, noting that the subject itself is not gendered if one takes into account the full range of technology and technological activity that could be included; humans are gendering it. Making technology education more inclusive does not mean making content more gender-specific but valuing both the technological process and the product. Gender-conscious teaching involves reflecting on gender, exploring its implications in the subject, and questioning preconceived ideas about gender in teaching. Gender inclusiveness can be achieved by encouraging diverse ways of problem-solving involving open-ended problems, context-related technology, and sustainability-related tasks. One suggestion is to create opportunities for varied collaboration during class to challenge traditional gender roles. Furthermore, understanding the different perspectives already instilled in girls and boys when attending technology education is essential.

The findings stress the need for a comprehensive approach to technology and STEM education. Addressing stereotypes, promoting gender neutrality, and fostering a supportive learning environment can contribute to dismantling entrenched gender norms. The study advocates for a nuanced understanding of gender dynamics at multiple levels (e.g., Harding 1986) and emphasises the potential for change within educational institutions. It can encourage educators to challenge themselves and their didactic capital to create a more inclusive environment.

**Similarities and differences found in the studies**

Here, I will briefly overview some similarities and differences in Studies I–IV. I will start with the similarities.

Harding (1986) is important as a unifying theoretical element, which can be seen as linking the studies. All studies are focused on girls aged 9–17 and emphasise the multifaceted nature of girls’ engagement with technology and STEM, acknowledging that various factors, including societal expectations and stereotypes, play a role. The studies discuss girls expressing less interest in technology, developing negative attitudes around a certain age, and the resulting underrepresentation of girls in technology specifically and in STEM fields more generally. Study III introduces the issue of ‘girlification’, especially when it comes to girls already identifying as being technical, and Study IV addresses the same
issue. The complexity of making male-coded activities girly with the hope of creating engagement can not only discourage already self-identifying girls, but also offers a false representation of the technology presented. In the studies there is an agreement on challenges in girls’ engagement with technology. However, it also emphasises the potential for improvement through inclusive teaching methods and addressing societal norms, such as the positive impact of encouragement.

All studies, in different ways, recognise the significance of the social context in shaping girls’ perceptions, attitudes, and engagement with technology, highlighting the interplay of symbolic, individual, and structural dimensions and advocating for the dismantling of gender norms and the creation of supportive learning environments. In Study III, the social context is recognised as its own level of gender, supplementing Harding’s 1986 framework.

Some differences are noted, too. While all studies address girls’ engagement with technology, Study I focuses on general attitudes and interests; Studies II and III explore activities, self-image, and performativity; and Study IV explicitly examines the implications for education. Studies II and III include insights from two different educational settings, offering an understanding of girls’ engagement inside and outside traditional classrooms, which is not present in Studies I and IV. Study II imposes different gender levels of analysis (symbolic, individual, structural) on the data, and a fourth social level is suggested in Study III to understand girls’ engagement, providing a more detailed framework compared to Study I, which focuses more on general trends. Study IV explicitly discusses teaching strategies challenging gender stereotypes, while Study I emphasises the potential for improvement through inclusive teaching methods without presenting specific strategies. Continuing with Study I, it can be noted that it briefly mentions the role of women teachers in encouraging girls’ interest. As Stevanovic (2014) and Rasinen et al. (2009) have noted, having female teachers and classmates plays a crucial role in enhancing girls’ engagement, potentially creating a positive ripple effect, and Study IV expands on this, suggesting that educators can reshape perceptions of masculinity and femininity in STEM through diverse representations. This is in line with research such as Mammes 2004 suggestion that fostering girls’ interest in science and technology is achievable through teaching approaches. Studies II, III and IV also partly address the challenges girls face in becoming a ‘technical girl’, focusing on self-identification and the impact of societal expectations, which is not as explicitly discussed in Study I.
Limitations of the results

The findings of the studies are based on a review of internationally published scientific literature and specific observations in particular educational settings. The scope may not cover all cultural or regional variations, and the results may not be generalisable to all populations of girls due to the qualitative nature of the methods. Cultural variations in societal expectations and gender norms could also impact the results.

The studies rely on existing literature, observations, and interpretations. The literature review may be subject to publication bias, where studies with significant findings are more likely to be published. Negative or neutral findings might be underrepresented, affecting the overall perspective on girls' engagement in technology education. The reviewed literature may have biases or gaps in representation, and some perspectives or voices may be underrepresented, leading to potential limitations in the comprehensiveness of the findings. The methodologies used in the reviewed articles may have limitations, and there may be variations in the quality of the research methods employed in different studies. The focus on girls aged 9–17 may not fully capture the nuances of girls' engagement in technology education across different age groups. The challenges and factors influencing engagement may vary at various ages. The studies cover different educational settings, including traditional classrooms and a technology camp. The variations in settings may introduce complexities that must be fully explored or accounted for in the analyses.

Interpretations of results and implications are subjective to some extent, and different researchers may derive alternative interpretations from the same data. The studies acknowledge the multifaceted nature of girls' engagement, but subjective interpretations could introduce bias. Recognising these limitations is crucial for maintaining transparency and ensuring that conclusions are appropriately qualified.
Chapter 8—Discussion

Discussing the problem

This dissertation as a whole aims to problematise the ‘problem’ of the (non)technical girl and to contribute through my work towards target 4.3 in the Global Goals, aiming to ensure equal access to education by 2030. I have used different perspectives, methods, and data to gain as much knowledge as possible to contribute to understanding the creation of the ‘problem’ of the (non)technical girl.

In this chapter, I will discuss the ‘problem’ of the (non)technical girl inspired by Bacchi’s “What’s the Problem Represented to be?”, or WPR, analysis method. I will start with answering the questions suggested by Bacchi to identify a ‘problem’. These questions are as follows:

1. What’s the ‘problem’ represented to be in a specific policy or policy proposal?
2. What presuppositions or assumptions underpin this representation of the ‘problem’?
3. How has this representation of the ‘problem’ come about?
4. What is left unproblematic in this problem representation? Where are the silences? Can the ‘problem’ be thought about differently?
5. What effects are produced by this representation of the ‘problem’?
6. How/where has this representation of the ‘problem’ been produced, disseminated and defended? How has it been (or could it be) questioned, disrupted and replaced?

(Bacchi, 2012, p. 21).

I will, after this, relate the above questions to the three research questions presented in the thesis. The chapter ends by discussing what it means to be ‘technical’ and the tools needed to solve the ‘problem’.
Defining the ‘problem’

The identified ‘problem’ revolves around girls’ perceived lack of interest and engagement in technology and STEM education. Historical contexts underscore persistent societal views influenced by governmental initiatives.

The ‘problem’ is represented to be the notion of the (non)technical girl. She is presented as lacking engagement, interest, and the will to work in technology and STEM fields. She is also described as a person who is not technical but one who should become technical. The presuppositions or assumptions underpinning this representation of the ‘problem’ are multifaceted. It is important to recognise that the problem is partly based on data on recruitment and research (e.g., as revealed in Study I) but also on biases, societal expectations, and persistent stereotypes that hinder girls from pursuing technology-related fields. The ‘problem’ can be seen as a clear yet multi-faceted picture.

There seems to be a lack of proof as to whether younger girls under the age of ten lack interest in technology. This is not a particularly controversial statement; however, it is accepted that interest generally decreases, but research also attempts to ask why (as was the case in Study I). However, it is crucial to recognise that it seems that we do not have enough research to make the construct non-technical girl a ‘truth’ (Bacchi, 2009, 2012; cf., Ardies et al., 2015). The persistent discourse of the untruthful ‘problem’ underscores the significance of addressing gender disparities in technology education from different angles within educational and political contexts.

Unpacking the historical context

The historical context reveals how this representation of the ‘problem’ comes about. This is where the representation of the ‘problem’ has been produced and has spread to current times. It is a ‘problem’ with foundations in societal views, together with a need for a skilled industrial workforce. As mentioned earlier in the introduction, a high percentage of women become engineers each year. However, from the heavy industry’s point of view, they are not necessarily entering the job market covering the needs of the manufacturing/industrial engineering sector, such as with an exam in Mechanical Engineering. Governmental efforts spanning the 1970s to the 1980s, aimed to address the
underrepresentation of women in technology and engineering roles and sought to provide equal access to technology education. However, challenges persisted, leading to active campaigns in the 1980s promoting technology education and careers specifically for women and implementing compulsory technology education for all pupils to reshape attitudes and increase the likelihood girls will choose engineering and technology careers. The curricular changes, such as Lp094, addressed gender equality in technology education, with explicit calls for stimulating girls’ interest in technology. Despite these efforts, the discourse around girls and technology persisted, encouraging initiatives, such as the 2009 governmental initiative for girls’ technology courses and the recent 2023 STEM strategy, indicating continuous dissemination and defence of the ‘problem’.

Challenging assumptions and silences

The ‘problem’, as mentioned before, is the non-technical girl. She is primarily represented as girls’ lacking interest and engagement in technology and STEM education. Here the ‘problem’ is often left unproblematised and can be seen as ‘solved’ if only the girls would become interested—making the girls both the problem and the solution. Thus, the ‘problem’ can be thought about differently. The thesis explores this issue from various perspectives, such as through research findings, societal expectations, and educational practices.

The silences, as Bacchi (2012) puts forth as possible gaps or limitations in this representation of the ‘problem’, could here be seen as a lack of focus on the early socialisation of children, where girls, from as young as three, form gendered perceptions and behaviours related to technology. Available evidence suggests that, at this age, girls are as equally engaged in technology as boys (Ankiewicz, 2018, Ardies, 2015, Sultan et al., 2019, 2020, 2023) The stereotyping and limitations imposed by societal norms, educational practices, and parental influences contribute to girls’ reduced exposure to and interest in technology. Primary school was identified as a critical period when girls’ interest and engagement in technology education declined and often did not recover (see Study I; Ardies et al., 2015, Sultan et al., 2019). If being non-technical can be argued to be a performative act, the findings in this study indicate that girls may adapt their performance in educational settings based on external perceptions (Studies II and III). The formation of a technical identity involves belonging and social
acceptance. The research highlights that determining who is seen as ‘technical’ varies based on contextual factors – by using Harding (1986), we can transition from external ‘eyes’ to seeing oneself as one is seen by others. These are reciting acts, gendered acts. The performativity of being technical is complex, especially as girls often self-identify as non-technical, such as in Study II. The complexity is the silence, as Bacchi (2012) puts it, the possible gaps or limitations in this representation of the ‘problem’ as (non)technical. Being non-technical is an accepted trait of girls—if we believe the ‘problem’ discourse.

Interrogating truths and certainties

Bacchi (2012) asks whether the ‘problem’ can be thought about differently. In studying the representation of the ‘(non)technical girl’ within research and policies, certain aspects are left unproblematised, leading to questions about whose problems and solutions take precedence. Bacchi (2012; Bacchi & Goodwin, 2016) highlight the concepts of ‘truth’. ‘Truth’ is not merely ‘true’ but rather what is considered to be ‘in the true’ or accepted as true. Adopting a stance that portrays the non-technical girl as an absolute ‘truth’ and a fixed entity makes it challenging to bring about change. There are aspects of being technical regarding educational equality and recruitment, yet being technical is also subjective and context-dependent. Thinking differently regarding what is expected of girls to be seen as technical and what specific skills or interests they should exhibit for this recognition can be fruitful. The societal and governmental ‘truth’ of the lack of interest and willingness to pursue technology as an education or career among girls ≥11 years of age (Sultan et al., 2019; Sultan et al., 2020; Sultan et al., 2023) threaten the disposition of thinking differently. The ‘truth’—the certainty—of what girls think and want, seems to veil our perceptions.

Effects on education and the role of teachers

The effects produced by this representation of the ‘problem’ can be seen in the literature review and in Studies II–IV, which highlight educational and governmental responses displaying the role of explicit and implicit biases in perpetuating gendered disparities in technology-related fields, often focusing on masculine-coded technology—concluding you are only interested in technology if you engage in certain technologies. The
distinction between ‘hard’ and ‘soft’ and ‘masculine’ and ‘feminine’ technology further compounds the problem, perpetuating a biased view of technology. As the problem is represented, teachers can be seen to have a role in disrupting the problem. Educators with proper instructional skills and awareness of gender differences in development can positively influence girls’ enthusiasm for technology. Early interventions, effective teaching methods, and a positive learning environment tailored to girls’ needs are essential strategies in fostering and maintaining their interest in STEM subjects. Furthermore, the text discusses the significance of role models in influencing girls’ perceptions of STEM fields, since this is a recurrent solution to the ‘problem’. While the impact of role models is complex and mixed, relatable and attainable role models, including peers like those in Study III, teachers and parents (men and women), could be supporting girls in pursuing STEM education and careers.

Disrupting the problem

Bacchi’s (2012) question regarding how the ‘problem’ can be questioned, disrupted, and replaced is, for me, a key inspiration and no easy answers can be given. One disruption can be unpacking the ‘problem’ of who is considered technical. Who is seen as being technical raises questions about the presuppositions and assumptions underlying this representation. Suppose we highlight what kinds of abilities, skills, and interests a technical person is supposed to have. In that case, we might come closer to replacing the ‘problem’ as an individual issue, or girls being seen as problems to be fixed, with the ‘problem’ being a structural one, existing outside the girls. As it is now, girls are considered the problem when they are defined as not being technical. However, the problem is constructed. The research indicates a journey from the external world to the internal, where some girls respond to societal perceptions by performing not being technical and adopting a non-technical self-image. The exploration of identity development as being technical involves considerations of belonging and social acceptance within the technology community. I suggest we challenge the binary perception of technical or not technical, suggesting that this division may contribute to gendered stereotypes and impact girls’ engagement in technology education. Instead, we can think of ‘technical’ as being in a relationship with technology at different levels, and levels could be like Harding’s (1986) suggestion of gender as constituted on three levels. On the structural level, the gender divide in STEM in the Western world can
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be seen as an example. It is a level of feeling of belonging in technology. When you are a minority within education or a career it can be harder to feel like you belong, especially if we also take symbolic gender into account. Symbolic gender can be seen in how we describe the ‘problem’ and how it affects the relationship with technology, as well as the language used and how it has different implications for girls and boys. On the individual level, girls’ self-image, performativity, or perception of being technical can come to light. Remember, however, that this does not necessarily mean any of those levels will result in a future career in STEM. However, the levels can contribute to girls’ development of technological knowledge and awareness to orient themselves and act in a technology-intensive world—an aim in line with the Swedish curriculum for technology education.

Revisiting the research questions

In this section, I will continue to discuss of the research questions and the results, together with earlier research.

RQ1: According to international published scientific literature, what is the nature of girls’ engagement with and interest in technology education and technological careers? (Study I)

Revisiting the research question covering the nature of girls’ engagement with and interest in technology education and technological careers includes scientific literature unfolding a multifaceted narrative. The discourse presented in the literature largely confirms but also partly challenges the prevailing notion of a general lack of interest among girls. Undeniably, the research uncovers instances where girls demonstrate equal engagement with and express interest in specific technological areas. This dichotomy stresses the complex and conflicting nature of gendering in the discourse surrounding girls’ interaction with technology. The decline in girls’ interest is not an intrinsic attribute but rather a result of societal perceptions and stereotypes, prompting a reconsideration of the prevailing narrative. Efforts to redress the underrepresentation of girls and women in STEM are highlighted, acknowledging the disproportionately low share of STEM degrees held by Western women (this is not the case for all STEM subjects).
and engineering can be seen as having high shares of women degree holders. The literature mentions the positive impact of encouraging girls to participate in STEM activities on their own terms, fostering motivation and sustained engagement. This involves questioning societal norms and challenging binary perceptions, ultimately contributing to dismantling stereotypes that hinder girls from feeling and being perceived as technical. The literature recognises the challenges faced in girls' engagement with technology. However, it accentuates the potential for improvement—sometimes the improvement of teaching and sometimes the improvement of the girls' interests and engagements.

**RQ2: What is the nature of girls' activities, self-image, and performativity when participating in technology education, inside and outside of school? (Studies II, III)**

The nature of girls' activities, self-image, and performativity when participating in technology education inside and outside of school, can be seen as an interplay between symbolic, individual, and structural dimensions, shedding light on challenges and opportunities for fostering inclusivity in this domain. The two different settings of a classroom setting (Study II) and a technology camp (Study III) unravel factors influencing girls' perceptions and behaviours and acknowledge the complexity of this problem, encouraging reconsideration of the concept of a '(non)technical girl'. The ‘(non)technical girl’ is a girl who is not considered technical but who sometimes is just that, but maybe not always in the way that is expected in the public discourse about school and recruitment in technology and in STEM.

The divergence in engagement between girls and boys becomes apparent, driven by factors such as identification with the subject, self-confidence, external influences, and educators' proficiency. The impact of this representation is found in the educational settings of the classroom and the camp, revealing explicit and implicit biases. The distinction between 'hard' and 'soft' technology and 'girlified' activities contributes to biased perspectives, reinforcing gender norms. Encouraging diverse perspectives and recognising individuality within groups is emphasised as reshaping perceptions of masculinity and femininity in STEM. The research question highlights the complexities surrounding girls' participation in technology education, and the results navigate challenges, propose possible solutions, and advocate for a more inclusive and nuanced perspective on girls' identity in the realm of technology and STEM.
RQ3: What are some implications for technology education specifically and STEM education more broadly regarding the empirical findings about the ‘problem’ of the (non)technical girl? (Study IV)

Some of the implications for technology education specifically and STEM education more broadly regarding the empirical findings pertaining to the ‘problem’ of the (non)technical girl addresses potential gender pitfalls and stereotypical responses to subject content.

The broad nature of technology education poses challenges in interpretation and delivery, influenced by teachers’ preferences and knowledge. The interdisciplinary nature of design and technology blurs traditional gender boundaries. Developing knowledge needed for everyday tasks in a technological world poses a challenge when content is perceived as excluding certain genders. Study IV emphasises that technology education has no inherent gender, and societal norms contribute to gendering. Inclusivity in technology education does not necessitate making content more gender specific. A gender-conscious pedagogy involves reflecting on gender, exploring its meaning in the subject, and questioning stereotypes. Activities should allow diverse problem-solving approaches, fostering engagement from both girls and boys. Observing gender roles during collaborative work ensures tasks and responsibilities are distributed, challenging traditional gender norms. Teachers are crucial in disrupting gender disparities by employing effective teaching methods and creating positive learning environments. Gender-inclusive teaching encourages girls to participate on their terms and provides positive feedback. In addressing stereotypes and pitfalls, the chapter suggests challenging the binary perception of technical or non-technical and considering a spectrum of engagement levels with technology (cf., Harding, 1986). It emphasises the role of education, teachers, and societal perceptions in shaping girls’ engagement with technology, calling for inclusive approaches to address gender disparities in STEM education.

As we come to an end to the discussion chapter, I want to address how the multifaceted nature of being technical, questioning societal norms, gender biases, and the performative aspects of identity influences in whose eyes a girl is seen as ‘technical’. The dissertation challenges perceptions by highlighting the performative aspect of being
technical, suggesting that girls often adopt a non-technical self-image to respond to societal expectations. It emphasises the importance of a nuanced understanding of individual preferences, interests, and self-perception in the broader context of technology and STEM. The studies question the binary perception of technicality and propose a shift toward understanding being technical as a relational concept, considering different levels, such as structural, symbolic, individual and social dimensions. Exploring identity development in technology involves analysing the interplay of societal norms, educational practices, and personal perceptions. The construction of a technical identity is a social process influenced by various factors, necessitating a gender perspective to unveil and address the mechanisms hindering girls from feeling technical and being perceived as such. My work advocates for a nuanced understanding of technical identity and the importance of fostering an inclusive environment that embraces diverse expressions of technical expertise. Thus, as with technology, being technical seems to also be in the eye of the beholder.

The historical context provided in the dissertation adds to the understanding of how the representation of the ‘problem’ has evolved, highlighting the persistent challenges despite efforts to promote gender equality in technology education. The examination of silences and assumptions in the representation of the ‘problem’ sheds light on gaps in focusing on the early socialisation of children and the impact of societal norms on girls’ exposure to and interest in technology. It also recognises the significance of educators in disrupting the problem by employing effective teaching methods and creating a positive learning environment tailored to girls’ needs. The work suggests that the perception of who is considered technical varies based on context, indicating the need to challenge stereotypes and broaden the definition of technology beyond the traditional hard–soft dualism.

Bacchi’s questions has helped me unpack the ‘problem’ of the (non)technical girl—but what does it mean to be a technical girl? Let us explore and discuss the concept of being ‘technical’ for a while.
Contributing to being technical

If being technical is hard to define since it constitutes an external perspective regarding what is expected of girls, then the essential questions for us to ask would be: what are we asking girls to be, become, or show us when we ask them to become technical? What are girls supported to be interested in or show skills about to be seen as technical?

Expressing oneself as good or terrible with technology is often a type of performance. While some forms of performance may be based on individual development, the process of being or becoming technical is formed within a social context. You perform what you are expected to be. Developing an identity as ‘technical’ has two aspects. One is the aspect of a psychological sense of belonging. Cheryan et al. (2015) suggest that the social environment and feelings of belonging in the field of technology and STEM may play a role in nurturing or boosting a STEM identity. The second aspect is social acceptance, or having the technological community recognise the individual as a group member who ‘fits in’ (González-Pérez et al., 2020; Rahm et al., 2021). Our studies confirm this, particularly Study III.

In whose eyes am I a technical person?

The research suggests that determining who is seen to be and considered technical can vary depending on the context—the results of the study point to a journey from the constructed world to the individual. When girls respond to the ‘eyes’ that see them as not technical they perform not being technical; an act which goes unquestioned by society and is sometimes even encouraged since girls themselves are seen as the ‘true’ ‘problem’.

By applying other perspectives of being technical in relation to technology, one can look beyond technology’s most common cultural images. Harding (1986) points to the issue of defining technology. Commonly, the definitions of ‘hard’ and ‘soft’ technology are present in educational and research settings, where hard technology is seen as the real form of technology, while this is rarely the case for soft technology.
Faulkner (2001) writes, “so the world of technology is made to feel remote and overwhelmingly powerful because the hard–soft dualism factors out those other technologies that we all meet daily and can, in some sense, relate to” (2001, p. 85).

There is a problematic gendering in hard and soft dualism, where one is culturally seen and presented as more feminine. Researchers such as Sainz et al. (2016) have shown that girls are usually less confident than boys in handling technology that is defined as hard technology. If you remember, when we looked into the research about girls’ interests, we could confirm that that research is often also conducted with a focus on hard technology. The distinction between hard and soft technology can also be a possible issue regarding who gets to feel ‘technical’. Technology exists on a spectrum from so-called ‘soft’ to ‘hard’. In very simplified terms, we can think of soft technologies as reliant upon and only functioning with the support of human action, like knitting needles, which require people for functionality. In contrast, hard technologies are physical objects, such as refrigerators, which are capable of functioning without active human intervention (Aggarwal, 1995; Beaudin, 2008; de Vries, 2016).

Being good at soft technology and STEM has traditionally been seen as a feminine trait, while being good at or working with hard technology and STEM has been more connected with masculinity (Beaudin, 2008; Light et al., 2022; Ottemo, 2015). Nevertheless, we should recognise the balancing act of hard and soft technology (cf. Norström, 2014). I believe it can be fruitful to question the divide of technology as hard and soft, since this divides technology into structures that can be thought of as one having more status than the other. Furthermore, you seem to only be seen as or be identified as technical if you engage with hard technology (Sjögren, 2015). For this same reason, girls might not enrol in technology courses as they are also performing gender (Juárez et al., 2018).

One of the key points in this thesis is that girls tend to have a negative self-image about themselves, which is not only caused by stereotyping. It is also caused by girls adapting to and taking on a non-technical self-image that fits the ‘problem’ discourse—while still describing themselves as technical and seeing themselves as the same (see Study III). It creates an interesting tension in whose eyes they get to be technical and what kind of technology they have to be interested in to be seen as technical by others. Whether or not it feeling technical matters is subjective and can vary from person to person (Bury, 2011).
Some individuals may find a sense of fulfilment, confidence, or identity in STEM (Anwar et al., 2023), and being considered technical, like the girls in Study III. It can be validating to have knowledge in a particular field and to be able to navigate and contribute to technical discussions or projects as expressed by the girls in Study III and seen in the younger girls in Study II.

However, I believe it is important to remember that not everyone needs to or wants to identify as technical. People have diverse interests, skills, and passions, and not all of them are rooted in technical domains, regardless of whether you are male or female. Feeling technical does not equal success in education or career choices or happiness. It is more important to pursue what genuinely interests and motivates you, whether that is a technical field or something entirely different. The key is finding fulfilment and satisfaction in whatever you pursue. In broader societal contexts, there may not be a definitive answer to who decides who is technical. Harding (1986) highlights that society, cultural norms, and general understanding shape perception in this specific context—being technical. These perceptions, says Harding (1986), are not static and can evolve over time, influenced by various factors such as technological advancements and shifts in societal values.

The performance of being technical is complex. What is known is that girls tend to self-identify as not being technical more often. They are also more often described as less interested in technology. It is argued in various gender-related research that specific attitudes and roles keeps girls from engaging in technology (Carlone, 2004; Faulkner 2011; Sjögren 2015; Smith & Hung 2008), fuelling ideas of what technological agency is—modelling what kind of technology is regarded as acceptable to be interested in. For example, is being interested in sewing being interested in technology? Why? Why not? One thing common for stereotypes in the field of STEM is that they tend to be male-biased (Berg & Lie, 1995; Cheryan et al., 2015, 2017). In these settings, girls are likelier to disengage and adopt a self-image of not being technical (e.g., Kim et al., 2018).

Technology and STEM have a masculine image, not only because men most often dominate them in numbers but because they incorporate symbols, metaphors, and values that have masculine connotations (Corneliussen, 2012), an image conflicting with what is traditionally seen as femininity (Wajcman, 2004). Zuga (1999) concluded that “women and girls often perceive the subject of technology education as a male domain, especially after they have had a
course in technology education” (p. 57). Cultures in technology influence girls’ engagement in technology and technology education from an early age (Cheryan et al., 2015). One of these cultures is how technology is presented as a male domain (Cheryan et al., 2017).

Our most common cultural images of technology, such as computers and machines, are seen as artefacts managed by men (Wajcman, 2004). Within all cultures, a performance can be seen as the most normative representation of a group in a social context (Hogg et al., 1995; Hogg et al., 2004). In technology, someone technical tends to be male, smart, handy, and obsessed with the latest technical artefacts (Ottemo, 2015). Boys are the norm for engagement and interest in technology education, and they define the norm. In earlier research, this has been linked with traits such as objectivity, rationality, and non-emotionality (Brickhouse, 2001; Connell, 1987; Lönngren et al., 2020). Individuals not displaying these traits are to be viewed as not belonging. Performance should not be analysed solely through one lens, which Lykke (2010) points out. Therefore, in this thesis, when discussing girls’ relationships to technology, it is also acknowledged that girls are adapting to and performing the belief of being non-technical.

The idea of becoming as a social construction is nothing new in feminist research, as mentioned earlier. This thesis focuses on the social construction of who gets to feel technical. This construction involves various factors, including communication, gender, culture, physical surroundings, emotions, discourse, media influence, and political contexts. Adding a gender perspective to research in technology education can help unpack the social mechanisms hindering girls from feeling technical and others from seeing them as technical, and there is more to unpack in this regard. A gender perspective can be used to shine a light on the formation of one’s technical self or how others perceive an individual in relation to technology. It can be used to analyse interactions with people, experiences with technology, discussions, comments, and performances, constituting a form of technical self.
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Chapter 9—Implications

Bacchi (2009, 2012) put forth The WPR approach as a resource and a tool, not a formula. “It reminds us that the banal and vague notion of ‘the problem’ and its partner, ‘the solution’ are heavily laden with meaning” (Bacchi, 2012, p.23). Since this is a technology education thesis and I am a technology educator, I want to highlight implications for teaching, or, if you will, ‘solutions’, to use Bacchi’s terminology.

Implications for practice

I will start with a short reminder of Harding’s three levels of gender and will then continue with a discussion of the implications for educators, researchers, and policymakers.

Implications for educators

Harding’s three levels of gender (1986) can provide an analytical tool for understanding the creation of gender patterns in teaching technology education. For example, Harding’s (1986) symbolic gender, illustrated by a primary school girl’s portrayal of her grandmother, highlights how societal norms influence perceptions. Structural gender is exemplified by the unequal attention paid to boys over girls in the classroom, impacting learning experiences. On the individual level, educators’ understanding of pupils’ self-images and identities in relation to technology can be seen as important. On the social level, the social context is put forth as shaping girls’ perceptions of themselves as technical beings. For an educator, this can mean creating spaces of belonging for girls.

My work and the work of others points to gender-conscious pedagogy in technology education, which can be important and an expansion of one’s didactic capital. Educators can exercise their gender consciousness by:

- identifying and challenging stereotypical roles in the classroom,
- exploring their expectations of the pupils,
- thinking about how they value certain technologies, and
- recognising their role in shaping gender perceptions.
Exercising gender consciousness can encourage teachers to consider diverse ways of problem-solving and promote collaboration that challenges traditional gender roles. Worth emphasises that technology education itself is not gendered—it is the human perspectives that gender it. It calls for a gender-inclusive approach that values both the technological processes and products, creating a diverse and open atmosphere in the classroom. An educator should be aware of the performative nature of being technical and its nuanced relationship with gender, societal expectations, and educational contexts. A balanced approach that benefits all pupils, regardless of gender, while avoiding the risk of reinforcing gender stereotypes in the curriculum is advised.

In Sweden, educators face the challenge of handling technology education’s content and subject broadness. My standpoint is that when it comes to teaching technology in Sweden, our existing technology education curriculum is adequate; there might not be a need for STEM education in this context. Nevertheless, I advocate for drawing insights and knowledge from the STEM educational research field to enrich approaches to technology education; for example, from implications of teaching and new content areas such as AI and how to work in in-context projects.

Implications for research and policy
More small data is needed. We, the research field of technology education, seem to have a good picture from surveys on what girls think, but we seem to have a lesser amount of data on what girls do, feel, and say, especially when it comes to younger girls aged 0–10. Research from preschool and classrooms that elevates girls’ activities and voices could be a valuable contribution to the pool of knowledge we have created over the years.

The dissertation explores disruptive strategies by questioning the certainties and truths associated with the ‘non-technical girl’. It emphasises the importance of considering diverse perspectives and acknowledging the complexity of the performative aspect of being technical. I want to call for a more inclusive approach, recognising individual interests, skills, and passions rather than conforming to gender norms. It could be fruitful in our field to add an STS perspective to our philosophy of technology to support the challenge of the hard and
soft aspects of technology and its implications for gendering. I believe this could be more favourable for Swedish technology education than focusing on STEM, since with STEM it tends to tilt into an already male-coded content, and now we have an opportunity to shape what STEM is or can be in Sweden.

A final note: unpacking girls’ technical identity can be of help in identifying effective educational strategies and interventions. Researchers, together with educators, can develop curricula and programmes that cater to girls’ specific needs by understanding their interests, motivations, and barriers. Such initiatives foster their engagement and success in technical subjects, ensuring that they receive equal opportunities to excel in technology-related disciplines. Teachers in STEM can contribute to a more equitable and inclusive technological landscape.
Chapter 10—Conclusions

Conclusions

The exploration of girls' engagement with and interest in technology education and careers, as per international scientific literature (Study I), unveils a nuanced narrative. While confirming girls' prevalent lack of interest, the literature also highlights instances where girls demonstrate equal engagement and interest in specific technological areas. The decline in girls' interest is attributed to societal perceptions and stereotypes, challenging the prevailing narrative. The literature recognises these challenges but underscores the potential for improvement.

Examining girls' activities, self-image, and performativity in technology education, both inside and outside school (Studies II, III), reveals a complex interplay between symbolic, individual, and structural dimensions. The concept of a '(non)technical girl' is problematised and examined, challenging stereotypes and emphasising individuality within groups. The study advocates for reshaping perceptions of masculinity and femininity in STEM.

The implications for technology education and STEM education of empirical findings about the 'technical girl' (Study IV) highlight potential gender pitfalls and stereotypical responses to subject content. Technology education's broad nature presents challenges influenced by teachers' preferences and knowledge. Challenging the binary perception of technical or non-technical and considering a spectrum of engagement levels is proposed to address gender disparities in STEM education.
Possible limitations of the study and questions for further research

This PhD project tried to challenge the prevailing narrative surrounding girls' engagement with and interest in technology education and careers. However, it is crucial to acknowledge certain limitations and consider avenues for further research to deepen our understanding and address gaps in current knowledge.

First, the reliance on small datasets, particularly those close to the girls, may limit the generalisability of the findings. Secondly, the exclusive focus on girls in the study provides valuable insights into their perspectives but may miss potential dynamics in mixed-gender settings. Thirdly, the study's context-specific nature may limit its applicability to broader international settings. Investigating how cultural and contextual factors influence girls' engagement with technology in different regions could enhance the study's external validity.

Questions for further research

Conducting longitudinal studies could provide insights into the evolution of girls' perceptions and engagement with technology and STEM over time, allowing researchers to identify critical intervention periods and the long-term impact of educational experiences. Exploring how boys and girls interact in technology education settings could reveal mutual influences and shed light on the role of peer interactions in shaping gendered perceptions of technology. Investigating how cultural differences impact girls' technological interests would contribute to a more nuanced understanding of the subject. Cross-cultural studies could identify commonalities and differences, helping us develop targeted interventions. Considering intersectionality by exploring how factors like race, socioeconomic status, and cultural background intersect with gender in influencing girls' engagement with technology could unveil nuanced insights. An in-depth analysis of educational policies and their impact on gender disparities in technology education could inform strategies for systemic change. Examining the effectiveness of existing policies and proposing new approaches would be beneficial.
By addressing these limitations and pursuing these avenues for further research, we can continue building a comprehensive and nuanced understanding of the challenges and opportunities for promoting gender inclusivity in technology education. Additionally, acknowledging these limitations validates the integrity of the research and underscores the need for ongoing exploration in this critical area.
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Epilogue

The PhD project has highlighted and stepped away from the ‘girls are the problem’ narrative. The reason girls stop identifying as technical is more complex, and it is all in the eye of the beholder. With small datasets close to the girls and only studying girls, the work hopes to have contributed to a more nuanced picture of girls’ interests in technology. The study raises the question of what it means for girls to be considered technical, highlighting the performative aspect of expressing oneself as terrible with technology. Such expressions may be a form of performance influenced by external expectations and societal norms. The study digs into the sense of belonging and social acceptance associated with developing an identity as being technical, emphasising the role of the social environment and feelings of belonging in the fields of technology and STEM.

The research findings indicate that determining who is considered technical can vary depending on the context, pointing to a journey from the external world to the internal. The study emphasises the impact of societal influences in school, after-school activities, and on girls’ perceptions of themselves as technical persons. It also addresses problematic gendering in the distinction between ‘hard’ and ‘soft’ technology, where certain technologies are culturally associated with femininity.

The dissertation argues that girls’ self-perception as ‘not technical’ is not solely caused by stereotyping but also by the adaptation and internalisation of a non-technical identity. The tension arises in the bodies of research, governmental initiatives, teachers, and society that perceive girls as not technical, influencing their self-perception and the types of technology they engage with.

The study highlights the subjective nature of feeling technical and the variation in individual preferences and interests. While the performance of being technical is complex, I acknowledge that not everyone needs or wants to identify as technical. It encourages individuals to pursue their genuine interests and passions, whether in technical fields or other domains, without feeling obligated to conform to societal expectations. The fluidity in community perceptions and societal values over time is recognised, influencing the perception of being technical.
In conclusion, the PhD project has confirmed earlier studies but also added new understandings of girls who see themselves as technical. I advocate for a gender perspective in technology education research to unpack more of the social mechanisms hindering girls from feeling untechnical and to analyse how individuals perceive themselves in relation to technology. It emphasises the need to question the ‘problem’, challenge gender norms, promotes inclusivity, and recognises diverse interests and skills within the domain of technology.
Syftet med avhandlingen är att problematisera "problemet" med den teknik(o)intresserade flickan. Följande frågeställningar ställs:

- Enligt internationell, publicerad vetenskaplig litteratur, hur ser flickors engagemang och intresse för teknikutbildning och tekniska karriärer ut? (Studie I)
- Hur ser flickornas aktiviteter, självbild och performativitet ut när de deltar i teknikutbildning, i och utanför skolan? (Studie II, III)
- Vad innebär de empiriska resultaten om den "tekniska flickan" för teknikundervisning specifikt och för STEM-utbildning i stort? (Studie IV)


När det gäller resultat så är den första artikeln (Studie I) – "Girls’ engagement with technology education: A scoping review of the literature" – en review av forskning om flickors roll och engagemang inom teknikutbildning i skolan som i mångt och mycket bekräftar bilden av flickor som mindre intresserade av teknik i allmänhet och tekniska yrken i synnerhet. Studie II heter "Technical or not? Investigating the self-image of girls aged 9 to 12 when participating in primary technology education" och handlar om flickors aktiviteter och syn på sig själva som tekniska (eller inte), med data insamlad i ett skolsammanhang där de deltar i teknikundervisning. Studien visar att flickorna bekräftar de rådande manliga normer och föreställningar som är kopplade till vad teknik är och vad det innebär "att vara teknisk", trots att läraren introducerar könsneutrala aktiviteter. Det finns dock också en tvetydighet i resultaten eftersom flickorna också motsätter sig bilden av
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sig själva av att inte vara tekniska, särskilt när de arbetar tillsammans
och har ägarskap i sitt arbete med och lärande om teknik.

Studie III, "Bringing Girls and Women into STEM?: Girls' Technological
Activities and Conceptions when Participating in an All-Girl Technology
Camp", handlar i likhet med artikel II om flickors aktiviteter och
uppfattningar om teknik och att vara teknisk, fast här på ett s.k.
"teknikläger" för flickor med den speciella kontext som det innebär.
Resultaten visar att de uppfattningar om vad teknik är som
presenterades på lägret var tvetydiga, och traditionellt manligt
oriente rad teknik "tjejifierades" ("girlify"). Men tjejifierade aktiviteter
var möj ligen inte så konstruktiva i detta sammanhang eftersom tjejerna
uttryckte intresse för teknik redan innan lägret och därmed visade få
tec ken på att könsbestämma teknik - de gillade alla typer av teknik.
Tjejifierad teknik kan därför i värsta fall ge en falsk bild av det framtida
industriella arbetsliv som lägerarrangören ville inspirera till. Trots detta
var lägeraktiviteterna fortfarande meningsfulla och relevanta för
flickorna. Lägret skapade möjligheter för dem att utveckla sin känsla av
att vara tekniska och skapa en känsla av tillhörighet.

Studie IV är en didaktisk tillämpning av empiri och teori från de tre
första studierna, och är publicerat i boken Debates in design and
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In whose eyes am I technical?
Exploring the ‘problem’ of the (non)technical girl

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