UNIVERSITY OF TWENTE.

Human-Robot Partnerships in various workplaces

MASTER'S THESIS

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Abstract

Due to the increasing usage of emerging technologies like robotics in various workplaces, the idea of collaborating with robots is becoming more realistic. And since it has not been that long since robots have been introduced in the workplace, other potential facets might appear and go beyond robot-worker interaction, such as social, organizational, or ethical facets. Therefore this study focused on understanding how designers and roboticists design the interaction between users and robots in the workplace while at the same time, they considering ethical and social facets in the design process. Gaining insights into designers' perspectives is essential to understand the factors that shape their design decisions and the potential implications for ethical and social considerations. In this study, nine participants from various universities in the Netherlands were interviewed and asked questions regarding their way of designing robots and how they take into account ethical and social considerations. The collected data, from nine participants from various universities in the Netherlands, was analyzed using Reflexive Thematic Analysis, which identified four themes and three sub-themes. The study revealed that common ethical concerns include deception and overtrusting technology, while social concerns related to acceptability, awareness, and trust were also identified. The study concludes by offering recommendations for future work in the field of Human-Robot Interaction.

Contents

Acknowledgements iii

Abstract iv

List of acronyms vii

1 Introduction 1
- 1.1 Background . . . 1
- 1.2 Thesis goals and Research questions . . . 2
- 1.3 Structure of the Thesis . . . 2
  - 1.3.1 Reflexivity and Positionality Statement . . . 3

2 Theoretical framework 4
- 2.1 Human-Robot Partnerships . . . 4
- 2.2 Understanding robots in various workplaces . . . 6
  - 2.2.1 Robots in the manufacturing industry . . . 6
  - 2.2.2 Robots in the agricultural industry . . . 8
  - 2.2.3 Robots in the Healthcare Industry . . . 9
- 2.3 Understanding the designers' POV in Human-Robot collaboration . . . 11
  - 2.3.1 What methods do designers use? . . . 11
  - 2.3.2 New ethical integrative approaches in HRI . . . 11
  - 2.3.3 Design guidelines for Human-robot collaboration . . . 13
  - 2.3.4 Social and ethical dilemmas in designing Human-robot collaboration . . . 13
- 2.4 Summary . . . 14

3 Method 15
- 3.1 Method description . . . 15
- 3.2 Participants and (ethical) Protocol . . . 17
- 3.3 Data analysis . . . 18
  - 3.3.1 Reliability and Rigor . . . 20

4 Findings 22
- 4.1 Exploring moral dilemmas in HRI . . . 24
  - 4.1.1 Privacy concerns and risk . . . 26
- 4.2 Technological transformations and social change . . . 26
  - 4.2.1 Revolutionizing HRI . . . 28
- 4.3 Requirements for a holistic approach . . . 30
  - 4.3.1 Empowering collaboration in design . . . 31
- 4.4 Navigating design complexities in HRI . . . 32

4.5 Intepretation discussion on findings between the researcher and second coder 34

5 Discussion and Conclusion **36**
5.1 Discussion 36
5.1.1 Reflection and evaluation on writing-up 38
5.2 Limitations 39
5.3 Conclusion 39

References **41**

Appendices

A Interview questions **49**

B Codes and Categories **50**

List of acronyms

HRI Human-Robot Interaction

AI Artificial Intelligence

HMP Human-Robot Partnerships

AMS Automated Milking System

Reflexive TA Reflexive Thematic Analysis

SCA Shared Cooperative Activity

HMI Human Machine Interface

HRC Human-Robot Collaboration

GUI Graphical User Interface

POV Point of View

List of Figures

1.1 Structure of thesis 3

3.1 Snapshot of Atlas.ti 18
3.2 Snapshot Codes and Categories 19
3.3 Data analysis 20

4.1 Thematic map with four initial themes 23

List of Tables

3.1 Example key interview questions 16
4.1 Theme summary table 24
A.1 Interview questions 49

Chapter 1

Introduction

With robots being relatively new in the workplace, potential aspects beyond robot-worker interaction need to be considered. The idea of working side by side with robots is coming closer because emerging technologies like Artificial Intelligence (AI) and Robotics are being used in various industries and workplaces such as hospitals, farms, manufacturing sites, and education. [1]. Collaborative robots, also known as cobots, are devices designed for collaborative operation or the joint execution of activities by robots and humans in a shared workspace [2]. The collaborative aspect of such a system results from how the application and interface are created. A collaborative system typically consists of a robotic arm and a graphical user interface (GUI) [2]. Collaborative robots are utilized in the manufacturing industry for tasks like picking, packing, and palletizing items, primarily in dirty, dangerous, or dull jobs [3]. On the one hand, it is clear that robots make life easier for humans, and collaborative robots automate and speed up small tasks. But on the other hand, robots may have unexpected but far-reaching impacts on human workers. Previous research found that when humans work together with robots, social dynamics, and ethical tensions come into play, such as information deception, emotional impact on workers, privacy, security, liability, dehumanization, and unemployment [4] [5]. Ethical tensions arise when a decision, scenario, or activity goes against the moral standards of society, such as privacy and technology practices and health and safety in the workplace [6] and the role of social consequences, in this case, is that over the last few years, people have seen their employment replaced by automation procedures [7]. Significant research is needed to understand how these robots might participate in interactions that go beyond robot-worker relations and possibly have an impact on social and ethical facets.

Despite research efforts focusing on critical design methodologies and approaches such as HRI feminism, [8], there is still a lack of extensive studies into how HRI designers and researchers address their own positionality, reflexivity, and viewpoints when taking into account the social and ethical facets in robot design across a variety of workplace contexts. Therefore to achieve this goal, the researcher will conduct interviews with designers and researchers, focusing on their approach to designing interactions between robots and humans in the workplace and, ultimately, establish design guidelines to steer the future use of robots across diverse work environments.

1.1 Background

This thesis is aligned with the premise of a workshop called: “Human-Machine Partnerships in the Future of Work: Exploring the Role of Emerging Technologies in Future Workplaces” [9]. This workshop emphasizes how the definition of Human-Machine Partnerships (HMP) will influence the technologies that are created for the future of work. This workshop aims to create a taxonomy of HMP to assess and reconsider the theories, techniques, and epistemologies currently used in HMP research and expand the engagement with embodied Agents. There are four themes related to this workshop [9]: "Unpacking the Meaning of Partnerships between Humans and Machines", " Agency and Autonomy of Human and Embodied AI Agents", "Political and Ethical Implications of embodied AI Agent Design" and "Epistemological and Methodological Challenges in the Future of Work with Machines". This thesis addresses the first theme as it explores Human-Robot partnerships in various workplaces to understand design considerations for the future work of robots.

1.2 Thesis goals and Research questions

This section elaborates on the thesis' main goal and formulates the research questions. The focus is on the perspective of designers and their influence on these interactions. Thus the aim of this thesis becomes:

> ***To understand how designers and roboticists design the interaction between users and robots in the workplace and how they consider ethical and social facets in designing these robots.***

This aim is then formed into research questions. As robots have not been in workplaces for very long, it is important to investigate whether workers still feel they are performing well and fulfilling the same role as before. With changes to their routine, workers may experience increased stress, and designing interactions that support them and prevent feelings of stress, overwhelm, or exclusion is crucial. Therefore, the thesis will address the following research question which is exploratory:

> ***RQ: How can designers take into account relevant ethical and social facets while designing robots in the workplace?***

To answer this research question we will ask the following sub-research questions:

> ***Sub-RQ.1: What are the ethical and social dilemmas when designing robots for the workplace?***

Lastly, to help designers take care of blind spots and for the future work of the Human-Robot partnership in the workplace, the last sub-research question is :

> ***Sub-RQ.2: What are potential design guidelines that can be generated from the insights gathered from designers?***

Design guidelines are the operationalization of ideas to improve their use in design practice [10]. Together these questions address the aim of this thesis, to explore the obstacles faced by roboticists and designers while creating robots, as well as the ethical and social considerations taken into account during robot design.

1.3 Structure of the Thesis

This thesis is organized as follows in Figure 1.1: Chapter 1 provides an introduction to the overall thesis. Chapter 2 discusses the theoretical overview of robots in various workplaces, the definition of Human-Robot partnerships, and the ethical tensions of robots. Chapter 3 presents the research study, including the methods used to interview the designers and the qualitative analysis of interview data. Reflexive Thematic Analysis (Reflexive TA) was used to analyze the data, which offers theoretical flexibility and encourages critical reflection on the research process [11]. In the next paragraph, the author of this thesis provides a reflexivity and positionality statement. Chapter 4 presents the results, and Chapter 5 concludes with a discussion of the study's implications for theory and practice and its limitations.

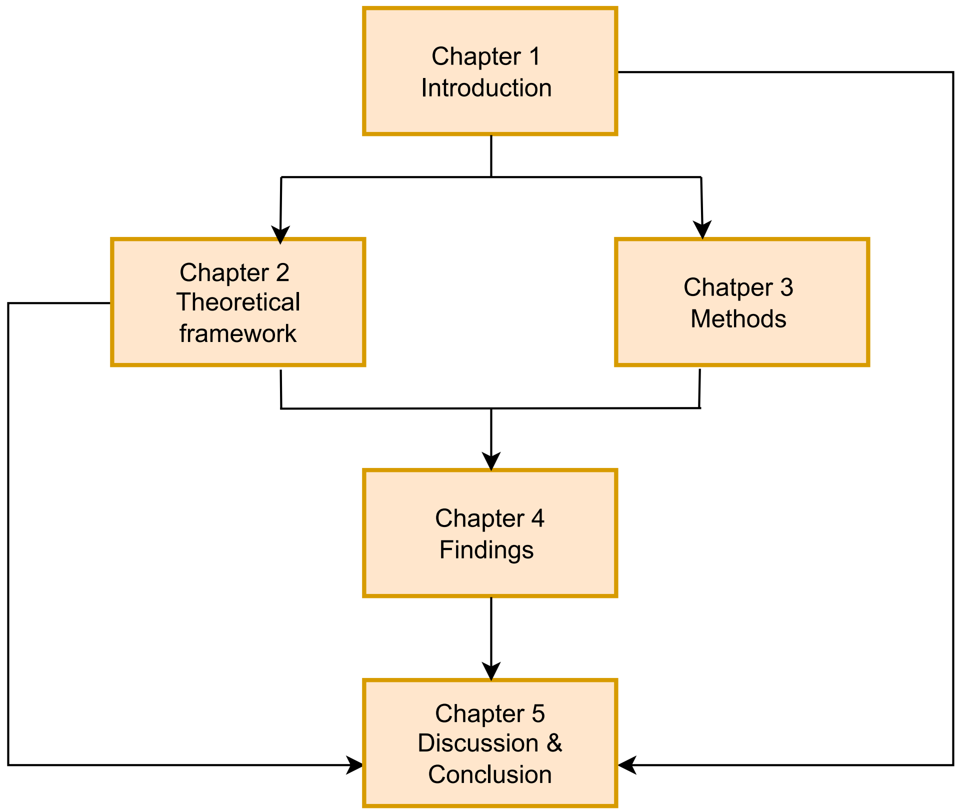

Figure 1.1: Structure of thesis

1.3.1 Reflexivity and Positionality Statement

Because reflexivity is emphasized in reflexive thematic analysis, the researcher's viewpoints, interpretations, and discoveries play an important role in defining the coding and thematic development. Therefore, it is critical to note the unavoidable bias of the author's viewpoint from which participants' data was approached and assessed: " I am a cisgender female from Suriname, a developing country in South America, who resides in a prosperous European country, specifically the Netherlands. I believe that HRI designers and researchers can shape and influence interactions between robots and workers; therefore, it is important that they address their positionality, reflexivity, and viewpoints when designing for HRI. They can aim to foresee the potential impact of technology in its usage context and design accordingly. Although I might have biases towards designers' perspectives due to my background in Human-Computer Interaction, I maintain a neutral and objective stance during participant interviews, asking critical questions and encouraging honest feedback."

Chapter 2

Theoretical framework

This chapter aims to explore the concept of humans partnering with robots in the workplace. The literature on how humans and machines interact will be analyzed, as well as the viewpoints of workers toward collaborative robots in various work settings. The attitudes of workers towards these robots and any ethical issues that may arise will also be explored. Additionally, the perspectives of designers on human-robot collaboration, the methods they use, and innovative, ethical approaches in HRI will be taken into account.

2.1 Human-Robot Partnerships

Humans invented machines to solve problems they could not solve on their own. From steam engines to combustion engines to computers to 3D goggles, humans continue to devise innovative and inventive solutions to complex engineering problems [12]. Not long ago, even if a machine was smart enough to pull down its levers, a human still had to make all of the decisions, such as when to turn it on, calibrate, or upgrade it. Machines were instruments, and humans could keep control over them [12]. However, nowadays, there is a growing trend of utilizing emerging technologies like artificial intelligence (AI) and Robotics in different workplaces such as hospitals, construction sites, and public areas [1]. Human-Robot Partnership entails humans and robots working closely together in several ways to improve the human experience. Humans and robots must be aware of each other's strengths and limits, negotiate and align intents, and support one another in these collaborations [13]. When appropriately constructed, human-robot partnerships can improve human reasoning, learning, decision-making, and problem-solving abilities, leading to growth and empowerment [13]. The human-machine relationship is no longer solely that of user and instrument, but rather of user and helper [12].

To further understand how humans and agents collaborate, this research will utilize Cila's framework for explaining human-agent collaborations [13]. Cila's work uses Bratman's Shared Cooperative Activity (SCA) framework [14] (on human-human collaboration) to pinpoint the essential elements of collaborations and explore the key concerns in developing collaborations between humans and agents [13]. However, in this research, the focus will be more on human-agent collaboration rather than human-human collaboration. Collaboration means that those who collaborate take shared intentional action together [15]. Joint action involves two or more individuals coordinating their actions in a specific location and time to make an impact on their surroundings [16]. According to Bratman [14], a Shared Cooperative Activity or collaboration occurs when the two parties' goals match, and their beliefs about interdependence and common knowledge appropriately coordinate a joint activity. Furthermore, Bratman identifies three characteristics central to collaboration: commitment to the joint activity, mutual responsiveness, and commitment to support [14]. Commitment to the joint activity means that each participant has a sufficient level of dedication to the joint work [14]. Here the participants must agree on how they will carry out the joint activity and who will take on each job as part of their commitment to the joint activity. The second characteristic, mutual responsiveness refers to each participant acknowledging and responding to the actions and intentions of the other, with the understanding that both parties seek to respond in a similar manner [14]. Moreover, the last characteristic, commitment to mutual support, means that each participant commits to assisting the other in fulfilling his or her role in the joint action [14]. Moreover, Cila [13] adapted these characteristics of Bratman to human-agent collaboration and discusses several collaboration features to achieve a successful partnership between humans and machines along with essential design considerations for future designers. Eleven design considerations were listed for these qualities: a code of conduct, task delegation, autonomy and control, intelligibility, common ground, agent providing help, and agent seeking help [13]. According to Cila [13], establishing a code of conduct and delegating tasks are essential steps in building the foundation for collaboration. In terms of the Code of conduct, individuals must be aware of the agent's intentions (or sub plans, in Bratman's language) and the expected behaviors that are based on the protocols embedded in its system. Additionally, individuals should be aware of the system's ability to respond to their intentions, actions, and values. As for task delegation, activities assigned to the agents should improve human skills rather than replace them; thus, identifying these jobs requires an awareness of the user's needs and the specific use context. Having this when committing to a joint activity with an agent is important because deciding who does what in human-agent collaboration raises new considerations for designers [13].

Another development in cooperative interaction between men and electronic computers is Man-Computer Symbiosis [17]. Licklider proposed the concept of symbiotic computing in 1960 [17]. He defines Man-Computer symbiosis as an expected development in cooperative interaction. The concept of a computer as a companion is becoming more popular in interaction design. During the industrial revolution, there was no aspect of human-robot symbiosis in this process: Humans confined robots to cages in order to ensure their safe functioning. The robots repeated operational sequences without any bidirectional contact, as human operators coded them once and for all. However, now Industry 4.0 allows robots to get out of their cages and interact safely with humans as collaboration robots or "cobots". Previously, researchers have linked qualities such as language comprehension, learning, reasoning, and problem-solving to both humans and intelligent computer systems [18]. During a cooperative task, symbiosis necessitates explicit/implicit communication channels and the ability to access and/or anticipate the partner's internal states and intentions [19].

Cooperative AI (Artificial Intelligence) is a subfield of AI that amplifies the relationship between humans and agents. The capabilities of AI are advancing quickly in various tasks that were once considered exclusive to humans, such as disease diagnosis, language translation, and customer service [20]. Nevertheless, an AI agent must first understand its surroundings and how to interact with them. [21] To integrate smoothly into society, AI needs social understanding and cooperative intelligence. Cooperative intelligence refers to a system's ability to work closely with people in various ways, with different levels of focus, to complete complex tasks in challenging environments successfully [22]. Sendhoff and Wersing [22] recommend broadening the term to include both the evolutionary perspective of "benefiting from each other" and the sociocultural perspective of "living in harmony". Cooperative intelligence is not just a skill that can be applied in any situation but rather a fundamental aspect of a system's nature that defines its relationships. Even when there are disagreements or competing interests, the ability to cooperate fosters actions that benefit all parties involved. Four elements of cooperative intelligence are [21]:

- Understanding: The capability to consider the repercussions of one's actions, to foresee another's behavior, and to consider the implications of another's ideas and preferences.
- Communication: The capacity to convey knowledge with others that are significant to understanding behavior, intentions, and preferences clearly and credibly.
- Commitment: When collaboration is required, the capacity to create trustworthy promises is required.
- Norms and institutions: Social infrastructure that fosters understanding, communication, and commitment, such as shared values or regulations.

Moreover, Wilson and Daugherty [20] did a study involving 1500 companies where they found that when humans and machines collaborate, companies experience the greatest gains in performance. Humans and AI actively increase each other's complementary qualities through cooperative intelligence: the former's leadership, teamwork, creativity, and social skills, and the latter's speed, scalability, and quantitative capabilities. According to Sendhoff and Wersing, there are some relevant concepts to successfully approach cooperative intelligence, such as Joint Goals, Shared Intentions, and HMI (human-machine interface) [22]. Creating a common ground of shared perceptions, attention, and intentions is a key challenge in human-machine interaction [23], permitting the negotiation and installation of joint goals [14]. For example, Gienger et al. [24] has developed a bimanual robot system for cooperative turning that employs haptic feedback to help humans and robots negotiate a successful, steady grip and turn sequence in real-time. Furthermore, the human-machine interface (HMI) makes communication between cooperative interaction partners possible. For the human interaction partner to anticipate and comprehend the activities of intelligent machines or robots, Norman [25] has stressed the need for consistent, intuitive, and expressive interfaces.

To understand how humans work alongside robots, one must first comprehend what a Human-Robot partnership entails. Researchers have focused on describing the relationship between humans and machines, with some examining the collaborative elements involved, such as the commitment from both parties. Others have looked at the qualities that humans and intelligent computer systems share, such as language comprehension, learning, reasoning, and problem-solving. Ultimately, researchers have found that establishing a successful partnership between humans and robots requires certain features and elements. To achieve this, one must have a system of good quality that can respond to humans' intentions, actions, and values. Furthermore, humans should use robots to improve their skills rather than having them replaced, and both parties need to communicate clearly to understand each other's intentions. Achieving this can be done by using consistent interfaces, giving verbal commands, making eye contact, and using gestures.

2.2 Understanding robots in various workplaces

Robots are very common nowadays and are used in various fields in today's world and they make some human tasks easier and simpler. The following are some of the key sectors where robots are used.

2.2.1 Robots in the manufacturing industry

In the past, companies only utilized industrial robots to automate a limited number of jobs, neglecting many small tasks that required automation. Robots provide a notable advantage in this regard. They can assist in automating and speeding up previously neglected small tasks that contribute to the overall processing speed of a process. Second, they offer to minimize or assist humans in completing "dirty, dangerous, or dull jobs", sometimes known as 3D jobs [26]. Manufacturing industries, particularly automobile manufacturing industries and assembly lines, use collaborative robots to perform various tasks, including picking, packaging, palletizing, welding, assembling goods, handling supplies, and product inspection [26]. Below are some of the most common collaborative robot applications in the manufacturing industry [26]:

- Picking, packing, and palletizing items
  Cobots commonly perform tasks such as picking and arranging objects, packaging items, and palletizing items related to the 3D occupations mentioned above.
- Welding
  The car manufacturing industry extensively uses cobots in welding, where they can work with great precision and speed on their own and assist human coworkers with welding as necessary. Other similar jobs such as machine maintenance and painting may also be available.
- Assembling items
  Cobots may also assist their human coworkers in assembling items. This improves part assembly efficiency and precision while assuring ergonomic safety and a human touch.
- Handling materials
  Collaborative robots can assist in creating a hazard-free work environment by handling hazardous raw materials that might be extremely dangerous or detrimental to human workers.
- Product inspection
  In comparison to their human counterparts, collaborative robots can accomplish this tedious work with excellent precision and without tiredness or boredom.

Collaborative robots offer many benefits to human workers as they assist in various tasks, accelerate processes, and reduce the need for workers to perform hazardous, tedious, or dirty jobs. The attitudes of factory workers toward collaborative robots are outlined in the following paragraph.

Attitudes of factory workers towards cobots

Many researchers have studied the social impact that cobots have on factory workers. The study of Sauppe et al. [27] of a collaborative industrial robot in manufacturing factories revealed that factory workers regarded their robot as a social entity and interacted with it, relying on nonverbal cues to understand its actions, which was critical for perceived safety; their study also revealed that operators who spent more time with the robot in the production line showed a higher level of anthropomorphism with metaphors like son, grandson, and team player than workers on the managerial team that rarely worked with the robot.

Human-robot collaboration design, as well as appropriate work allocation between humans and robots, are both linked to social-physiological concerns. According to Ogorodnikova [28], human aspects such as workload, vigilance, situation awareness, errors, and so on significantly impact human-centered robotic cell design. When a robot has a higher level of autonomy, it is often unfairly held responsible for negative results. This is especially true when robots work alongside human employees, as people may have misunderstandings and negative opinions about autonomous systems [29]. According to the "Attitudes towards the impact of digitalization and automation on daily life report", European citizens associate AI with negative feelings because they fear that robots with AI capabilities will take their jobs [30]. People tend to attach various sorts of human-like qualities and behavior to AI systems as a result of this prevalent misperception about AI among the general population [30].

In industrial settings, robot arms have limited communicative capabilities due to the high levels of noise, making verbal outputs ineffective. Research shows that text panels can enhance a robot's ability to communicate effectively, which can lead to numerous benefits, such as reducing stress and increasing positive emotions for human collaborators by providing robots with communication skills that make their actions more transparent to humans [31].

Elprama et al. [32] did a study on factory workers' perceptions of using Baxter as a collaborative robot and found that employees feared that robots would take their jobs. Despite their fears that robots would take their jobs, many admit that robots can reduce their (mental and physical) workload. A couple of employees claimed that robots reduced the amount of time they spent with their coworkers. Moreover, elderly workers stated that they could not assess the working speed on their own due to the employment of industrial robots at work (which was not an issue before the implementation of robots). Overall, this paragraph shows that using collaborative robots improves human worker health and safety, lower operating costs, speeds up production cycles, and reduces downtime. However, not all workers have a positive attitude towards working with cobots. As for elderly workers who have problems with keeping up the working speed of industrial robots, it implies that a collaborative robot's working tempo should be adjusted to match the workers' preferred working speed.

2.2.2 Robots in the agricultural industry

Currently, automated systems perform numerous agricultural procedures. Agriculture robots boost productivity while improving working conditions for farmers and workers [33]. Many types of robots are used in agriculture, for example, harvesting and picking, planting, monitoring, spraying, and pruning [33]. The ability of the autonomous robot to navigate is crucial for all of these procedures, and it is challenging to ensure that systems are reliable enough for long-term usage because agrarian fields are complex, unorganized, and unpredictable, in contrast to indoor settings [34]. Advancements are still needed before agricultural robots will be widely used, such as machine vision in crowded surroundings, autonomous navigation, dexterous handling, and battery technology [34]. In the livestock industry, automated milking systems are developing relatively independently and have been used for quite some time [35]. Automated milking systems (AMS) have replaced traditional milking parlors since the early 1990s in the Netherlands and other developed countries [36]. Modern-day farmers use these machines that do the milking automatically, without a farmer's direct involvement. Northwestern Europe (including Scandinavia, the Netherlands, Germany, France, and the UK) is where most of these machines are located, but they can also be found in North America, Australia, and New Zealand [36]. According to Stichting KOM ('Kwaliteitszorg Onderhoud Melkinstallaties'), in the Netherlands in 2010, 2252 milking robots were counted, and in 2020 this number increased to 4479. Therefore, the share of milking robots in the Netherlands has increased from approximately 12% to almost 29% in 10 years [37].

In AMS-equipped farms, individual cows choose when and how often to visit the milking robot and are mainly encouraged by a supply of concentrates supplied in the milking box during milking [36]. The system recognizes cows through sensors, and anomalies in the milk can be found. Operational data, milking reports (such as the daily average per cow, the amount of milk, and the time between milking), and milk quality characteristics are all stored in specialized software. Cows are detected and put on a so-called attention list if they exhibit strange behavior or do not visit the robot for a predetermined amount of time. The cows must be watched by the farmer, and in some installations, they may be placed in a fenced waiting area where they can only come out to see the robot. [36].

Experiences of farmers with AMS

Milking robots or AMS offer many advantages when used properly, such as increased health of cows, more straightforward health detection [38], less labor, and greater lifestyle flexibility for farmers [39]. Farmers must plan their time and their farms around the demands of the AMS and the ability to access, evaluate, and respond to the massive volumes of data the AMS can produce [40]. Tse et al. [38] did a study on AMS to determine how Canadian dairy farmers handled the transition to and use of AMS, with a particular emphasis on cow training experiences, transitional challenges, and quality of life effects [38]. He found that farms could increase herd size while maintaining the same cleaning and feeding procedures by making the appropriate improvements to housing to suit the AMS. Farmers had to adapt their health-management procedures with AMS, but most said health detection was simpler. After switching to AMS, several farmers reported an increase in conception rates, a decrease or no change in the prevalence of clinical disease, and no change in the culling rate [38].

Driessen and Heutinck [36] studied the ethical implications of adopting milking robots in the Dutch dairy farming industry. These robots have entailed significant changes in dairy farming, including how cows are milked and the relationships between farmers and cows. The adoption of these robots requires significant changes in farm management and can be stressful for farmers. It also changes how farmers see their role and professional identity, moving them away from manual labor and towards supervision and management. Milking robots may also have alienating effects, leading to the loss of meaningful practices and relationships between cows and farmers. Another reason for using these robots has been promoted as a way to save time and improve the social lives of farmers is by reducing the time spent on milking. However, the effects on the social lives of farmers are more complex and may involve increased flexibility but also the need to be on standby for 24 hours a day and manage cows at irregular hours [36].

Moreover, the robots had an impact on cows as well. For example, the system required the animals to adapt to new physical requirements, and sometimes the operators culled those that were unable to meet them or learn how to use it. Introducing a robot also changed the cows' relationships with their herd. They needed to unlearn some herd mentality and instead function as individuals deciding when to be milked. The cows' behavior also changed as they were no longer driven into the milking area by the farmer and became more relaxed and less agitated [36]. Thus, farmers and cows undergo a process of change when using milking robots. The milking robot has benefits for farmers and cows such as greater lifestyle flexibility and increased health of cows.

In contrast, other farmers went through a challenging time using these robots and experienced stress with their new role on the farm. Milking robots raise questions about ethical implications, such as whether they deskill the farmer or alienate them from the cows. The future of milking robots in dairy farms requires consideration of these aspects. The following paragraph introduces robots in healthcare.

2.2.3 Robots in the Healthcare Industry

The healthcare industry first adopted robotics through surgical robots, which are still the most widely used and accepted type of healthcare robot today. The first healthcare robot was a surgical robot, introduced in 1985 [41]. Nevertheless, there are other various types of robots used in healthcare, such as assistive therapeutic robots, including those used for nursing and companionship, surgery and rehabilitation, assisting the disabled and cognitively impaired, providing motivation, facilitating telemedicine, managing medication, and delivering meals [42]. These robots often work close to people and must recognize faces, gestures, speech, and objects to navigate their surroundings and communicate effectively based on emotions. Medical robots play a significant role in healthcare because they can accurately control medical equipment, improve safety, track patients' vital signs, and perform certain diagnostic tests. Robots designed for service can lighten the workload of healthcare personnel by taking care of routine tasks, freeing up their time to attend to more critical duties [43]. However, the increasing use of service robots can lead to less personal interaction between patients. Treating elderly patients raises ethical questions since they may feel dehumanized [43].

Barriers and ethical concerns of using robots in healthcare

Robots in healthcare have the potential to improve safety, quality, and efficiency in various applications. However, overcoming four significant barriers is necessary to realize these benefits [44]. One barrier to adopting robotics in healthcare is the need for more support and interest from professionals and patients. According to Cresswell et al., [44], [45], negative attitudes and concerns from the public, patients, and healthcare staff contribute to a lack of demand and acceptance for some robotic applications in healthcare settings. These attitudes seem to be influenced by fears about job loss and the negative portrayal of robotics in popular media [44], [45]. Another barrier to adopting robotics in healthcare is the unsettling appearance of some robots. The "uncanny valley" phenomenon, refers to the discomfort that people often feel when confronted with robots that look too much like humans [44], [45]. People may perceive these robots as threatening "ghostly human counterparts", which can lead to mistrust and suspicion. In addition, some robots may need to meet human expectations, which can lead to them not being used effectively. The third barrier to adopting robotics in healthcare is the integration of robots into existing healthcare work practices. There may be difficulties in reconciling the tensions in the healthcare industry between standardization through automation and the unpredictable nature of healthcare work. Robots designed to work in specific settings with only a few humans around them are perceived as more straightforward to implement than those designed to operate in crowded environments with many humans [44]. The final barrier to adopting robotics in healthcare is the emergence of new ethical and legal challenges. There is a need for a responsible or ethical framework as well as the challenge of laws keeping up with the swift progress of technology in this domain [44].

While there are several advantages of utilizing various systems and devices, such as the outcomes they yield, they have also introduced new ethical and social challenges and conflicts within the legal system. These challenges include impacts on privacy, human dignity, and autonomy, as well as the potential for human augmentation and technical dependencies that could hinder learning (e.g., medicine without doctors). Dr. Chatila [45] emphasized the importance of ethics and values in regulating the use of these technologies. He pointed out that AI-based systems present ethical problems that cannot be adequately addressed by the existing ethical framework within the field of medical care rooted in the values of doing good, avoiding harm, preserving human agency, and being fair [45]. Additional ethical issues for AI-based systems that handle data should be aligned with certain values and principles to achieve technical dependability. These values include transparency, accountability, explicability, auditability, traceability, and neutrality or fairness [45]. AI systems must exhibit transparency and reliability by disclosing the decision-making process involved in their design [45]. Accountability, involving liability and responsibility, is also important and should involve humans in the chain of command for any output produced by an AI-based system, with humans ultimately being responsible for AI-based decisions. When creating and developing autonomous systems, it is important to keep track of the decision-making process and communicate it clearly to users so that they can understand how the decisions affecting them are being made. Lastly, it is imperative that AI systems operate with neutrality and fairness to prevent any biased factors from influencing their outcomes [45]. From this paragraph, it became clear that although medical robots ease the workload of healthcare staff, researchers found some barriers and ethical tensions in this field. Therefore, we need to look into how the designers of these robots implement ethical considerations and how to bridge the barriers.

2.3 Understanding the designers' POV in Human-Robot collaboration

This section discusses the designers' point of view regarding design guidelines, collaboration, and how designers work. Understanding the designers' point of view is vital for gaining insights into the design process, which helps identify the factors that influence design choices and the potential impact on ethical and social considerations. Because designs can have unforeseen consequences and far-reaching effects on users [32], [36], car safety features can result in more reckless driving. However, by taking this into account at the early design stage, designers can help to make some of the consequences foreseen and have shown their ability to predict and consider these changes in human behavior during the design process [46].

2.3.1 What methods do designers use?

As robot technology advances and robots become more common daily, their design becomes increasingly relevant. In order to cater to human needs, overcome technical obstacles and encourage acceptance in everyday contexts, designers must take a comprehensive approach to designing and developing robots. Design plays a crucial role in this endeavor as it involves understanding the current state and envisioning an improved future state [47]. The design community has come up with various ways of creating captivating objects and has even branched out into sub-fields like interaction and product design, which are useful for human-robot interaction. Designers have the chance to improve the attraction and practicality of robotic products beyond their technical abilities [47].

The majority of design-focused HRI projects typically follow the traditional knowledge-generation methodology used by the HRI community, which includes steps like (i) defining a problem or question, (ii) creating an artifact or interaction, (iii) running tests, (iv) analyzing the results, and (v) iterating from step (i) until desired results are attained [10], [48]. Moreover, in HRI, it is a typical practice to use design methods and tools [10]. For example, designers employ human-centered design methods to understand users and their contexts. These methods include interviews [49], questionnaires [50], personas [51], focus groups [52], and observations [52]. Another example is that of using co-design approaches [53]. Especially in technical projects, a high-tech product, system, or service can actively interact with the consumers for which it is intended, making them a vital practice. It is crucial for researchers to comprehend the possible consequences of robots on individuals, situations, and the community. Therefore, they have implemented critical design methods such as Futuristic Autobiographies [50]. This technique extracts values and viewpoints from users, designers, and researchers to guide the design procedure. Another method still being used in HRI is the Wizard of Oz technique for evaluating new robot designs and exploring human perceptions of potential robotic qualities and behaviors [54], [55].

2.3.2 New ethical integrative approaches in HRI

As the field of HRI advances, concerns about robot technologies' effect on society are growing. It is important to use ethical approaches to reduce the negative impact of autonomous systems and address public fears, which is also a more widely accepted narrative in academic, regulatory, and corporate contexts [56]. Building robots sustainably and resiliently is crucial, and ethical approaches provide possibilities to establish and reaffirm this notion. Additionally, highlighting the crucial ethical issues that are essential for democratic and open societies, such as human rights, inclusivity, and participation. One approach is by using the Feminist approach in HRI. According to Katie Winkle et al., [8] feminist theory holds a greater relevance in HRI because roboticists frequently engage with embodied technology and actively construct or design robotic bodies and identities. The term feminism refers to an approach to designing and developing robots and human-robot interactions that consider power structures. It involves awareness of the intersections and interactions between various power structures relating to gender, racism, class, ability, sexuality, religion, and more.

According to Katie Winkle et al., [8], adopting a feminist perspective can aid in the analysis and shaping of research on robots and human-robot interaction. Moreover, a feminist approach guides researchers on how research is carried out and urges researchers to take responsibility for their own positionality, privilege, and point of view. Integrating feminist theories and practices in HRI can address power imbalances, promote social justice, and foster more ethical and inclusive human-robot interactions. Researchers should critically analyze their work, question prevailing standards, and actively work towards establishing a fair and socially conscious field of HRI [8].

As reflection is proposed as a crucial component in the design process [57], it involves analyzing and evaluating the interactions and experiences with robots to gain insights and make improvements. In the work of Pelikan et al., [57] the authors argue that reflection can occur at various stages, including during the design phase, after user testing, and through ongoing evaluations. By reflecting on the successes and challenges encountered during the design process, designers can refine their approaches and iterate on their designs to create better HRI experiences. Moreover, Pelikan et al., [57] also highlight the importance of involving end-users in the design process and incorporating their feedback and perspectives.

That is why it is important not only for researchers and designers to reflect critically but also for users and stakeholders. Understanding how these technologies work and their consequences have become difficult as people are exposed to more complex technologies in their daily lives. Therefore, promoting critical thinking skills is essential [58], [59]. Critical thinking is a methodical approach to actively and skillfully conceptualizing, analyzing, and evaluating information. It highlights the value of critical thinking as a cognitive ability that enables people to generate logical conclusions, work through issues, and come to informed decisions [58]. Different contexts can benefit from applying critical thinking, including education. In order to foster a society with better critical thinking skills, educators must begin by teaching individuals from a young age. Critical thinking is essential for active learning, intellectual growth, and acquiring higher-order thinking skills [58]. Previous studies have explored how to design robots that promote critical thinking in educational settings [60]. Further research in this field can help individuals better understand how to develop critical thinking abilities in students and ultimately lead to a society that values critical thinking.

HRI designers often utilize human-centered design methods, participatory design, critical design methodologies, and specific techniques tailored for HRI to gain insights into users, contexts, and societal impacts. Ethical approaches are crucial for reducing the negative impact of autonomous systems and addressing public fears. One approach is the Feminist approach, which considers power structures and their intersections in robotics and human-robot interactions. Reflection is another crucial component in the design process, involving end-users and fostering critical thinking skills. Education can help develop critical thinking abilities in students, leading to a more critical-thinking society.

2.3.3 Design guidelines for Human-robot collaboration

Previous work from [13], [61] discusses AI-related design guidelines and different considerations for designing agents. In order to work together effectively, the operator and the (collaborative) robot must have a mutual understanding of capabilities and decide how to divide responsibilities accordingly. According to Cila [13], key factors impact the success of the collaborations, such as the agent's communication style, the user's level of control over the agent's behavior, and the level of feedback provided by the agent. Therefore she proposes specific design recommendations for agents, such as providing clear and consistent feedback, adapting to user preferences over time, and allowing users to set goals and track progress. Amershi et al. [61] focuses on interactions with AI specifically and proposes guidelines for designing transparent, fair, and accountable systems. These guidelines include clearly explaining how the system works, being transparent about any biases or limitations in the data, and ensuring that the system is designed to serve the user's needs rather than perpetuating existing power imbalances. The work of Cila and Amershi et al., [13], [61], demonstrates that effective human-agent collaborations require technical and interpersonal design considerations. Technical considerations include providing clear feedback, adapting to user preferences over time, and allowing users to set goals and track progress. Interpersonal considerations include building trust and rapport with the user, communicating clearly and appropriately, and giving users control over the agent's behavior. Overall, the combined design guidelines emphasize the importance of designing human-agent collaborations that are responsive, supportive, transparent, and accountable, with a focus on building trust and rapport between the user and the agent. By following these guidelines, designers can create more effective, user-friendly, and trustworthy systems.

2.3.4 Social and ethical dilemmas in designing Human-robot collaboration

Designing robots involves many social and ethical dilemmas because while robots help to solve problems and simplify life, concerns have arisen about their impact on society. The safety of a product is usually the top priority when it comes to most technologies, and robotics is not an exception [62]. Concerns about privacy with robots must also be taken into account. Robots rely on gathering and analyzing large amounts of data to operate effectively. This can involve collecting information about customers' preferences or using facial recognition to personalize their experience. In order for robots to interact intelligently with people, they need access to certain data. However, this also means they are subject to laws and regulations regarding data privacy [63].

Another major concern is job displacement. This means that robots could potentially improve working conditions and human productivity by taking on mundane tasks [64]. However, certain human skills such as empathy, communication, creativity, and flexibility are still important and give people a competitive edge over robots [65]. Trust is crucial to any social relationship, including the relationship between people and technology. As people become increasingly reliant on technology, trust has become a vital issue in the development of new technologies [66]. As we have discussed a few ethical and social dilemmas, the work of Etemad-Sajadi et al. [62] explores the ethical issues raised by human-robot interaction and how they can impact the user's intention to use the robot. The study identifies five ethical considerations: privacy and data protection, trust and safety, responsibility, social cues, and autonomy. The paper argues that companies using service robots must address these ethical issues to ensure the user's intention to use the robot. Moreover, they recommend addressing crucial ethical considerations such as designing robots with human-like social cues, ensuring the robot's safety and trustworthiness, regulating the robot's autonomy, defining the robot's responsibility for its actions, and protecting the user's privacy and data. Etemad-Sajadi et al. [62] highlight that companies must proactively address these ethical considerations to build trust and ensure that users are willing to use the robot.

2.4 Summary

This chapter discussed the theoretical framework of Human-Robot partnerships in various workplaces and the designers' points of view on human-robot collaboration. The users' perception of robots in different workplaces and industries was first examined (Section 2.2.1, 2.2.2, and 2.2.3). The literature review shows that various industries use robots and that users have different experiences with them across industries. In the manufacturing sector, workers interact with cobots through nonverbal cues and perceive them as social entities. Nevertheless, employees may negatively view cobots with greater autonomy and hold them responsible for unfavorable outcomes. Dairy farmers consider milking robots to be beneficial for cow health, as they allow for easier health detection, reduce labor, and provide more flexibility. However, their use necessitates adjustments to farming practices and may raise ethical concerns. In the healthcare industry, robots have the potential to enhance safety, quality, and efficiency. However, future researchers still need to address some obstacles in order to fully achieve these advantages. Collaborating with robots may trigger ethical tensions despite their advantages across various industries. Then, the focus was on the designers' perspective on Human-Robot collaboration, the methods designers use, and the ethical and social dilemmas(section 2.3) they deal with. Understanding how ethical and social aspects are addressed requires comprehending the designer's perspective. Prioritizing such considerations during the design phase can help alleviate such issues and lead to more effective human-robot partnerships in the workplace. Additionally, new ethical approaches, such as the feminist approach in HRI, were discussed. The literature reveals that HRI designers use several methodologies, including human-centered design, participatory design, and critical design, to understand users, contexts, and societal effects. Literature indicates that design guidelines for effective human-robot collaboration incorporate technical and interpersonal considerations. Technical considerations include providing clear feedback, adapting to user preferences, and enabling users to set goals and track progress. Interpersonal considerations involve establishing trust and rapport with the user, communicating clearly and appropriately, and giving users some control over the agent's behavior. However, the design of robots poses social and ethical dilemmas that require consideration, such as protecting privacy and data, ensuring trust and safety, acknowledging responsibility, recognizing social cues, and promoting autonomy. Designers must take a proactive approach to address these ethical considerations to establish trust and ensure that users are willing to use the robot. The following chapter explains the methodology for collecting insights from designers working with robots in various workplaces.

Chapter 3

Method

The aim of this study was to understand how designers and roboticists design the interaction between users and robots in the workplace and how they consider ethical and social facets in designing these robots. The researcher utilized Reflexive Thematic Analysis (Reflexive TA) as a qualitative research method to gain insight into the subjective experiences, meanings, and viewpoints of the participants. The researcher obtained in-depth perspectives through the use of semi-structured interviews. The study's methods, participants, and data analysis techniques will be explained in the following paragraphs.

3.1 Method description

Reflexive TA is a method of analyzing qualitative data to answer broad or specific research questions concerning people's experiences, perspectives, and representations of a given phenomenon. It is theoretically flexible, and the reflexive nature of the analysis involves a critical and self-reflective review of the researcher's role and involvement in the research process. This type of analysis recognizes that the researcher's perspectives, biases, and assumptions can influence the interpretation of qualitative data [11]. During the reflexive analysis, the researcher of this study actively engaged in reflexivity by constantly questioning her position, assumptions, and preconceptions. The researcher kept a reflexive journal, documenting her thoughts, reflections, and self-awareness throughout the research process to achieve a reflexive analysis. Chapter 3.3.1 contains further details on this topic. The researcher needed to utilize a fully qualitative research method for several reasons:

1. This study explored a complex phenomenon (ethical and social facets in design). Therefore, a nuanced approach was needed to understand the participants' perspectives

2. The sample size was small, and the participants came from different domains within the HRI community, so it would have been challenging to compare the different domains of the participants' expertise by using positivist measures

3. The study focused on designers' perspectives, which are subjective by nature

Thus, the researcher chose the Reflexive TA method as the most appropriate approach to achieve the specific goals of this research.

Designers and researchers in the Netherlands were interviewed in a semi-structured format to gather data on how they incorporate ethical and social aspects into their work. A semi-structured interview is a conversational exchange in which the interviewer asks a series of prepared questions.

It also allows the participant to discuss additional issues they feel are important. The interview questions were structured using an interview guide to ensure a systematic and well-prepared approach to the interviews. First, the researcher identified the study's objectives and selected semi-structured interviews as the interview type. Then the researcher developed the interview questions by aligning each question with a specific goal, aiming to gather insights into how designers and roboticists design workplace interactions between users and robots while considering ethical and social aspects. Afterward, the researcher asked warm-up or icebreaker questions to establish a comfortable environment for the participants. Then, she used key questions to delve into the ethical and social considerations of robots, the presence of robots in different workplaces, attitudes, and perceptions towards robots, challenges faced by designers, and the overall design process. These main areas guided the formulation of predominantly open-ended interview questions. Table 3.1 shows an example of the key interview questions. Appendix A shows the complete set of interview questions. An example of which questions belong to which main area are questions 1,2,3 and 4, which are related to the design process. In contrast, questions 7 to 14 relate to the ethical and social considerations of robots. For example, question 10 aimed to understand how designers determine the extent to which robots replace human workers in their designs. Human-worker replacement refers to a situation where robots or automated systems take over tasks or roles that human workers carry out. Robots can process a lot of data, operate quickly, and tend to be more precise. Thus, they may replace jobs. On the other hand, they can work well with humans to complete unpleasant or menial activities or increase human workers' productivity and efficiency [67]. This question helped researchers understand how designers and researchers evaluate the potential impact on human workers and make decisions regarding tasks or roles that can be automated. Question 13, on the other hand, focused on the techniques used to ensure that the interactions between robots and human workers are positive and beneficial. The question emphasized the significance of creating a harmonious and productive human-robot interaction environment to prevent any unfavorable outcomes or conflicts arising from the interactions. This question led participants to think about aspects like user experience, user-centered design, and the incorporation of ethical issues into robot designs. Additionally, the researcher included a summary question to capture the designers' broader perspectives on future robot-related work, followed by wrap-up questions to bring the discussions to a close (see Appendix A). To ensure the quality and effectiveness of the questions, the researcher sought feedback by testing them with peers, the project supervisor, and a professor specializing in the social implications of intelligent technologies in the workplace.

1. Who do you design robots for? And how do you do that?
2. What are the important factors you look for when designing robots?
3. What did you hope to achieve with the robot design?
4. What specific methods do you use to design interactions between robots and workers in the workplace?
5. What types of challenges do you face when designing robots?
6. How do you make sure that your design matches what users need/ expect?
7. During the design, are there any ethical considerations you're taking into account?
8. How do you address ethical considerations when designing robots for the workplace?
9. What measures do you take to ensure robots are designed with user privacy?
10. How do you determine human worker replacement in your design?
11. Are there any other ethical considerations/ facets that you deal with during the design of robots?
12. What social considerations do you take into account when developing robots?
13. How do you establish the robots that you design to have positive interactions with human workers and avoid negative outcomes?
14. Are there any other social considerations/ facets that you deal with during the design of robots?
15. What impact do you think robots will have on society in the future?

Table 3.1: Example key interview questions

The next paragraph will describe information about the participants and the interview protocol.

3.2 Participants and (ethical) Protocol

The researcher recruited 9 participants for the interviews. The participants' profession included their expertise in designing and working on robots or Human-Robot Interaction in several domains, ranging from Child-robots, Logistic robots, Social robots, agriculture robots, and Teleoperated robots. The supervisors of this project selected the interview participants who are researchers, designers, and roboticists working at different universities across the Netherlands. Before contacting participants, the researcher had to follow a research procedure and risk protocol.

The ethical committee of the University of Twente approved this study. The study's protocol and conflict elicitation was developed in collaboration with the supervisors of this project and the ethical committee of the University of Twente and aimed to ensure the emotional well-being of the participants involved. First, it was important to indicate that this research followed the rules for processing personal data, including acquiring explicit consent for processing Personal Identifying Information (PII) and including a possibly necessary GDPR registration. Second, the researcher had to indicate that this research was with Human Participants and who the research population was going to be, the number of participants, and the inclusion and recruitment of participants. Third, there were questions about the research procedure and risks. Next, the researcher had to indicate that the study employs interviewing participants, both online and face-to-face. Participants were expected to spend a maximum of 60 minutes or less exploring their responses during semi-structured interviews, which took place at the university and online.

Participants were then provided with relevant study information and asked to read and sign an informed consent form at the beginning of the interview. Furthermore, the interviews were recorded using Microsoft Teams for online interviews and Audacity for the physical interviews. The recordings were transcribed using ATLAS.ti, as shown in Table 3.1. The research measures are qualitative, focusing on ethical issues and societal challenges during the design of robots. The researcher provided the participants with a detailed information brochure and informed consent form, thoroughly explaining the research goals, activities, potential difficulties, and risks. The participants were informed that they can withdraw from the research at any time without explanation. No deception is involved, and a debriefing statement was provided at the end of the interview, allowing participants to receive the researcher's thesis and ask further questions if desired. To avoid the information provided during the interview is not recognized in any way nor can be traced back to the participants, one week after the interviews, the participants were allowed to review parts of the transcripts or rewrite if they thought they wanted to change something (self-censorship). They were also informed that future designers would use the information to create effective collaborations with robots. And that they could reach out to the researcher or supervisors if they had any further questions or wanted to learn more about the study's results.

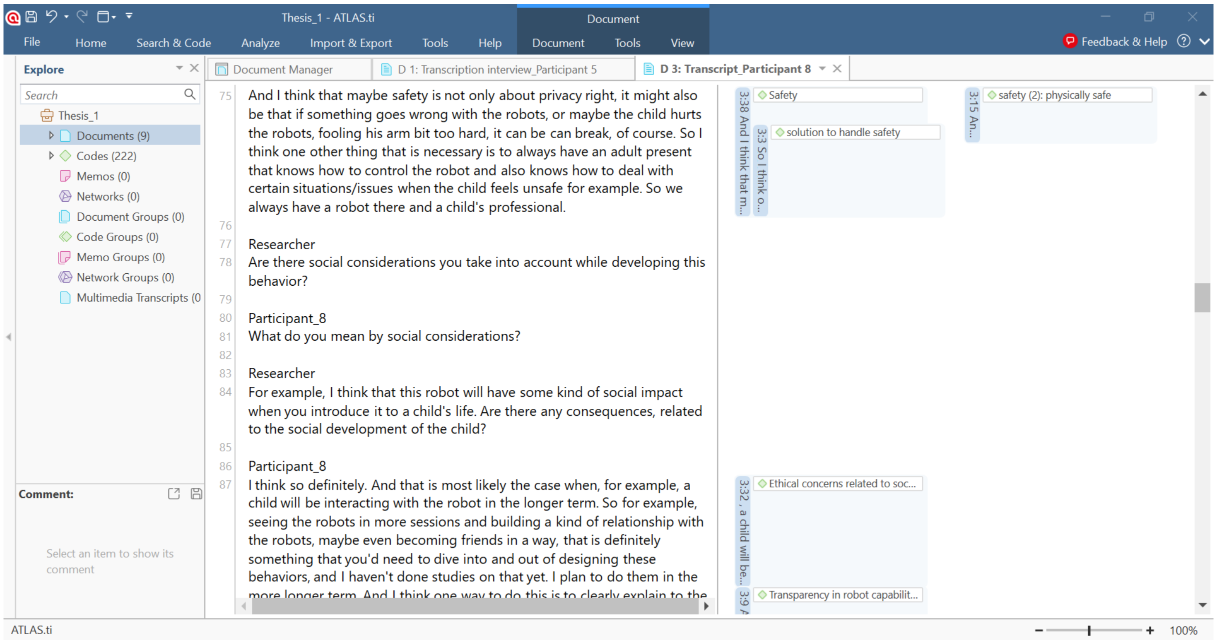

Figure 3.1: Snapshot of Atlas.ti

3.3 Data analysis

There are 6 phases of Reflexive TA used for this research [68]. In order to begin the analysis, the initial step involved getting acquainted with the data through activities such as reading transcripts, listening to audio recordings of the interviews, and taking notes. The researcher primarily utilized digital copies of the data while alternating between various physical settings, such as the university library, the researcher's own desk, the researcher's family residence, and outdoor locations like the park. And with excitement, the researcher entered the familiarisation phase, which constitutes the first phase of the analysis. Moreover, the researcher was aware that these shifting environments influenced her mood and thus the analytical perception and interpretative reactions to the data. The analysis approach combined inductive/deductive, latent/semantic, and critical realist. In the inductive approach, the research theme is continuously established and revised depending on new data, whereas in the deductive approach, codes are formed from the researchers' hypotheses or pre-existing theories [11]. Semantic coding entails identifying and coding clear, surface-level content in data. It focuses on capturing the data's explicit meanings, ideas, and concepts. In contrast, latent coding seeks to find deeper underlying patterns, themes, or concepts in the data. It entails searching for and categorizing latent, underlying meanings, assumptions, or ideas that are not directly expressed in the data [11].

Based on the theoretical framework discussed in section 2, the researcher made certain assumptions about the participants' perspectives and formulated relevant interview questions about the topic. Through reading the transcripts and incorporating critical realism into the sense-making process, the researcher remained open to the possibility of the data challenging those assumptions. Upon entering the more systematic second phase of analysis, involving coding, it became apparent that both semantic and latent coding was necessary to gain insights into the perspectives of the designers and their integration of ethical and social aspects. Figure 3.2 demonstrates a snapshot of some of the codes with categories that emerged from this process. The complete list is found in Appendix B.

Initial Category	Initial Codes	Description	Interview transcript
Requirements for inclusive design	- Child-appropriate dialogues - Not endorsing stereotypes - Adaptability - Flexibility - Accessibility - Inclusivity - Inclusion - Trust - Interpretation and subjectivity - Need for reflection - Need for regulation - Need for critical awareness - Need for more inter- and transdisciplinaryaryarity - Involvement of stakeholders	These codes refer to recommendations, ensuring that the design (end-product) is accessible and usable for a wide range of individuals regardless of their abilities, backgrounds, or circumstances. These guidelines include accessibility, adaptability, flexibility, and the avoidance of stereotypes to create welcoming, accommodating, and empowering designs for all users.	-" We need to give this freedom to the farmers that they are not afraid of the system, they know how to manage it, they understand all of the safety and security concerns, and that system is capable of autonomously doing some sort of task. But in the end, after that, all the data collected and processed by the system should also be displayed to that person in a way that that person with very limited skills, and technical skills is also able to interpret that data." - "And what I learned by working a lot around this topic is to try to avoid stereotyping when your gender. And since everything is gendered around us, even this the slightest queue enables you to gender so you don't really need to put a pink ribbon on a robot which people have done in the past to make it perceived."
Ethical concerns	- Deception - Human behavior - Informed consent - Being biased - Manipulation by hackers - Commercialization and misuse - Overreliance	Ethical concerns involve the evaluation of values, beliefs, and norms to ensure that behaviors are consistent with what is right, just, and fair.	-"It's actually very difficult. So i necessary for relationship formation. And if the children feel a connection, they feel safer around the robot, they also are more interested to keep interacting with the robot longer, which increases the effectiveness of interventions. So this is the reason why we do it. But on the other hand, we're also kind of slightly deceiving the children on a social level." -" So the wizarding that we do, can be seen as unethical. In a sense that we basically lie to the

Figure 3.2: Snapshot Codes and Categories

Furthermore, the researcher carried out the data coding process in three iterative rounds. Each round involved the application of the data, followed by the integration of codes into categories, then themes, and finally, returning to the data to validate and refine themes. Figure 3.3 shows a step-by-step schema of the data analysis. For coding the data, the ATLAS.ti software was used. The coding process is demonstrated in figure 3.1 as an example. Semantic coding was initially performed during the first round to understand the data comprehensively. In the second round, the researcher applied latent coding, focusing on interpreting the data, verifying new codes, and renaming and aggregating codes by similarity. By the third iteration, the codes were representative enough, and the researcher proceeded to phase three, identifying key patterns in the data by grouping codes into categories to generate initial themes. In phase four, the themes were developed and reviewed. Subsequently, the themes were refined in phase five to ensure they accurately represented the coded data and were named and defined for clarity. During phase six, the researcher fully developed the themes and started writing the analysis of these themes in relation to the research questions.

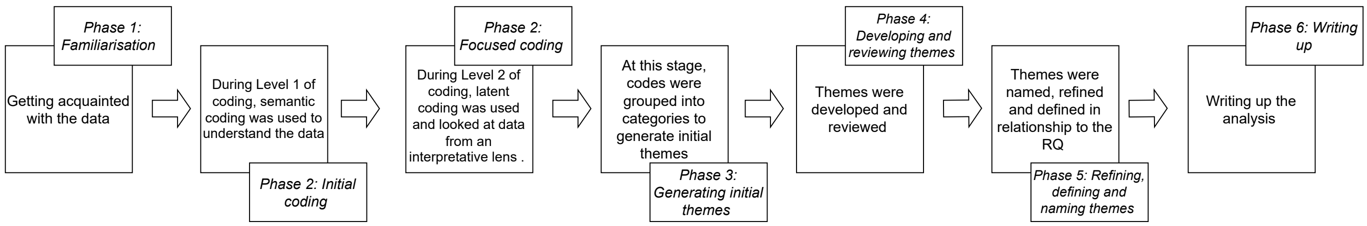

Figure 3.3: Data analysis

3.3.1 Reliability and Rigor

Coding reliability is a measure of the extent of agreement between different coders [69]. After several researchers have independently coded the data, the degree of agreement among the coders will be determined using statistical tests such as Cohen's kappa. Such assessments of inter-coder agreement determine whether coders applied the same codes to the same data segments, and therefore it can be considered reliable. However, in Reflexive TA, the consistency and stability of the analytical process and outputs are referred to as reliability [70]. It refers to how well the analysis performs when applied to the same data by various analysts or at different times. Reflexive TA advises against pursuing "accurate" or "reliable" coding or using particular methods(statistical tests) to find consensus among multiple coders because coding reliability may often result in shallow and insufficiently developed themes [71]. Instead, Reflexive TA emphasizes the researcher's reflective and thoughtful interaction with the data and the analytical process itself [70]. According to Braun and Clarke, it is important to understand that qualitative analysis, as a whole, does not seek to offer a single, "correct" solution [72]. And having many coders can be beneficial when reflecting, such as validating concepts or investigating various interpretations of the data. For this study, we invited another researcher (second coder) to achieve richer interpretations of the meaning of the themes actively generated. Thus, the researcher coded ten percent of the data with the codes used for the coding process and looked at the already generated themes. After that, there was a discussion between the researcher of this project and the second coder. Section 4.5 provides a detailed analysis of the discussion held between them.

To achieve rigor in this project, the researcher made sure to have a transparent approach, clearly defined the research questions, and critically reflected on biases and assumptions throughout the analysis process. The researcher maintained a reflexive journal to facilitate this. First, the researcher engaged in personal reflexivity and considered her social privilege and how her personal background and life experiences influenced the research approach. For example, the researcher was born in a developing country in a middle-class family, is female, and is an international student in the Netherlands who is religious and politically left. Some other questions that the researcher asked herself were: (1) What assumptions do I have about this study? (2) How might participants perceive me, and (3) Where and how do you occupy positions of privilege and marginality to this study and to the participants? For instance, it was assumed by the researcher that the study would align with what has been described in the literature (section 2) regarding ethical and social obstacles. Furthermore, the researcher reflected after each interview and wrote in the journal what she could have done better, and how she could have asked questions differently. For example, some quotes from the journal are: "Realizing how designers go through the design process while taking into account many facets and being grateful to participants for being open towards me and admiring that someone would be able to say what they could do better in the future, regarding their job and also that the interview was working kind of reflective for them." The researcher also reflected on the coding process and writing the results. Some quotes from the journal are: "There was also a time when I felt overwhelmed because of the many codes, and also critically thinking about which code is actually related to my research question. There is a reason why I did descriptive coding first, to make sure that I captured what the participants were saying before I gave it my own interpretation." The next chapter presents the findings of this study, discussing the themes and sub-themes that emerged from the data analysis, as well as offering insights and interpretations based on these findings.

Chapter 4

Findings

This section presents the main findings. The analysis results are shown visually in Figure 4.1, and a summary of the themes is given in Table 4.1. The interview data yielded four themes and three sub-themes after analyzing the process. These themes include: (1) Exploring moral dilemmas in HRI with sub-theme of (1a) Privacy concerns and risks, (2) Technological transformations and social change with a sub-theme of (2a) Revolutionizing HRI, (3) Requirements of a holistic approach with a sub-theme (3a) Empowering collaboration in design and (4) Navigating design complexities in HRI.

The topic of "Exploring moral dilemmas" focuses on the ethical obstacles designers encounter while creating their designs. With the emergence of Human-Robot Interaction, which explores the interaction, teamwork, and overall relationship between humans and robots, ethical concerns have arisen regarding their integration into different parts of society, such as healthcare, caregiving, education, and entertainment [1]. These ethical dilemmas revolve around the impact on human dignity, privacy, autonomy, and responsibility.

Comparatively, "Technological Transformations and Social Change" focuses on the transformation of using robots, its impact on society, and how this changes society. Integrating robots into various domains can lead to societal changes, including shifts in employment patterns or altered social interactions [7], [62]. These two themes are closely related to each other as they both revolve around the impact of technology on society and the ethical considerations that arise from it. Including how societal values and norms are reflected in the design and use of robots.

The theme "Navigating design complexities" encompasses the many diverse elements required in robot creation. It focuses on the problems and obstacles designers and researchers face and emphasizes the significance of overcoming several hurdles. This theme relates to the themes of "Technological transformations and social change" and "Exploring moral dilemmas in HRI" as they address the challenges and considerations that arise in designing technology and systems within these broader themes. Navigating design complexities becomes crucial in the context of "Technological transformations and social change" because technological transformations can significantly affect various aspects of society [73]. Designers must anticipate and address potential societal impacts, both positive and negative, to develop technologies that align with social values, norms, and needs. Similarly, when dealing with design complexities, it is important to consider ethical problems that arise during the development of robots. This is especially relevant within the context of "Exploring moral dilemmas in HRI". Designers and researchers must carefully consider how their design decisions could affect human privacy and well-being. This theme highlights the need for designers to consider the partnership between technology and society by considering ethical dilemmas and social concerns.

Future designers and researchers can develop technology that aligns with social values and encourages ethical considerations by addressing design complexities. That is where the theme "Requirements of a holistic approach" comes in. This theme is developed to give recommendations and requirements for designers and researchers to make sure that the design (final result) is useable and accessible for a variety of people regardless of their backgrounds, abilities, or circumstances. In this study, a holistic approach means considering a wide range of factors and stakeholders that go beyond the technical aspects of design. Therefore, this theme relates to the other themes as they all share a focus on thoughtful and thorough design. Designers must consider the broader implications and effects, including social and ethical considerations in their design decisions, consistent with the holistic approach. The following paragraphs will unpack each of the four themes in subsections and the sub-themes in sub-subsections. The notation "P" and the participants' number indicate the included quotes from the participants. For instance, Participant 1 is represented by "P1".

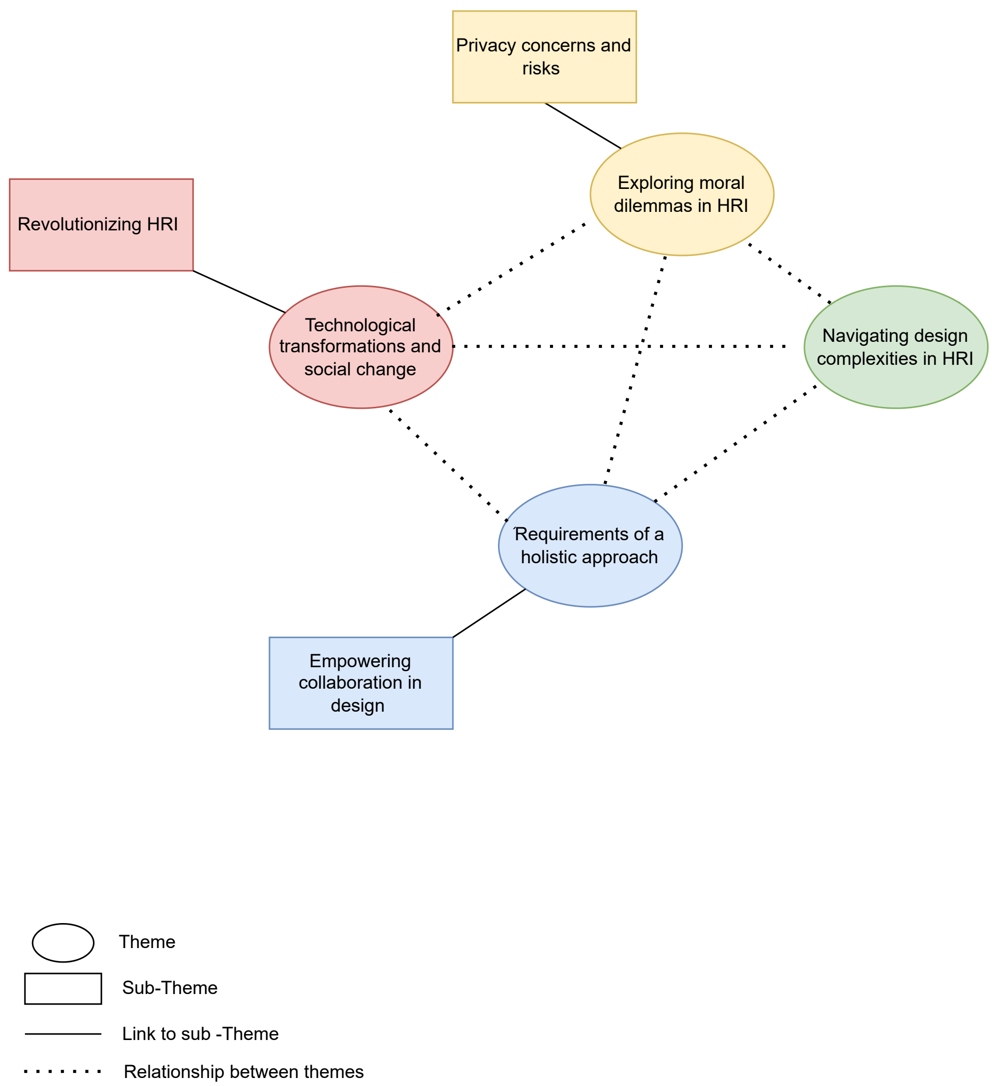

Figure 4.1: Thematic map with four initial themes

Theme	Characteristics
Exploring moral dilemmas	Focuses on the ethical obstacles that designers encounter while creating their designs
Technological Transformations and Social Change	Focuses on the transformation of using robots, its impact on society, and how this changes society
Requirements of a holistic approach	Focuses on requirements, ensuring that the design is accessible and usable for a wide range of individuals
Navigating design complexities	Focuses on the problems and obstacles designers/researchers face and emphasizes the significance of overcoming several hurdles.

Table 4.1: Theme summary table

4.1 Exploring moral dilemmas in HRI

Exploring moral dilemmas in HRI refers to the ethical issues designers and researchers deal with during the design process and its effect on users. The codes used to generate this theme are: "Overreliance on technology", "Human behavior", "deception", "Informed consent","Being biased", "Manipulation by hackers" and "Commercialization and misuse".

Deception

Deception generally is misleading someone regarding the actual state of affairs. Previous studies have highlighted that deception is an ethical concern in human-robot interaction (HRI) and is often a topic of discussion. [74]. *From the interviews conducted*, it was found that participants working in social robots and child robots mentioned that deception is also among their ethical challenges. Some participants working on Child-robot Interaction mentioned that they slightly deceive children to get good results and that "deception" is necessary for the relationship between the child and the robot. This way, the child feels safer around the robot, increasing the interaction's effectiveness. However, they are also aware that it can be unethical:

P2:" So the wizarding that we do can be seen as unethical. In a sense that we basically lie to the child and make it seem that the robot works autonomously. And it doesn't. "

P6:" We create a character onto robots, we give it a personality and an identity, and personal anecdotes from that its own repertoire of fictional experiences. But these, of course, are fake."

And the participant working on social robots for people with dementia mentioned that these robots are a useful tool because of their positive impact on people with dementia. But individuals with dementia frequently mistake robots for animals and do not realize they are not living creatures. They also perceive the robot's actions as a reaction to their behavior, considering it feedback.

P6: " I have been working with people with dementia for a long time...and sometimes they interpret the things that the robot does as some kind of feedback to what they do."

According to research, individuals may consider deception appropriate in certain situations, such as when their goal is to provide the user with a satisfying or positive experience [75]. Based on the results of this study, participants in child-robot interaction admit that they resort to deception to create a more enjoyable experience for children. However, other researchers argue that robot dishonesty is morally troubling regardless of the situation [76]. For example, robots persuading a child into an unreliable relationship can have long-term emotional and psychological effects on the child's development. [77], [78]. De Graaf [75] found that extended exposure to social robots and engaging in caring tasks could hinder children's ability to form trusting attachments and may cause them to miss out on the reciprocity of human-to-human relationships. Another consequence of this seemingly harmless deception is that individuals tend to overestimate the capacity of robots to understand the world and various situations [79]. As a result, they may rely on robots to make decisions and take actions that could significantly influence the overall quality of human life. Therefore, it is important to consider the potential emotional and psychological consequences when introducing children to social robots.

When it comes to social robots for people with dementia, there is ongoing deceit. It is unclear how to develop robots that avoid deceiving individuals with dementia, which remains a significant challenge for HRI researchers to create robots that do not deliberately deceive people. However, there is a lack of research specifically addressing deception in non-social robots for use in workplace settings. Despite there being literature on deception in social robots, it is crucial to consider how people working with non-social robots in various workplace settings deal with deception. Deception can significantly affect trust, productivity, and overall work dynamics. Understanding how individuals perceive and respond to deception in workplace robots is crucial for ensuring these technologies' ethical and effective integration. Furthermore, by exploring the ethical boundaries and implications of deception in robots used for the workplace, we can gather information for the development of guidelines to ensure the responsible and accountable use of these systems in workplace environments.

Overtrust on robots

OVertrust is defined as a scenario in which an individual misconceives the risks linked with an action due to either underestimating the potential loss caused by a breach of trust, underestimating the likelihood of the robot making a mistake, or both [80]. *The interviews revealed* that participants also face the challenge of dealing with overtrust, which can result in a society lacking critical thinking skills:

P3: "People tend to interpret this as more reliable than when a human says it because the robot said it.""

P6: " Because you can explain to a child that the robot is not acting independently and has no thoughts...I'm not sure if they will always understand that."

P2:"So trying to ensure critical attitudes in the children that are using the robots."

Other participants were also concerned that overtrust in robots could lead to commercialization and misuse, especially in Child-robot Interaction and these concerns highlight the requirement for ethical and responsible design, implementation, and regulation of technology to protect people, especially children, from potential harm or misuse:

P3: "But as a company grows, the salespeople get detached from the development people and so you get products that are misused and like, weirdly applied."

P6: "And I'm very fearful when it does happen is if it's commercialized... And even worse, how do you know if some kind of hacker is manipulating children to do stuff they don't want to or shouldn't do?"

Previous research argues that transparency about how robots work is essential to avoid overtrust. Individuals must understand how robots may malfunction, so they can use them properly [80]. Overtrust in robots can lead to a less critical-thinking society. For example, participants working on Child-robot

Interaction mentioned that they need informed consent from parents of children participating in their studies. They noticed that some parents might be too enthusiastic about their child's participation, which could result in overlooking ethical implications and consent issues. This highlights the need for better critical awareness. Academia should consider fostering critical thinking skills in people through education, as suggested by previous research [58], [59]. Educational settings lack sufficient research on the implementation of critical thinking. There is also a need for studies on fundamental theory as to why critical thinking might benefit the HRI community and society. The application of critical thinking can benefit education by prompting individuals to consider the ethical implications of their actions, including the design, use, and impact of robots in human-robot interaction. It is important to take into account contextual factors that can influence the development and application of critical thinking skills in this field, such as cultural differences and societal norms that may impact how critical thinking is perceived and practiced.

4.1.1 Privacy concerns and risk

The sub-theme "Privacy concerns and risk" is a specific aspect of the broader theme "Exploring moral dilemmas in HRI design" because it focuses on the overall understanding of ethical challenges and considerations in the design and implementation of robots. Safety and privacy are the most important aspects of technologies [62]. *The interviews revealed* how participants deal with safety and privacy, how they collect, store, and share personal data, and their fears of commercialization and misuse (see previous paragraph).

P1: "So what it needs to remember is stuff about personalization. But that's all linked to like an ID number. So there is no personal information connected to the number."

P4: "So we have a lot of children going. So there is no ID number or so you would make it as hard as possible to really know, from Google to know which child is starting when etc."

P8: "We have rules of how long we store the data and how we anonymize it and we have informed consent so that's how we deal with the privacy issue."

Privacy has become a major concern in most technological fields. The question is, why is robotics unique compared to other technologies? Because users develop a stronger emotional bond with personal and consumer robots than with other technological artifacts, this seems to be neglected [81]. Marketers' invasive methods of collecting personal data from children have raised data privacy and security issues, mainly related to children's personal information. Children are least capable of comprehending and managing commercial privacy on their own [82]. This shows that the privacy concerns of the participants are valid and that further research is required to investigate the connections between privacy concerns and negative outcomes for children, especially in terms of long-term implications.

Overall, this theme and its sub-theme emphasize how critical it is to address these ethical issues to ensure that technology is used ethically and in a way that benefits both users and society.

4.2 Technological transformations and social change

The theme *Technological transformations and social change* refers to examining the relationship between technological advancements in HRI and their impact on various aspects of human society. This theme relates to the research question about the social facets considered while designing robots and their broader societal impact. The interviews with participants yielded the following codes: “Social relationship with robots”, “Social acceptance and awareness”, “Trust relationship with robots”, and “Transparency in robot capabilities”.

Acceptance and Awareness

The findings show that the majority of participants find it important that users accept their design and, therefore, that users are aware of how it works:

P7: “So there is the social consideration, for me that is more important, is that I’m capable of explaining what we could reach and that people accept it in their forms. Another social consideration is awareness also that those systems are not toys.”

P5: “And it ties again with the whole acceptance of the robot. So as soon as socially it is in Human Centered environments.”

Previous literature has shown that users’ awareness of the robot’s ability significantly impacts the effectiveness of the interaction [83]. Through the robot’s looks and behavior, including their previous interactions with people, humans can learn about a social robot’s capabilities [84]. Thus, researchers and designers should keep in mind that when users clearly understand what a robot is capable of, they can effectively engage with it. And that the robot’s physical design, form, and embodiment can shape users’ initial impressions. For example, a robot resembling a human-like figure may elicit different expectations than a more abstract or mechanical-looking robot.

Trust and Transparency

Another factor that plays an essential role in the acceptance of robots by users is trust [85]. *The findings show* that in order to have people trust the robots and form a relationship with them, it is important to be transparent from the beginning, especially with social robots. Bhaskara et al. [86] define transparency as aiming “to provide operators awareness of an autonomous agent’s behavior, reliability, and intention”. Participants believe that with good social communication, society will better understand the benefits of using technology:

P7: “I think what is important is also to transmit to society and to teach society what are the benefits of these new technologies and try to make them aware of how all the technology that is out there works.”

P8: “And I think one way to do this is to clearly explain to the child that it’s just a robot.”

P6: “Because the robot is more honest about its capabilities and incapabilities. Then also if the expectations are managed better, you have a more productive interaction and effective interaction.”

Research has shown that design significantly impacts trust in ways beyond physical appearance. For instance, the robot’s representation plays a significant role in shaping people’s perception of its trustworthiness [87]. Therefore, trust is crucial in HRI and is important for successfully integrating and accepting robots in various workplaces. To achieve a successful design, designers and researchers must carefully consider how the robot is represented to its users. This understanding enables users to set appropriate expectations, utilize the robot's capabilities, and optimize their overall experience. As the findings have shown that transparency is crucial for building acceptance and trust in robot design, there is no universal framework for achieving transparency in robot design and interaction. Future researchers should create standardized methods to ensure consistency across different robots and applications to achieve transparency. Additionally, explainability in robots needs to be improved. Moreover, improving the explainability of robots is important to help users understand the reasoning behind their choices and actions. Developing clear and understandable methods for explaining robots' underlying processes, algorithms, and reasoning to humans should increase transparency.

4.2.1 Revolutionizing HRI

The sub-theme "Revolutionizing HRI" focuses on the developments in robotics technology that can change how people and robots interact. The relationship between this theme and "Technological transformations and social change" is that the idea of Revolutionizing HRI is a key aspect of the larger technological transformations and social change in society. The dynamics, effectiveness, and overall experience of humans interacting with robots can significantly influence factors like "Robot learning and adaptation", "Robot's Role in the Workplace", and "Size, build, and appearance". *The interviews show* that it is crucial to identify and address these characteristics for developing and using robots effectively in diverse human-interaction settings. For example, participants explained that it is important that a robot can adapt to its environment and is flexible:

P4:"So really, adapting the robots' behaviors across different environments in the hospital, where it should be quieter or where it should be louder."

P5: "The important factor for me, well, in the first place, that is robots should be flexible so that they are not just limited to certain operation conditions, but they can be a bit broader."

Studies indicate that adaptive robotics describes techniques that allow for the design of robots with the ability to evolve or learn on their own [88]. This method emphasizes the use of robot behavior with minimal human involvement. However, adaptive techniques usually require lengthy training processes. This means that designers and researchers must consider specific tasks, such as adapting to different environments, and factor in the training process to achieve the desired performance.

Size, build, and appearance

People are more likely to accept robots when they resemble humans [89]. *During the interview*, one participant mentioned that the size, build, and appearance of the robot matter to how people perceive or behave towards a robot:

P3: "So imagine that you are not very large if you occupy a robot, which is, you know, a big muscley robot. It makes a difference, and people interact with you through that robot differently than with you as a person."

Previous literature mentioned that using anthropomorphic features in the design of robots can predict how humans perceive robots [90]. This goes back to shaping the users' initial expression and the robot's capabilities discussed in the previous paragraph. And such features are thought to facilitate more intuitive engagement by providing indications that refer to social scripts from human-human interaction [91]. However, in HRI, transferring scripts involves more than just intuitive interactions. It can also involve the unintentional transfer of other social considerations. For example, gender stereotypes and biases can be reinforced if the robot is designed to have gender-specific features [**?**]. In caregiving and therapy settings, robots that are designed to mimic human emotions may cause ethical concerns as they can create a fake sense of empathy or emotional bonding [92]. Considering both the wider sociological and cultural contexts in which robots are used and the potential consequences of blurring the lines between humans and technology is crucial due to the unintentional transfer of other social considerations.

Human worker replacement

Participants were asked for their opinion on the topic of "Human worker replacement" because many articles discuss the potential loss of millions of jobs to technology advancements like robotics [93], [94]. The goal was to understand how designers and researchers decide which tasks or roles can be automated and how they evaluate their potential impact on human workers. They shared that through interactions with users during the design process, they learned that robots are typically viewed as tools:

P3: " It is really a tool to make the people that do the work better at doing their work, and better able to do their work without wasting time traveling, for example. It will not replace jobs."

P8: "Having the robot there as an extra tool, and not as a replacement for the human worker."

P6:" So that the robot has information about what it says basically, it's a teacher tool, that's how we see it. And it's also how our teachers see it themselves."

The literature revealed that one factor that affects workers' attitudes toward robots is their level of interest in technology [95]. Workers interested in robotics and technology typically have more curiosity about, desire to experiment with, and engage with this technology than those who do not [95]. However, some workers perceive Human-Robot Collaboration (HRC) as a possible threat due to anxiety about working with robots or concerns about the transformation [95]. The anxiety results from the uncertainty of leaving behind normal work tasks without having the time to consider the effects thoroughly. Interestingly, the study [95] found that, despite most employees supporting collaborative robots, many express a negative attitude towards the introduction of HRC. These negative attitudes are not directly related to the technology itself but rather it is implemented in the workplace. Another study by Smids [96] suggests that it is more important to focus on how the robot is introduced rather than focus on the "number of jobs lost". Therefore, it is crucial to consider the perception of robots and the anxiety of workers surrounding the potential consequences when investigating human worker replacement. Future research can also explore the cultural impact of human worker replacement by incorporating knowledge from diverse fields such as sociology and psychology.

In short, these sub-themes address the effects on individuals and society as a whole, and researchers can gain insights into the reciprocal relationship between societal changes and the acceptance and integration of robots in the context of evolving robot technology. Furthermore, people view robots as mere tools and do not fear that their jobs will be replaced.

4.3 Requirements for a holistic approach

This theme refers to requirements, ensuring that the design (end-product) is accessible and usable for people of diverse backgrounds regardless of their abilities and circumstances. A holistic approach means that designers must consider broader ethical, social, cultural, and environmental considerations and address several interconnected elements beyond a narrow focus when designing robots. These requirements include the design to have “Accessibility”, “Adaptability”, “Flexibility”, and the “Avoidance of Stereotypes”to create welcoming, accommodating, and empowering designs for all users.

Avoidance of Stereotypes

Categorizing individuals based on social characteristics like age and gender can lead to stereotyping [97], which often results in prejudice and bias [98]. *During the interviews*, it was evident that participants strive to create designs that are inclusive by taking into account several factors, such as avoiding stereotypes in their design:

P2: ”I’m not endorsing stereotypes. Because it’s really easy to fall for stereotypes... that’s one thing that I always try to look out for.”

P9: ”And what I learned by working a lot around this topic is to try to avoid gender stereotyping.”

Research has indicated that gender plays an important when it comes to stereotypes [99]. These stereotypes have been identified as prevalent in the workplace, with certain tasks perceived as either masculine or feminine [100]. Studies suggest that the gender features displayed by agents may impact the user experience, depending on the agent’s role [101]. Stereotyping in design can be avoided by promoting inclusivity and diversity in the design and development process of robots in the workplace. In the context of inclusive design, experts suggest that understanding users’ needs, goals, challenges, preferences, and interactions with the design is the first step in inclusive design and communication [102]. Moreover, it is suggested to use inclusive language that is respectful, truthful, and appropriate for the audience in context [102]. Inclusive design embraces diversity and representation by acknowledging the richness of different kinds of humans. To ensure successful design, testing, and iteration should be conducted. This means evaluating and refining the design based on users’ feedback. By challenging stereotypes and embracing diversity, designers can develop more inclusive and fair user experiences. Another step for future designers would be to aim for a gender-neutral design approach that avoids reinforcing traditional gender stereotypes.

Methods used by designers

In this study, the majority of participants utilize use co-design methods and believe that collaborative efforts, iterative design, and user-centric approaches are crucial during the design process to ensure that the end product meets user needs, preferences, and expectations:

P8: “I also did some co-designing sessions with end users... I like to brainstorm with them about how they think such robots should be designed, and how the robots can be used and to hear different perspectives on that.”

P6: "So we use co-creative elements in there where we have, in-depth different stages of the design process."

P1: "I think it is a really important way to go and kind of recommendation that researchers explore those methods to co-design."

According to the literature, co-design approaches have become important practices, especially in technological projects involving high-tech products, systems, or services that engage actively with their intended users. The method of co-designing with end users is also supported by other authors [53], [103], [104]. By involving end users in the design process, designers can gain valuable insights and perspectives that can lead to more successful and effective solutions.

4.3.1 Empowering collaboration in design

The sub-theme "Empowering collaboration in design" emphasizes the importance of collaboration in overcoming obstacles and creating innovative and efficient approaches for collaboration in HRI. Bringing together people with diverse skills and perspectives to work towards a shared goal is crucial for ensuring that all aspects of a project are thoroughly evaluated and addressed. Collaboration empowers human participants to have greater influence in shaping the research decision-making processes, such as adjusting to research directions and identifying key themes [105]. Ultimately, empowering collaboration in design is essential for achieving the holistic approach required for successful project outcomes.

Many participants agree that collaboration and involvement of different stakeholders are needed: *P2: "Get as many perspectives as you can get. Not only from the stakeholders but also from other*

researchers, roboticists, etc. Because if you have many perspectives, you're on your way to making it more ethical."

P8: " What I want to do is also focus groups with questions on how they think the robot should be implemented and what things should indeed be taken into account before implementing the robot."

Researchers need to acknowledge the value of non-researchers contextual knowledge and actively engage with their experiences [105]. Collaboration with non-academics enables researchers to explore societal issues that may have been overlooked due to limited diversity among researchers regarding their social, cultural, and economic backgrounds [105]. Lee notes that users often need to collaborate more effectively with researchers, resulting in lost opportunities to gain valuable contextual knowledge. The field of Human-Robot Interaction (HRI) requires more empowering approaches that involve them in the design process. Including users in developing new technologies creates a space for their input and perspectives to shape the design process and ensure that the resulting technologies positively impact society.

Reflexive and Transdisciplinary

Transdisciplinary research refers to techniques that are inclusive and socially responsible research methodologies that involve equal participation from academics, stakeholders, practitioners, and citizens [106]. HRI is already an interdisciplinary field as it examines the interaction dynamics between humans and robots [107]. Interdisciplinary thinking and collaboration involve the integration of diverse perspectives or insights through interactive processes to understand complex phenomena better.

One participant from the interview argued that designers and researchers should be more reflective towards their work and that they should work towards a more interdisciplinary and transdisciplinary community:

P9: "I think we need as a community to become more interdisciplinary. We are not interdisciplinary enough and transdisciplinary."

P9: "So it's not just about not designing robots as humanoids. But that but also like OK, who is the community that will use this robot?"

Another participant expressed appreciation for being presented with the interview questions, as it allowed him to contemplate his work.

P7: "It's nice to have these questions...It makes me think and reflect on my work, and I am also thankful for that."

Although most of the participants did not talk about this, it was significant to dive into this topic as the field of HRI seeks to use transdisciplinary approaches [106]. A transdisciplinary approach refers to bringing together researchers, designers, practitioners, stakeholders, and end-users who possess varying expertise, perspectives, and skills to tackle complex societal challenges that cannot be understood or tackled by a single academic discipline or a particular group of professionals [108]. Zaga et al., [106] proposed four tools to encourage reflexivity and futuring with HRI scholars, marginalized communities, and other stakeholders in the early stages of HRI projects. Recent studies are exploring ways to make the field of HRI more transdisciplinary. However, additional research is required to explore the practical implementation and effectiveness of a transdisciplinary approach in the workplace, including investigating the challenges of integrating multiple disciplines and stakeholders in designing and deploying workplace robots. Understanding how different perspectives and expertise can be effectively combined to address complex workplace issues and ensure the successful development of inclusive robotic systems is crucial.

The quotes from the participants above indicate a need for greater reflexivity and critical thinking about the reasons behind designing a robot and conducting thorough research into its necessity. Recent studies suggest that adopting more human-centered, equity-focused, holistic, and critical approaches in HRI is crucial. [10], [109], [110]. Pelikan et al. [57] suggest that reflection can occur at various stages, including during the design, after user testing, and through ongoing reviews. It is also necessary for designers to reflect on their decisions during the design process to refine their approaches and iterate on designs for more effective HRI experiences. By taking a more thoughtful and self-aware approach to robot design, we can create robots that are not only technically advanced but also socially responsible.

Overall, this theme shows that within the HRI community, researchers and designers are becoming more aware and responsible in designing robots by emphasizing reflexivity and transdisciplinary. These considerations are essential for creating technologies that align with human values, promote societal well-being, and address the diverse needs of individuals and communities.

4.4 Navigating design complexities in HRI

This theme covers most of the complex and multifaceted aspects of designing robots. It pays attention to the difficulties and challenges experienced by designers of robotic systems and underlines the importance of overcoming several obstacles. Some of the codes that generated this theme are "Need for different participants", "Implementing feasible behaviors", "Lack of time in implementing robots in education"

Need for different participants

Participants working on Child robot Interaction experience that they do not have enough participants to do user testing, which can influence the outcome of the study:

P2: "However, it's very hard to get enough children, of course. You might be dependable on the same children. And then you have the problem that the children are already framed."

P1: "It's also hard to or a little bit intensive to get access to the target audience."

P8: "It's very hard to get a hold of people because they're very busy. So for example, co-designing with people that have work to do /a job to do."

Although there is limited research on researchers facing difficulties in finding participants for their studies, it is essential to ensure that a diverse group of individuals is included in the studies. This allows for designers and researchers to gain unique perspectives and insights when working with different groups. It also helps to prevent biases when using the same participants for multiple studies. By involving various participants, co-designed robots can become more accessible and inclusive.

Managing expectations

Designers and researchers face the challenge of implementing feasible behaviors. *One participant in child-robot interaction mentioned* during co-design sessions, end-users may have unrealistic expectations if they are not aware of the robot's capabilities:

P8: " The biggest challenge is to design behaviors that are feasible to implement in the robot... they might not know exactly what the robot can do and therefore might have unrealistic expectations."

The literature supports this finding, as Belpaeme et al. [111] argue that establishing appropriate expectations among children and stakeholders, such as parents, medical personnel, and teachers, is crucial when developing social robots. Additionally, Belpaeme et al. found that significant effort is required to educate adults responsible for children, as they often face difficulties. To address this challenge, exchanging expectations with users and listening to their feedback is essential. Even if the desired behavior is not entirely feasible, it can still provide valuable insights into how users want the behaviors designed.

Lack of time in implementing robots in education

During the interview, a participant highlighted the concerns around the time it will take to implement robots in education and the opinions of stakeholders regarding the same:

P6: "The majority would rather see it as it will take us so long to implement this use because it's not working properly."

Research shows that social robots can improve language learning outcomes and increase enthusiasm among young children when compared to traditional methods [112]. Additionally, robots can have a significant impact and contribute meaningfully in educational contexts (Davison, 2021) [113]. However, teachers need help incorporating robotics into the regular school curriculum due to the time-consuming activities, equipment costs, and the practical work required to manage robot kits in the classroom [114]. In order to tackle the challenges that have been identified by participants and teachers, additional research is necessary to investigate potential solutions and strategies. One potential solution for the future is time-efficient integration, which investigates ways to easily integrate robotics activities into current educational curricula without adding excessive workload for teachers.

Limitation of using specific robots

During the interview, a participant raised concerns about the limitation of using specific robots in child-robot interaction. The participant explained that the designer or researcher is limited to working with a particular age group of children instead of the intended target audience. The conversational focus must be on children at least seven years old, as younger children may not be able to engage in appropriate conversations. This limitation is due to the hardware being predetermined, which restricts the customization of the robot's interaction with different age groups:

P6: "We're having this specific robot already the Nao robot. So it's already like a robot push for incorporating a robot solution in the problem space, which necessarily, does not always need a robot or this type of robot. "

There needs to be more research on how researchers and designers work with a specific robot. Therefore, it is essential for them to carefully consider the robot's capabilities and limitations and align them with the specific needs, preferences, and developmental stages of the chosen age group. Doing so could enable them to customize the interactions for that particular age group.

This theme illustrates the difficulties that designers encounter and how future research is needed to overcome them and produce efficient designs for Human-Robot Interaction (HRI). The following paragraph discusses the findings between the researcher in this study and the second coder.

4.5 Intepretation discussion on findings between the researcher and second coder

The second coder agreed upon the themes and sub-themes but raised questions about their relevance to workplace settings during the discussion with the first coder. The researchers discussed whether the themes were patterned in meaning, relevant to the research questions, and underwent a high-quality analytic process. One sub-theme in particular, *Empowering collaboration in design*, was initially grouped under the overarching theme of *Navigating complexities in HRI*. This sub-theme highlighted the importance of participants' design methods and collaboration to overcome challenges and create innovative and efficient HRI designs. It was first part of this theme because to comprehend the complexities, it seemed crucial to understand the methods utilized by designers. However, the second coder suggested that this sub-theme may fit better under the theme of *Requirements of a holistic approach*. This is because the requirements of a holistic approach encompass broader ethical, social, cultural, and environmental considerations and address several interconnected elements beyond just the narrow focus of designing robots.

Additionally, the sub-theme *Empowering collaboration in design* also emphasizes the importance of collaboration in overcoming obstacles and creating innovative and efficient approaches for collaboration in HRI. After discussing this matter, the group agreed that this sub-theme belongs under the overarching theme of *Requirements for a holistic approach*. This sub-theme no longer emphasizes design methods. Instead, it centers on collaboration in HRI and how the field can adopt more collaborative approaches to empower designers.

The discussion about how relevant the themes are to workplace settings mentioned that the study had a broad approach since it did not focus on a particular workplace. However, if designers and researchers keep these themes in mind, they can create better-suited and adapted robots to these environments. As a result, the issue became better understood by the second coder, and they resolved any concerns or questions.

Chapter 5

Discussion and Conclusion

This section briefly discusses the topics related to the findings and answers the research questions. Possible explanations for the answers to the research questions will be explored, and recommendations and limitations of this study will be acknowledged.

5.1 Discussion

This research aimed to understand how designers and roboticists approach designing interactions between robots and users in the workplace while considering ethical and social considerations. By gaining insight into the designers' perspective, factors influencing design choices can be determined. As designs can have significant consequences on users, it is important to think about how they might affect people, both ethically and socially. This should be considered right from the beginning of the design process to ensure that any negative impacts are avoided. By doing so, designers can predict some of the effects and mitigate some of the consequences that may arise. Therefore, the research question focuses on designing robots in a way that considers ethical and social factors: **How can designers take into account relevant ethical and social facets while designing robots in the workplace?** To answer this question, two sub-research questions were formulated: **Sub-RQ.1: What are the ethical and social dilemmas when designing robots for the workplace?** The findings show that designers often face ethical and social challenges while creating designs and addressing privacy and safety concerns. First, the ethical dilemmas are explained. The design process prioritizes privacy and safety among the major ethical considerations. The findings also highlight that designers commonly face ethical challenges such as deception and overtrust of technology, especially when working with vulnerable groups like children and the elderly. For instance, designers may resort to slight deception when working with children, claiming that forming a bond between the child and the robot is necessary. However, such actions can negatively impact the child's development, as previous studies have noted [77], [78]. Then deception in individuals with dementia, researchers observed that robots were often mistaken for animals, and people with dementia believed that the robot's actions were responses to their behavior, seeing it as feedback. This highlights the need for further exploration and continued research to develop frameworks that address the ethical implications of deception in HRI. Moreover, deception can lead to individuals overtrusting robots and potentially relying on them when human judgment and intervention may be necessary. Previous research suggests that being transparent about how robots function could reduce overtrust. However, in the field of HRI, there needs to be more understanding of the specific effects of overtrust. Therefore, there is a need for a common framework to help researchers and designers study this phenomenon more effectively.

Designers and roboticists face social challenges of acceptance, awareness, and trust. Participants emphasized the need to ensure that users accept and understand the design. Consequently, the trust users establish with the robot significantly impacts its acceptance [87]. To foster a clear understanding of the robot's capabilities, transparency and effective communication are crucial [86], especially with vulnerable groups like children. However, achieving transparency in robot design and interaction lacks standardized methods, which can be helpful in ensuring consistent and meaningful transparency across robots and applications. Standardized methods for transparency can work by providing a clear and consistent set of guidelines for developers to follow when designing and implementing transparency measures in their robots and applications. Additionally, improving the explainability of robots is crucial, enabling users to comprehend the rationale behind the robot's decisions and actions. Developing methods for clear explanations of robots' underlying processes, algorithms, and reasoning will enhance transparency. Therefore, since ethical and social issues are interconnected, and technology's effect on society raises ethical concerns, the ethical and social dilemmas in Human-Robot Interaction require a delicate balance between the potential advantages and risks of employing robots in various workplaces.

To answer the second sub-research question: **What are potential design guidelines that can be generated from the insights gathered from designers?** After conducting the study, it was determined that providing recommendations is more practical because this study is not focused on one specific type of robot designer/ roboticist but rather on designers/roboticists working on robots in various contexts. It was more effective to give recommendations. And because the field of HRI is still evolving, recommendations offer a more flexible and adaptable approach. Based on the findings from this study and the ethical and social dilemmas designers and roboticists face, these recommendations offer valuable insights. The recommendations can also serve as a guide for future research and the development of comprehensive design guidelines.

Some recommendations for the field of HRI are:

1. **Fostering collaboration and a Transdisciplinary approach**

   Fostering collaboration and a transdisciplinary approach refers to bringing together researchers, designers, practitioners, stakeholders, and end-users who possess varying expertise, perspectives, and skills to tackle complex societal challenges that cannot be understood or tackled by a single academic discipline or a particular group of professionals [108]. And collaboration empowers human participants to have greater influence in shaping the research decision-making processes, such as adjusting research directions and identifying key themes. [105]. It is important to foster a transdisciplinary approach for robots used in the workplace because other complexities arise with the interaction between humans and robots, such as ethical and social issues. Researchers and designers can achieve a more thorough understanding and better handling of the challenges by taking a transdisciplinary approach and allowing participants to have a say in the design process. In addition, recent research has already started to create the foundation for the design discipline to expand progressively toward transdisciplinary approaches [106], [108] by developing tools and methods. In the context of Robots used in the workplace, designers and researchers could consider implementing effective communication and language usage when they take on a new role, like "a mediator". Effective communication and language usage are fundamental elements of transdisciplinary collaborations. Thus, one recommendation for HRI designers would be to establish an open communication and collaboration environment where researchers and practitioners can freely share their insights, findings, and challenges. Online platforms or workshops can facilitate this.

2. **Reflecting on Design Motivations**

   Although only one participant mentioned the need for reflexivity among designers, it is essential to reflect on design motivations that urge designers to critically examine and understand the reasons and intentions behind their design choices. Reflection entails examining and assessing the interactions and experiences with robots to acquire insights and improve since reflection is a significant part of the design process [57]. According to Pelikan et al., reflection can occur at different times, such as during the design phase, following user testing, and through continuous reviews. One recommendation for future designers would be to ask questions like “Why did I make this design choice?” and “What are the potential consequences of this choice?” during the design phase. After user testing, designers can reflect on feedback and adjust their designs accordingly. Continuous reviews of the robot’s performance and interactions with users can also provide valuable insights for reflection and improvement. By prioritizing reflexivity in the design process, designers can create workplace robots that are more effective, efficient, and safe for everyone to use.

3. **Cultivate Critical Thinking**

   As technology becomes more complex, it is crucial to encourage critical reflection among researchers, designers, users, and stakeholders. As participants in this study expressed their concerns about society’s decreasing critical thinking abilities, it is important to highlight ways to foster critical thinking skills. Particularly, previous research has shown the need for approaches that foster critical thinking skills [58], [59] as this will help individuals in the future to deal with emerging technology and develop a critical understanding of the current views and claims about it. Thus, a recommendation for the field of HRI is to implement critical thinking in education by encouraging design students at the university level to reflect on the potential ethical, social, and cultural implications of their technology designs.

4. **Developing standardized methods for transparency**

   The results indicate that dealing with ethical and social challenges, such as acceptance, awareness, and trust, requires transparency. To address these challenges and avoid overreliance, developers should design and implement their robots and applications using standardized transparency methods and effective communication. In the future, designers ought to create standardized methods that compel users to receive information on the robot’s purpose, capabilities, and limitations, including data on how the robot processes information and makes decisions. Having this ability can enhance people’s trust and confidence in technology. By doing so, users will clearly understand the robot’s operations, enabling them to make informed decisions on how to interact with it.

Thus, to answer the research question, *How can designers take into account relevant ethical and social facets while designing robots in the workplace?* It is recommended that they promote collaboration and use a transdisciplinary approach. It is also important for designers to reflect on their motivations, encourage critical thinking and establish standardized methods for transparency. These recommendations will promote responsible and inclusive HRI designs that prioritize trust, openness, and positive results for people in the workplace.

5.1.1 Reflection and evaluation on writing-up

The author included a reflection and evaluation to consider the decisions, choices, and actions along the journey of this project:“ On reflection, I chose Reflexive TA because I wanted participants’ standpoints to be prioritized rather than existing theories I had read, such as robots replacing workers. As I feel that designers and researchers can shape and influence interactions between robots and users, they can best describe on how to consider ethical and social facets in their design. This required a critical realist approach and an inductive/deductive orientation. After talking to designers, I discovered that some of their ethical and social challenges align with theoretical concerns, such as privacy and safety concerns. However, not all of them do. It appears that designers acknowledge the importance of transparency and collaboration in addressing this project's ethical and social challenges. However, not all designers are aware of using a transdisciplinary approach and reflecting on their design motivations. Thus, I strongly encourage future designers to think about using a transdisciplinary approach and reflecting on their design motivations while using critical thinking. This approach will shape inclusive robotic systems.

I recommend that others go through this process of understanding what you want to do before figuring out the exact steps to get there. Embracing Reflexive Thematic Analysis' flexibility will help you reach your goals more effectively. By reflecting on your intentions and being open to different approaches, you can make better-informed decisions and be more adaptable in your design journey."

5.2 Limitations

This study had several limitations. First, the sample size of this study is 9 participants from different universities in the Netherlands, which limits the generalizability of the findings to a broader population. Furthermore, the supervisors in this study selected participants through their personal networks, which may have resulted in some bias. Consequently, the findings may not completely align with the research question. The research question aimed to understand how designers can take into account relevant ethical and social facets while designing robots in the workplace. However, some participants designed robots used in various contexts and not for the workplace, which could impact the results. This is because each context has unique ethical and social considerations that designers must consider, leading to findings that may be less applicable in other situations. Reflexive TA, as a research method, has some limitations as it can introduce subjectivity and bias during the analysis process. Since Reflexive TA mainly relies on the researcher's interpretations and reflections, personal biases and prior beliefs like the researcher's cultural background or theories of previous literature might have affected the theme identification and interpretation. Although this potentially limits the topic-specific generalizability of the results, it does not undermine the overall message communicated in this paper.

5.3 Conclusion

This study contributed to the well-established call for "Human-Machine Partnerships in the Future of Work: Exploring the Role of Emerging Technologies in Future Workplaces" [9]. The researcher asked designers and roboticists about their approach to designing human-robot interactions while taking into account ethical and social factors. Understanding the designers' perspectives is crucial to identify the factors influencing their design decisions and their impact on ethical and social considerations. The study found that there are a number of ethical and social facets that designers deal with during the design process apart from privacy and safety. Deception and overtrust in technology emerged as common ethical dilemmas, particularly when working with vulnerable groups like children and the elderly. Ensuring a balance between forming relationships and potential negative effects on the development of these individuals is essential. Acceptability, awareness, and trust are significant concerns in the social context of human-robot interaction. Designers highlighted the need for users to accept and understand the design, emphasizing the significance of transparency. To address potential issues, providing recommendations proved to be more effective than specific guidelines, given the diverse range of participants working in various contexts with robots. Therefore, recommendations have been given. These recommendations include promoting collaboration and transdisciplinary approaches, fostering critical thinking, encouraging designers to reflect on their design motivations when developing robots, and establishing standardized methods for transparency. The field of HRI could develop comprehensive design guidelines that reflect the evolving ethical and social challenges by further developing these recommendations.

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Appendix A

Interview questions

Warm up Questions
1. What inspired you to become a roboticist?
2. What kind of robots do you usually design?
3. What is your day-to-day work?
Key Questions
1. Who do you design robots for? And how do you do that?
2. What are the important factors you look for when designing robots?
3. What did you hope to achieve with the robot design?
4. What specific methods do you use to design interactions between robots and workers in the workplace?
5. What types of challenges do you face when designing robots?
6. How do you make sure that your design matches what users need/ expect?
7. During the design, are there any ethical considerations you're taking into account?
8. How do you address ethical considerations when designing robots for the workplace?
9. What measures do you take to ensure robots are designed with user privacy?
10. How do you determine human worker replacement and responsibility in your design?
11. Are there any other ethical considerations/ facets that you deal with during the design of robots?
12. What social considerations do you take into account when developing robots?
13. How do you establish the robots that you design to have positive interactions with human workers and avoid negative outcomes?
14. What strategies do you use to ensure that robots are designed to be non-discriminatory and respectful of workers?
15. Are there any other social considerations/ facets that you deal with during the design of robots?
16. What impact do you think robots will have on society in the future?
Wrap-up
1. Is there anything we didn't talk about today that you'd like me to know?
2. Do you have any questions for me?

Table A.1: Interview questions

Appendix B

Codes and Categories

Initial Category	Initial Codes	Description	Interview transcript
Requirements for inclusive design	- Child-appropriate dialogues - Not endorsing stereotypes - Adaptability - Flexibility - Accessibility - Inclusivity - Inclusion - Trust - Interpretation and subjectivity - Need for reflection - Need for regulation - Need for critical awareness - Need for more inter- and transdisciplinaryaryarity - Involvement of stakeholders	These codes refer to recommendations, ensuring that the design (end-product) is accessible and usable for a wide range of individuals regardless of their abilities, backgrounds, or circumstances. These guidelines include accessibility, adaptability, flexibility, and the avoidance of stereotypes to create welcoming, accommodating, and empowering designs for all users.	-” We need to give this freedom to the farmers that they are not afraid of the system, they know how to manage it, they understand all of the safety and security concerns, and that system is capable of autonomously doing some sort of task. But in the end, after that, all the data collected and processed by the system should also be displayed to that person in a way that that person with very limited skills, and technical skills is also able to interpret that data.” - “And what I learned by working a lot around this topic is to try to avoid stereotyping when your gender. And since everything is gendered around us, even this the slightest queue enables you to gender so you don't really need to put a pink ribbon on a robot which people have done in the past to make it perceived.”
Ethical concerns	- Deception - Human behavior - Informed consent - Being biased - Manipulation by hackers - Commercialization and misuse - Overreliance	Ethical concerns involve the evaluation of values, beliefs, and norms to ensure that behaviors are consistent with what is right, just, and fair.	-“It's actually very difficult. So it's necessary for relationship formation. And if the children feel a connection, they feel safer around the robot, they also are more interested to keep interacting with the robot longer, which increases the effectiveness of interventions. So this is the reason why we do it. But on the other hand, we're also kind of slightly deceiving the children on a social level.” -” So the wizarding that we do, can be seen as unethical. In a sense that we basically lie to the

			child and make it seem that the robot works autonomous. And it doesn't."
Social considerations	- Impact on job-displacement - Social Relationship with Robots - Social Acceptance and Awareness - Trust relationship with robots - Transparency in robot capabilities	Social considerations analyze the broader societal impact and implications of acts, decisions, and policies. These factors address the effects on individuals, groups, and society as a whole, such as social dynamics, cultural values, equity, and well-being.	- "So it should not be a replacement friend, where it's like, okay, this will be my friend from now on. I was getting bullied in school. And now this is my friend. And at school, I don't care anymore about any other human being. When I come home, my friend is there and I'm happy". - "So what I mostly have seen so far is that children just tend to trust robots. And we try to make it very untrustworthy. With it being incapable is flickering, no fun emotions, all that kind of stuff. And they still trusted it." - "And I think the part of these interactions is to manage the expectations, but also manage this relationship to be appropriate and that they are. So I think transparency is very essential here, what kind of friend is it really?"

Privacy concerns and risk	- Data collection - Data privacy - Data managemen t - Privacy	The category "privacy concerns and risk" refers to the potential risks, vulnerabilities, and ethical considerations related to personal information protection and the right to privacy. It entails investigating how personal data is collected, stored, and shared.	- “Well, when you work with the aero platforms, one of the big issues is also privacy. So make sure that you don't capture people, the information that you're gathering, all the authorizations from the producer from the field owner, etc.” -”So there are different privacy concerns. So first is, okay, we're using Google. So we're sending basically, audio files to Google. So that's definitely a major privacy risk. So what we do to reduce it, for example, is that we set the system in such a way that it doesn't listen, the microphones are off. By default, only. The robot asks that question they're turned on, and the robots eyes turn green. And children are, there is a tutorial on how to talk to me, they now care if the robots eyes or green is listening. This is the only moment when audio is actually being recorded, that will be sent to Google”.
Factors impacting HRI	- Robot learning and adaptation - Robot’s Role in the Workplace - Size, build, and appearance affect HRI	These factors influence the interaction between humans and robots. They can significantly shape the dynamics, effectiveness, and overall experience of humans interacting with robots. Recognizing and solving these characteristics are essential for developing and using robots that can interact with humans in a variety of settings.	-”I feel like we are still working towards a robot that it's able to learn for its environment. Because it is really impossible to build a robot that takes into account for example, all people’s backgrounds, and what are the social norms of every culture is different in the robot that is able to really adapt towards all of them.” - “So imagine that you are not, very large if you occupy a robot, which is you know, a big muscley robot. It makes a difference and people interact with you through that robot differently than then with you as a person.”

Barriers to implementation	- Lack of imagination in design - Lack of time - Lack of user-centered design - Limitations of using specific robot - Limited applications with children	These barriers refer to the challenges, obstacles, or limitations that hinder the successful execution of the designers' project.	- "I mean, I think we are missing really the design methodologies to design robots. I mean, I think we are missing really the design methodologies to design robots in a way that is respectful but like, and we have to engage different groups of people, not just one." -" So few of them are just sitting a person down and letting a conversation happen. So there is very little happening in there and within that I'm also specifically looking at kids, also narrowing it down, and then in the robot world there's also a lot happening for kids, but there is not so much focus on dialogue and search. So there is not that much that I can directly build upon."
Preferred design method	- Co-design - User-centered design - Iterative design - Collaboration	These methods describe a specific approach or methodology that designers refer to use when creating robots or robot interactions.	-"And then, of course, when we design the behaviors we will test them with the people in the hospital and make edits from different angles. The patients, nurses, but also hospital staff." -" I also did some co-designing sessions with end users. So the parents, the healthcare professionals, but also the children. And also we like doing that, even though there's not necessarily directly a robot involved. I like to brainstorm with them about how they think such robots should be designed, and how the robots can be used and to hear different perspectives on that. And not only think about what I think is useful but also think about what the user in the end thinks is useful, especially when working with children, they will definitely come up with out-of-the-box creative ideas, which is a lot of fun to work with."

Challenges of designing robots	- Creating realistic scenarios - Need for different participants - Implemen-ting feasible behaviors - Meeting unrealistic expectations - Co-design challenges - Not enough (child) participants - Ensuring effective signaling - Ensuring interpretatio n/communic a-tion cues	The challenges of designers include different complexities, hurdles, and considerations that designers face during the design process. These difficulties can arise from a variety of sources, such as the project itself, the design context, and the designer's role.	-" So it's hard to, I would say, create a test environment or a methodology in which you can see, in a realistic scenario, how it would work for them. That's one of the big things that I'm always struggling with." -" It's also hard to or a little bit intensive to get access to the target audience." -" Because often it's very difficult to do co-creation in a more participatory way, I would love to do that more. But I'm not sure if it's a lack of experience or using the right tools, or we often notice that there's a big gap between the things that come out of those sessions and something we can actually implement with an autonomous robot, which is often far more limited than when you have a more freeform co-creation." - "And because, it's probably clear to the humans when somebody is trying to communicate with the robot, but it's very hard to make it clear to the robot when it is addressing humans. So it's very hard for the robot to know when to interpret the signal and when not to interpret the signal. And, and these kinds of considerations are really best discussed with the humans on site."