Chapter 11

Gender Matters

I think there's a difference between those who produce the robots and those who actually utilise them. I don't think there's any gender imbalance really with how they're used.

(Conor, recruitment agency general manager, affected stakeholder, WAREHOUSE)

◀ Normative gendered perceptions can become embedded in design.

11. Gender Matters

Disrupting an inequitably gendered society

You will find here

- Discussion of the question of gender and gender biases in robotics and the industry
- Empirical examples of the typical gender-related challenges that come with the design and use of robots

You will acquire

- Awareness about feminist perspectives on robots and robotics
- Awareness of the role and relevance of female perspectives and female experiences in robotics
- Gain sensitivity towards gender biases in robotics

Among different ethical concerns robot developers face in their work, one challenge is particularly pressing: Gender equality. When selecting cases for the purposes of the REELER research, gender was not a factor, though we were careful to include also female robot developers if we found them in our case studies. However, as it turns out, several important patterns emerged across all cases in relation to the role and overall presence of women in the design and use of robots. When we first noticed this pattern, we had made 163 interviews (some of which were 'extra material – and the number since grew to 177, see Methods and Methodology, Annex 1 responsiblerobotics.eu/annex-1). Of these 163 interviews we noted that 118 were with men, and 59 of these were male technical people, mostly engineers and 10 of these headed robot developing companies as CEOs. We only have one female CEO in our data material – and to our surprise only eight of the 14 female robot developers we had interviewed were actually engineers. The rest were working for robot developing companies in many different functions such as HR, marketing directors and policy makers. We had two cases (in construction and inspection) without any female robot developers at all. In other words, even if we were aware of the need to hear the voices of female robot developers (especially engineers) there were hard to find. If we did not explicitly seek to represent more females in our project, we would have ended up with even more male engineers.

Among the affected stakeholders, the gender representation differs in relation to types of robots. In the case of cleaning robots, almost all developers were male, whereas almost all affected stakeholders were female. In relation to other robot types the representation of gender was more balanced however with more females in areas tied to health than for instance inspection. We have therefore devoted a whole chapter to this issue to raise awareness that gender is an issue in making responsible and ethical robots – even though we have touched upon this issue in the chapter on Inclusive Design (*see 5.0 Inclusive Design*). Gender inequality in design is not just a matter for the engineers to solve – it includes society as a whole.

Why is an absence of female engineers and robot designers an ethical problem? The question of gender in robotics continues to be bound to the distinction and relationship between men and women and the related absence of female perspectives in robot design. The latter emerges as an ethical problem both in terms of underrepresentation of women in the robotics sector as well as overlooking women as end-users /affected stakeholders with their own needs and viewpoints. Thus, it is not gender per se that raises concerns but the bias that may come with an unacknowledged discrimination between perspectives that include different working and life conditions for men and women. Though REELER has not been able to research if the lack of female voices among robot makers actually affects the types of robots that get funding and are realized, we can raise the awareness that this may be the case. Thus, it may very well be that more female engineers – *and* more voices of female affected stakeholders – may lead to new types of robot engagements. Thus, the

gender perspective holds the potential of disrupting the field of robotics.

These cleaning ladies from Portugal for instance have many good ideas for robots, which may have been realized if the situation of cleaning staffs (mostly women) were taking more into account. Here they are talking about the robots they would need to clean houses at a resort with many stairs and high ceilings.

> *Carmen: "Aesthetically, it had to be a robot that managed to get up very high because we don't manage to take away the spider webs. Or some arms that are removeable, that raise the hands."*
>
> *Malena: "And the houses are also big."*
>
> *Carmen: "It has to be malleable in the knees to climb stairs because here all entries and exits have stairs, and there are also stairs in the storage rooms. For a robot to bend the knees they have to be malleable. I'm talking of knees, but also of its feet."*
>
> *Interviewer: "And the arms also need to have the full range of movement."*
>
> *Carmen: "Exactly. A robot can't occupy a lot of space here. And it must turn around, and I don't mean 180 degrees, but a robot needs to be able to turn 360 degrees because we move a lot."*
>
> (Carmen and Malena, cleaning staff, affected stakeholders, SPECTRUS)

This type of cleaning robot that can help, and not replace, the cleaning staff has yet to be developed. Looking at different working conditions from the perspective of *male vs female* makes it possible to become aware of how the present-day situation may be ripe with unacknowledged unethical gender inequality. This is because bias involves thinking or treating other individuals differently based on perceived characteristics of such individuals, which often leads to unjust discrimination (Howard 2018) and ignores the actual people and their practices (Report 2013). A different way to discuss biases is by focusing on stereotypes. In general, stereotype is a widely held and simplified belief about a specific group of people and it is embedded within wider cultural and social institutions. Gender stereotypes reflect normative notions of women and men, typically portrayed as binary opposites (Report 2013). While 'sex' concerns biological qualities that determine whether an individual is a female or male, gender refers to a socio-cultural process and social meanings attributed to men and women (Report 2013)(Criado-Perez 2019). From this perspective, the topic of gender is closely related to that of culture and the need for an inclusive design (*see 5.0 Inclusive Design*).

Sex: *biological characteristics that classify an individual as female or male*

Gender: *socio-cultural process and social meanings ascribed to men and women (Report 2013; Rüst 2014)*

Over the centuries, the overall exclusion of women from different institutions and socio-cultural spaces or the gendered division of work was justified by 'natural laws' or 'tradition'. However, nowadays, there has been a growing recognition of the arbitrary and cultural character of gender stereotypes and roles (Rüst 2014) also in relation to design (Schiebinger 1989). In science and engineering, the nature of discrimination against women has gradually changed from overt discrimination to more subtle unconscious and often unintentional biases (Schiebinger 2008). This chapter aims to help identify and understand the existing gender stereotypes in robotics as well as propose alternative ways to bring more gender balance to both the design and use of robots based on REELER research.

11.1 How gender comes to matter

Over the centuries, different answers were given to why we see so few women in science (or the women scientists we know about) (see for instance Schiebinger 1989, Hasse and Trentemøller 2008). Nowadays, while we have a better understanding of how women were excluded from scientific institutions, the problem of underrepresentation of women in science and engineering persists. Efforts to monitor women's participation in science started in the 1980s with the involvement of national governments and international agencies. Such efforts were subsequently followed by different initiatives and policies aimed at supporting women's participation in science and engineering in terms of education and career (Schiebinger 2011). One way to better understand different levels that require efforts to remove gender bias from science and engineering is to "fix the number of women" to increase their participation and competitiveness in science and engineering. This imply "fixing the institutions" and male-dominated cultures that come with them as well as "fixing the knowledge" with the goal to enhance human knowledge (Schiebinger 2008, 5). In other words, by 'fixing' science cultures so more women can be included, the knowledge, interests and engagements changes as well (Hasse and Trentemøller 2008). This implies that more women in engineering are not just a question of balancing the *number* of males and females, but also an effort to ensure that other priorities and interests are represented. Efforts to increase and acknowledge women's contribution to the robotics field include such initiatives as establishing an international professional organisation dedicate to women in science and engineering, IEEE Women in Robotics (WIE), and regularly listing the top '25 women in robotics you need to know about'

by the Robohub online platform[1]. And yet, as is clearly seen in the REELER research, still much needs to be done to achieve the actual gender balance in robotics.

The underrepresentation of women is of course a much wider issue than robotics. In the technical areas of the engineering sciences, it can be detected already with the beginning of computer science and related fields that have been developed before or in parallel to robotics. For example, Marvin Minsky, one of the founding 'fathers' of AI, said: *"AI is the science of making machines do things that would require the intelligence if done by men"* (Minsky 1968, 23). This quote is typical in so far, no explicit attempt is done to exclude women – it is 'only' an expression of normative thinking (*see 5.0 Inclusive Design*).

As both fathers and creators, men can be said to be the sex that has carefully and culturally forged AI and robotics in their own image (Richardson, 2019). The result of this deeply male-dominated culture is that the male experience, the male perspective, has come to be universal, while the female experience has been overlooked. It is the product of a systematic way of thinking, because across different domains, when we refer to the human, on the whole, we often mean 'man'. Feminist and social theorist, Simone de Beauvoir made the point most famously when in 1949 she wrote: *"Humanity is male, and man defines woman, not in herself, but in relation to himself; she is not considered an autonomous being" (de Beauvoir 1949, 27) and "He is the subject; he is the Absolute. She is the Other"* (de Beauvoir 1949, 27).

A new technological context makes the need to address gender equality even more urgent when it is primarily males who are designing a world that profoundly impacts the world for everyone. As not much is written about women in robotics, we turn to the general development of the computing sciences to get a wider picture of gender in the applied sciences.

Robotics has the potential to challenge the existing gender stereotypes in many ways. For example, some robot developers pointed to the possibility to reduce or eliminate the gap between men and women in the sectors where human physical features and capabilities will stop playing any role. This included developing a robot that in order to be functional needs to be assembled by two persons and applying the same lifting standards (similar weight limits) for both female and male operators.

> *Today, many jobs require big, strong men or little, petite girls. That will be evened out dramatically within the next generation or two, because physical exertion will be much less needed within industrial work. I think it will disappear, or at least diminish. I also think the requirements to operate the machines will be different.*
>
> (Valdemar, engineer and CEO at WIPER, robot developer, WIPER)

Given men's overall interest in engineering and robots, the introduction of robotics technologies to women-dominated sectors, such as for example healthcare or primary education, can potentially attract more male employees and contribute to the social change that comes with redefining the existing gender-related roles and identities.

11.2 The general lack of women in technology

The narrative of technology exposes, seen through the lens of gendered structures, a gender data gap, i.e. *"a gap in our knowledge that is at the root of perceptual systematic discrimination against women, and that has created a pervasive but invisible bias with profound effects on women's lives"* (Criado-Perez, 2019 editor's note). It is male data that informs the majority of what we know. In particular, early computing literally defined the process of computerization to this day at the expense of women contribution. For example, as discussed elsewhere (Hicks 2017), in the 1940's in the UK, computer operation and programming was viewed as women's work. Soon, women became synonymous with office machine operations and their work became tied to typewriters, desktop accounting machines, and room-sized punch card equipment. It did not take long for offices to accept the idea that competence in working with machines was a feminine attribute as opposed to the more intellectual work done my male counterparts. Women's alignment with machine work in offices persisted through waves of equipment upgrades and eventually through the changeover from electromechanical to electronic systems. Yet, the physical segregation of gender in the workplace and the fact the women's labor in the workforce was considered unskilled, presented female workers with fewer opportunities for promotion or a career. In other words, slowly, but surely women were pushed out of the industry, and computing experienced a gender flip in a field that was assumed to be rote, deskilled, and best suited for women - a sign of specific gendered labor hierarchies - until the rise of technocratic ideals in the 1960's, that reshaped the status of machine workers. Gender-segregated categories of work persisted in defining women's economic position as lower than men's, and in making women's economic lives secondary

1 https://robohub.org/25-women-in-robotics-you-need-to-know-about-2018/

The only woman found in an active robotics lab. Photo by Kate Davis.

for most of the 20th century (Hicks 2017) and continues until today.

Sexuality plays a silent, but critical role in the history of computing. Coding was originally seen as a women's game, before the machine that took their name replaced them and took even more years before they were replaced by men. Women's labour had become so closely allied with computers that some machines actually took on their identities, for example BETSIE (a betting and bookmaking computer) and SADIE (which stood for Sterling and Decimal Invoicing Electronically) (Hicks 2017, 125). As the 1960's progressed, advertisements showed woman's computer work as simplistic, and 'dumbed-down' the job, in order to better sell machines. So much so, that in many later images, women were used to showcase machines and advertising went from focusing on machines and workers, to focusing on primarily (female) workers. The machines (they built) would disappear and the female workers became objects of desire themselves - men's ideals about women's sexuality used to structure jobs in computing. This layer of sexual subtext on the representation of women in the field of computing blended with the shift already underway and the expectations about women's lives based on a form of mid-century heteronormativity, that left most women with limited career prospects (Hicks 2017, 5). To this day, despite decades of equal pay legislation and significant investments in educational strategies across different countries, patterns of underachievement and perceptions of women as less technically competent persists, including within Anglo-American culture, business, and high-education (Hicks, 2017 231). Yet, this image is a recent historical construction and a distinctly masculine perception that computing has acquired, and is not a fair reflection of women's skills, ability, and interest.

Turning to the uptake of undergraduate and, graduate, faculty posts and business relating to AI and robotics, for instance, we still see a significant gender difference/imbalance. The upper ranks of academia – particularly those in STEM fields - are dominated by a majority of white, middle-and-upper class men. When compared to other industries (including non-STEM), the information technology industry had the lowest representation of women – 28.4% of companies surveyed still had zero women on their boards in 2017 and only 18% had three or more women (Catalyst 2019). However, women in Europe are gradually closing the gender gap in science and engineering, with an increase of women who made up more than a third (40.5%) of scientists and engineers in the EU-28 in 2017, yet negative work experiences impact women's decisions to leave – isolation, male-dominated work environments, bias and lack of effective women role models are all factors pushing women to leave STEM jobs – they are 45% more likely to leave than men (Catalyst 2019).

REELER has not explicitly looked into the lack of women in technology-focus careers, but the significant lack of women as engineers and CEOs of engineering companies in our case studies indicate this as a major ethical problem in engineering. Awareness about gender issues would, if embedded in robotics, create new knowledge about how government practices

and new technologies can challenge, perpetuate or undermine social and economic equality.

Following feminist studies there is a need to counter the assumption that gender equals biological sex, and that women by nature differ from men in their ability to create (due to biological sex). By countering this claim, we make sure that the differences in representation of males and females in the REELER data, it cannot simply be explained as because women do not want to work as CEO's or engineers. Creating a distinction between sex and gender is critical to ensure that we are not mistaken in the idea that biology is destiny. For a long time, feminists have challenged the synonymity of sex and gender and believe both have two, very different meanings – and inequality is culturally shaped, not biological. Although, it is important to acknowledge that there are biological differences that are unique to male and females, many of these differences are relatively minor compared to the vast, socially constructed gender differences we see in some Western and some Asian cultures; such as the classical social roles ascribed to men and women; men need to be the assertive leaders, workers and breadwinners, and women must to be passive, domesticated mothers and wives. It is crucial to ensure that robot makers as well as engineering and indeed society in general move away from such socially constructed gendered norms and do not allow these existing ideals to manifest into the development of robots and AI.

In response to this, it is important to set out theoretical feminist positions to inform studies on gender and ethics. A new field of study has emerged, concerned to develop a feminist perspective on technology, ranging from women's limited access to scientific and technical institutions, to exploring the gendered nature of technology itself. We cannot, of course, do justice to all the contemporary feminist thought in our study, yet, hope to touch upon enough theoretical background to highlight the female politics of technology, thus key to achieving gender equality.

Feminism: *The advocacy of women's rights on the ground of social, political and economic equality of the sexes.*

- *Liberal feminists* take an individualistic stance, whereby they focus on women's ability to maintain their equality through their own actions and choices. Liberal feminists seek no special privileges for women and simply demand on making the legal and political rights of women, equal to men. When it comes to information technology jobs, most engineers and others involved with information technology take a liberal feminist view and assume that the focus should be on employment, access and discrimination issues (Rosser 2005). Similarly, this is the standpoint robot developers tend to take in regard to lack of female representation in STEM fields and association of sex and gender. Liberal feminism does not address the potential of gender to affect 'fundamentals' and reaffirms, rather than challenges positivism and individualism, suggesting that 'fundamentals' would always remain the same - gender and sex (Rosser 2005, 2).

- In contrast, *socialist feminism* rejects individualism and positivism. The basis is formed under the Marxist-social theory and work of numerous scholars of technology have produced large amounts of research, commonly known as 'the social shaping of technology' (Rosser 2005, 3). This term brands information technologies as a social product and suggest that information technologies comprise human activities (Rosser 2005). Socialist feminist critique includes women and place gender on equal footing with class in shaping technology; capitalism and patriarchy function as mutually reinforcing parts of a system, where the sexual division of labour stands with wage labour. This is a central feature of capitalism and drives patriarchal and power relations in society, that has limited the work done by women. As a result, middle-and-upper class men tend to create and design most new information technology and serve as the sources of money for design, and creation. Socialist feminist reform suggests that the allocation of resources for technology development should be determined by greatest benefit for the common good (Rosser, 2005), and this approach would lead to better inclusion and ethical decision making within the development of robotics and AI.

- An alternative approach began developing in the early 1980's, what is often called *'difference feminism'*, and holds the idea that there are differences between men and women, but not as argued in liberalism and biological determinism. Difference feminism did not argue that there was an inherent link between women and traditional feminine values, but instead sought to recognise that women and men are significantly different, and to revalue qualities that our society had devalued as 'feminine', such as empathy, tolerance and cooperation (Schiebinger 1999). The 'superior nature of women' could reform science, by directing knowledge away from the pursuit of power and instead, toward greater equality and freedom for all humankind (Schiebinger 1999). It has been said that women have distinct ways of knowing, that has been excluded from the practices of science, largely due to the domination of men in these fields, and when making moral judgments, that they value context and community over abstract principles (Schiebinger 1999). Difference feminism believes that attributes generally tied to women have been excluded from science and gender equalities have been built into the production and structure of knowledge. However, postmodern feminists have pointed out that this framework to easily posits a 'universal woman', and excludes the notion that women have diverse histories, needs and aspirations (Schiebinger 1999).

- *Radical feminism* aims to dismantle the patriarchy and views patriarchy as dividing societal rights, privileges, and power primarily along the line of sex, and as a result, oppressing women and privileging men. Radical feminism rejects most scientific theories, data, and experiments not

only because they exclude women, but also because they are not women-centred (male perspective). Because patriarchy pervades and dominated all institutions, ideologies and technologies, women have difficulty placing their experiences, lives, and needs in central focus in their everyday lives and environments - gender bias (Rosser 2005). We have learnt that the domination of men and the absence of women from the design process in fields of STEM, is a factor to why we experience technologies which are closely aligned to the needs of men and therefore do not consider the requirements of women. Radical feminism suggests that because men, masculinity, and patriarchy have become completely intertwined with technology and computer systems in our society, no truly feminist alternative to technology exists (Rosser 2005).

Also, it is important to observe that the dominant cultural ideal of masculinity has an intimate bond with technology. Through the lens of computerisation in society and the gendered division of labour, men have been known to affirm their masculinity through perceived technical competence and assert women as technologically ignorant and incompetent – attitudes that still reflect in our present technical culture (Wajcman 2010). As a result of these social practices, women may attach very different meanings and values to technology (Schiebinger 2008). To emphasise the ways in which the symbolic representation of technology is sharply gendered, is not to deny that real differences do exist between women and men in relation to technology, nor is it to imply that all men are technologically skilled or knowledgeable. Rather, it is how the male perspective has, in turn, become universal and one with machine (Wajcman 2010).

Engineering culture has been said to adopt a quintessential masculine image. So much so, that of all the major professions, engineering contains only a small proportion of females. For example, as far as the UK is concerned (the country that after all is a pioneer of the Industrial Revolution), it has the lowest number of women in engineering occupations in Europe, namely 12% (Neave 2018). In modern societies, the education system, along with other social institutions, plays a key role in the formation of gender identity. They add values and meanings that can identify with rigid ideals of masculinity and femininity; not allowing young people to escape that pigeon-hole. There is now a lot of coverage on sex stereotyping in general schools and addressing the processes in which girls and boys are channelled into different subjects and interests. There are links between education and the extreme gender segregation in the labour market, particularly in STEM fields, and this must be set about, providing schemes to open up opportunities for women to enter into technical trades.

Lastly, concentrating on gender in this chapter, allows us to look at how the design and use of technology are shaped by male power and interests, which not only exclude women but also men who do not fit the male designers norms (Schiebinger 2008) and insists that technology is always the product of social relations (Wajcman 2010). A very extreme and recent case of this within the robotics and AI industry, and a reflection of gendered (patriarchal) design, is the development of sex robots. These machines are a new addition to the sex trade that commodifies the female body. Sex robots are a reminder of the patriarchal system that constructs our society and reinforces relations of power that do not recognise women as fully human. A company behind the build of these robotic 'lovers' is RealDoll by Abyss Creations, who label these devices as 'companions' for people who struggle to form and sustain lasting relationships with fellow humans, due to social, psychological and/or physical reasons. No matter what creators and consumers claim about the harmlessness or social good of sex robots, they project clear messages about male entitlement and what women are good for - male gratification. Technology is never innocent. Though REELER did not study sex-robots as a case, we still emphasise that ethically we must resist any forms of robotics and AI which perpetuate damaging norms, including sexual norms and inequalities in society, whether it be through the design of robots or the application of them.

11.3 Key issues for gender awareness

In general, the subject of gender in robotics concerns as much the wider field of robot makers, including robot developers, as their creations. While some of the findings came as no surprise, like the underrepresentation of women in the robotics field and STEM industries, what does raise concern is the way a predominantly male perspective may affect the outcome of robot developers' work. This is particularly true for the cases where predominantly male roboticists develop robots for sectors that are dominated by women, e.g. education (ATOM) or the cleaning industry (SPECTRUS). In some cases, gender has been explicitly discussed in terms of ethical challenges. The following sections provide examples of how the question of gender emerges in practice in robotics and in relation to broader socio-cultural contexts. The first concerns the underrepresentation of women in our REELER material as well as a gendered work division. The second concerns male perspectives on female realities, and the third the 'gendered' robots.

1) Underrepresentation of women and gendered work division

As far as robotics and robot applications are concerned, women participation is seriously limited. Comparing to men, there are much less women who are involved as robot developers, both in the academia and industry, as well as robot end-users in certain sectors. Gender is understood here not only in terms of differences between men and women but also gendering of skills, work, knowledge and social life among others (Adam 2005).

As the REELER research has shown in robotics, underrepresentation of women is something that robotic developers are usually well aware of, when asked about it. They are aware most of the colleagues and project partners robot developers deal with are men and some also wish for more women. However, the degree of underrepresentation of wom-

en in engineering varies between countries – and as we have previously seen in the natural sciences, women are more represented in e.g. physics in Italy, than in Denmark (see Hasse and Trentemøller 2008). Even if women do contribute to robot design and development, our REELER research often find them to be hired in their role of non-technical experts or assigned the tasks that require so-called 'soft skills' (social and communication competencies) that some view as 'natural' female skills (Weber 2005). It is therefore no surprise we find a relatively high participation of women in the field of social robotics and Human-Robot Interaction (HRI), whereas there are fewer at ERF (European Robotic Forum). The absence of women also is prevalent in some sectors and industries that make use of robots, for example in the agriculture or warehouse sector. This often leads to a situation where male roboticists develop robots for predominantly male end-users, and therefore, further perpetuate the existing gender gap.

REELER research well-illustrates the above-mentioned trends. In general, across all 11 cases, women constitute only 18.9% of the REELER participants among robot makers – and, as mentioned, rarely as CEOs and often in other roles than as engineers. Women constitute 38.8% among our affected stakeholders, which is also tied to the types of robots we study – e.g. robots in construction sites, where the affected stakeholders are mostly male. As shown in Fig. 11.1 and Fig. 11.2, two cases hold no interviews with women among the robot makers, namely 'OTTO' and 'WAREHOUSE', and three cases involve interviewing only male affected stakeholders, i.e. 'HERBIE', 'OTTO' and 'WAREHOUSE'.[2] One of the cases with a very low participation of female roboticists, i.e. 'SPECTRUS', included almost exclusively females among affected stakeholders (cleaning staff) and thus exemplifies the application of male perspectives to women's domains.

The underrepresentation of women among the REELER participants was due to the conditions found in the field, i.e. the access granted to the robot makers or workers who were all men. Also, even if working for or collaborating with robotics start-ups and companies, with some exceptions, women were typically in charge of non-technical tasks. For example, the development of teaching scenarios for educational robots, providing expertise on HRI and user involvement or running the company's communication and PR activities. Last but not least, there was only one female roboticist holding a position of Director of R&D.

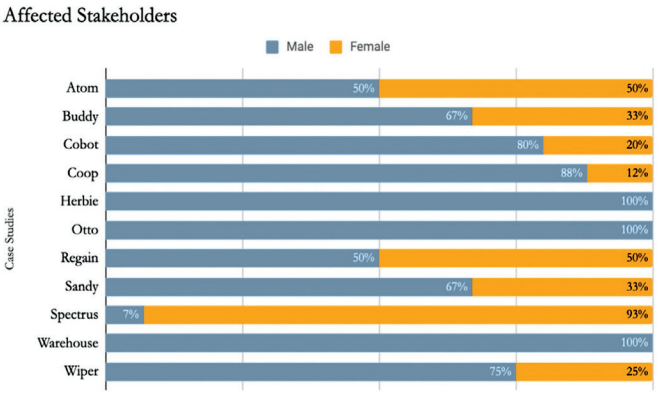

Fig. 11.1 Proportion of male and female REELER participants among affected stakeholders

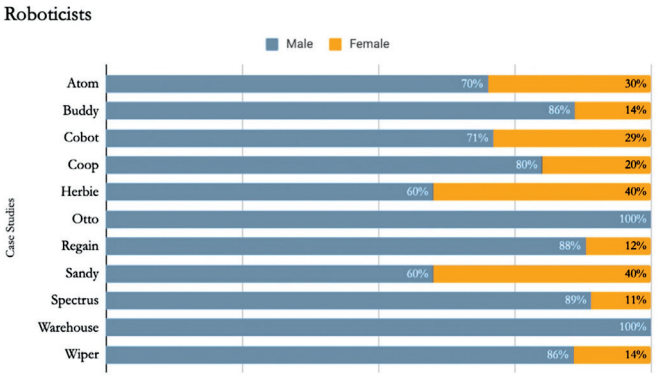

Fig. 11.2 Proportion of male and female REELER participants among robot makers

On the one hand, underrepresentation of women in robotics is due to different structural factors inherent to education and employment that foster men participating in engineering. On the other hand, the absence, or a high dropout rate, of women in engineering is also due to women's social roles that traditionally involve family assignments and the overall organisation of society that go far beyond robotics. A limited presence of women in technical fields or job sectors is also due to the roles imposed on women in the process of upbringing where girls are often explicitly discouraged from pursuing engineering careers. Both parents play a role in gender stereotyping: According to some studies, female parents are even less likely to recommend engineering to their children, in particular to the girls (Neave 2018). Also, comparing to female parents, male parents demonstrate more positive perception of educational robots in terms of their usefulness and confidence in teaching with the use of robotic aids, as well as are more willing to support children in learning from educational robots (Kwok-Kong 2012). Therefore, it can also be women's own bias that complies with the dominant male culture and make them believe that certain jobs as 'men's jobs' (note the persisting association between the notion of 'men' and 'tradition'). Such an approach fuels gender stereotypes and often turns biases into self-fulfilling prophecies (Howard 2018). In principle, some women freely choose not to engage with robotics or some types of jobs that tend to be undertaken by

2 The few participants who hold a double role of robot maker and affected stakeholder, e.g. robot end-users who actively contribute to the process of robot design and development, are included in calculating the percentage for both robot makers and affected stakeholders.

men instead. As discussed by some of the participants, some robotic companies make deliberate efforts to hire more women, however, finding female engineers and breaking a vicious circle is apparently a difficult task; there is not enough female engineers who apply for jobs in robotics (the same applies to some other male-dominated jobs). Furthermore, even the way jobs are advertised may be biased towards men and discourage women from applying (Criado-Perez 2019). The ethical implications of a gender imbalances are of course a complex issue that requires structural solutions that cannot be solved by individual engineers.

When involving affected stakeholders, whether considered end-users, or directly or distantly involved stakeholders, in the role of the study participants, they are more diversified in terms of gender. However, problems with gender imbalance still persists. It is apparent that underrepresentation of women may not strictly be the complete absence of women in a given field, but indicative of a sharp separation between the type of tasks that men and women do, the education they have and jobs they assume (the subject has also been addressed in terms of 'gender segregation' (Neave 2018) or 'gendered division of labour' (Schiebinger 2011). For example, in the manufacturing industry, males tend to be in charge of the tasks requiring physical strength while female staff are typically dedicated to small items assembly. Such a division is true for any type of jobs considered to be physically demanding. In one of the REELER cases, when training operators to use a transport inspection robot, only approx. 7% of the trainees were women, which generally reflected the employment structure of the company in question. At the same time, some sectors tend to be almost entirely dominated by women. This was the case of the cleaning sector or primary education that are addressed in the REELER research. Since most of the robot developers are men, the situation where they develop robots for female end-users without actually involving women to address their needs and preferences is highly problematic.

When addressing gender inequality across different sectors, it is important to note that closing the gap in terms of numbers (e.g. through gender quota) is only the first step needed to increase gender equality and gender balance. The change must apply to the entire male-dominated culture and the overall organisation of society, and the related male perspective treated as 'universal'. In the context of science and engineering, it may involve 'gendered innovations', such as *"transformations in the personnel, cultures and content of science and engineering brought about by efforts to remove gender bias from these fields"* (Schiebinger 2008, 4). Such a change must involve not only 'including' female perspectives (the approach that may only reinforce the view of the male perspectives as the norm one should be aspiring to) but also actively acknowledge, value and prioritise women's approaches and contribution to the design and use of robots. Moreover, it is important to note that amplifying existing gender stereotypes, robotic technologies have the potential to actually redefine our understanding and perception of gender and related roles whose consequences may go far beyond robotics.

2) Male perspectives on female realities

Male perspectives are often treated as the norm for the design and use of robots, and man is generally viewed as 'default human' (Criado-Perez 2019). Despite being half the population, women's qualities, needs and perspectives are often overlooked or analysed only as relative to male norms. Yet, male perspectives are often depicted as 'gender-neutral' and 'universal'.

The underrepresentation of women in engineering and tech industries has an explicit impact of what type of robots we develop and how we do it. This is because it is typically men's presence and perspectives that determine standards and requirements for the design and use of robots and related user experience.

Sometimes the reason for choosing male perspectives are a simply a matter of practical choices. For example, during REELER research we experienced a video demonstrating a robot in use involved a male actor instead of a female actor, because he was the only person capable to operate a machine at the time of shooting the video. More often than not, such practical reasons are inherently linked to the unconscious bias many male robot developers hold that allow them to not prioritize or even simply exclude women's perspectives. In other words, while men are taken as the norm, women are often analyzed as an afterthought and in terms of deviation from the norm (Schiebinger 2011). In this way men's perspective come to be considered 'objective' and values tied to female experiences and needs appear as 'deviant'. For example, the REELER research on construction robots show this field has been typically dominated by male workers, and a female body is sometimes viewed as 'small', and hence, 'out-of-shape'. And this is a best-case scenario because the robot designers discover 'female bodies' when they decide to include women as potential end-users of their robots. Most often these biases go unnoticed till the robots are on the market (*see 5.0 Inclusive Design*). Other studies on age and gender differences in operating a robot manipulator have shown that men are being considered to be 'better', 'faster' or 'more efficient' than women rather than simply address the differences between the individual people involved (Paperno 2019). In REELER studies we have seen that even when designers really want to include women, the main and often the only difference between genders that robot developers explicitly take into consideration is that related to body features and physical capacities. A typical example is that of categorizing a task or a job as physically demanding, and hence suitable for men, or considering different body sizes when designing robot interface. In this sense, robot developers typically approach the subject of men and women in terms of 'sex' and not 'gender' and with the male norms and values considered a main point of reference. Just as when ethics is reduced to be a matter of safety (*see 4.0 Ethics Beyond Safety*) gender is reduced to biology and not a question of different life experiences and values. This is potentially a highly traditionalist and objectifying approach where women are perceived through the lens of their bodies in the first place.

Based on the REELER findings, in most of our cases the subject of gender is nearly inexistent in our interlocutors' thinking about work and robots: When asked about the differences between men and women in terms of the use of robots or performance at work, several affected stakeholders simply stated there are none. Such thinking applies also to the perceived suitability of robots for both male and female operators. The question is, however, how often such assumptions have been empirically verified by robot developers with the actual involvement of women or by affected stakeholders who in certain sectors are predominantly men. For example, one of the robots studied in the REELER research is developed in close collaboration with the actual robot operators. In that case, however, all operators involved in the process of robot development were males. Other examples include developing solutions that would be suitable for people with small hands, including women, that, however, had the male engineer's male (and big) hands as a normative frame of reference.

STORY FROM THE FIELD:

On the 'universality' of male perspectives

In our Western culture, be it in robotics or other fields, the male perspective and the male experience are generally seen as universal (Criado-Perez 2019). Thus, even when testing solutions with the goal to make them suitable for women, in this case in terms of the size of the hands, it sometimes involved participation of men with smaller body parts rather than involvement of the actual women. In one of our best-case scenario's this process even involved a female designer. In such a case, 'our way' [i.e. male's way] to do things is supposed to count for the women or anyone else's perspective (indeed to be 'universal'):

Interviewer: "In relation to this thing about creating a model that fits every hand…You write really well about the fact that women should also be able to use it, and large hands, and small hands. How did you do that? I know I've asked about this before, but could you be more specific?"

Liva: "Well, I think [Male 1] had the largest hand, it was just, I mean, he had a pretty big hand, and for a guy, [Male 2] had a pretty small hand, and [Male 3]'s was somewhere in the middle. So, it was basically just a question of handing it to them and seeing, "How does it feel for you? What kind of issues do you have with it?"

Interviewer: "And then simply try to find a version that fits everybody."

Liva: "Yes. Simply feel our way through it."

This case was special, because they had an explicit desire to include women – which was not seen in other cases. In some cases, it is even end-users themselves who may impose gender stereotypes on the robot design. This was the case of the educational social robot. While robot developers aimed to develop a robot that does not have any specific gender assigned or can be treated as both a male-like and female-like robot, eventually they were forced to change the colour of lights in robots to address boys' preferences. Once again, it was the girls who needed to adopt to boys' (future men) preferences and accept the blue colour in robots without using the pink.

Leon: "As for the robot itself, we were trying to develop a totally unisex design here, right? So, neither for boys nor girls – universal."

Interviewer: "Because the robot has no gender assigned to itself?"

Leon: "No, the robot is a bit masculine, but for example, in the first chapter of the application scenario we have a female hero. So, we have a robot dressed up as a woman."

Interviewer: "Ah, so they get dressed."

Leon: "Yes, because we also have a lot of gadgets, applications, we can buy different items of clothing, and we have some things that are typical of women, typical for boys, but there are things that are typical of anyone (laughs). So, for both boys and girls. We noticed that for example the pink color, right? This is a generally perceived girly color and the boys don't like it. They don't like it and we often had situations where we were to split the group into two groups, one would be blue, the other one pink. Because pink looks good against the backlight. (…) And the boys are always rebelling. "No, we don't want pink, we don't want to be in this group," and then we always had to give them gold or green. And so, we decided that the primary color will be blue, because the girls accept the blue."

(Based on interviews with Leon, robotics start-up co-founder, robot developer, ATOM and Liva, production technologist, robot developer, WIPER)

Occasionally, potential gender-related challenges have been identified in relation to women's attitudes towards technology in general, and robots in particular. Gender, or rather being woman, along with old age, are sometimes seen as factors in creating resistance towards learning about and using robotic systems. Some robot makers view interest in robots as inherently 'men's thing', unless it involves women who already have technical backgrounds, i.e. are prepared to address robots. However, they did not wish to be quoted for these views. The outcome of such views is that it is female end-users, and/or other affected stakeholders, and not the male robot developers who are seen as responsible for the potential failure of the process of integration of robots into our gendered society. Only a single study participant (affected stakeholder himself) explicitly observed that the gender-related biases are not so much in the way people use robots, but instead are the ways in which robot developers adopt their own approach towards gender.

Thus, it is the implicit bias and normative thinking within the inner circle in robotics that needs to be addressed, both on the individual and collective level. In general, in order to identify and tackle bias in system design, it is important to critically engage with systematic ethical reflection (Howard 2018). This can be done only in direct collaboration with female roboticists and affected stakeholders mediated by helpers like alignment experts. Also, it would be useful to expand the focus to address not only 'gender bias', but also 'gender dimensions. The latter do not have negative connotations the way bias does (an approach similar to addressing ethics in terms of human well-being rather than only prevention of harm). Overcoming gender bias has the potential to prove beneficial for the robotics research itself: By addressing the actual women and their points of view, robot developers may develop robotics technologies that are better fitted for our society, including both women and men in all their diversity (it is often the case that changes made with women in mind also improve the situation of men that differ from the normative expectations of robot developers (Schiebinger 2008). Also, reflecting on the women's perspectives may help male robot developers to better understand and expand their own thinking as well as identify and overcome biases related to gender. Last but not least, removing gender bias from science and engineering generally helps to enhance human knowledge and technical systems (Schiebinger 2008) in novel and creative ways that otherwise could never emerge.

3) Gendered robots

Given the human tendency to anthropomorphise inanimate objects as well as human-like appearance and behaviours designed into some robots, the question of gender also literally applies to robotic systems and related human-robot interactions. This is also where potential gender bias may be more overt and explicit than in other areas of robot developers' work.

When designing robots, especially human-like social robots that resemble human appearance and behaviour to a varying degree, it is not uncommon for robot developers to assign gender to robots. This can be achieved through different means, for example the robot look, shape, voice etc. Gender is generally viewed as one of the characteristics that may help creating an anthropomorphic effect in robots and improve the social acceptance of robots. End users also tend to project gender-specific characteristics onto robots, even those far from being human-like, e.g. by giving to the robot a female or male name. One could argue that adding gender features to robots in the process of their design and development aims to facilitate interaction with robots for the benefits of end users. In practice, however, the use of gender may serve mainly to achieve particular design objectives rather than look at end-users/affected stakeholders' well-being in the first place. For example, the role of gender in robot design has sometimes been described in terms of increasing the robot's 'persuasiveness' (Siegel 2009) and its capacity to provide social clues that trigger specific responses in end-users (Tay 2014). This is how, just as in the real life, gender is subject to instrumental approaches and attempts to control the way it is perceived and experienced.

Also, as already mentioned, both robot design and human interactions with robots may be shaped by the existing gender stereotypes. A decision to apply specific gender characteristics to the design and use of robots may not only reflect but also reinforce gender stereotypes, both on the side of the robot developers and affected stakeholders. For example, one of the promotional videos identified in the REELER research shows a robot bringing a rose to a woman, apparently because it's what people like. Such an approach is of course ethically questionable (Shaw-Garlock 2016) because it shows a robot that does not exist. However, it is also cementing the gender stereotypes that are unreflectively adopted by the male engineers. A potential bias inherent to the robot design may concern not only the way the robot is designed but also how it classifies and treats affected stakeholders based on their gender. Also, the way gender stereotypes is reinforced can also be assigning specific roles to robots; for instance, robots that conform to occupational role stereotypes related to gender, namely female healthcare robots versus male security robots (Tay 2014). A different example is that of robots presented as young and attractive women performing jobs in the service industry, e.g. receptionists (Richardson 2016). This also well illustrates robot developers' tendency to focus on sex and biological features rather than gender (see above) and incorporate male views of females into the system hardware and software, often without even being aware of it. Dealing with such a bias and related practices is a much a cultural as technical challenge.

One could argue, an alternative approach is to design gender-neutral robots, both in relation to the system design as well as the conception of the affected stakeholders. However, despite claims to objectivity, science and engineering as such can never neither value- nor gender-neutral (Schiebinger 2011). We also realise it is not an easy task to create robots without gender (as it for instance has been attempted by professor Hiroshi Ishiguro in Japan with the *Telenoid*; *see photo on next page*).

The presumed genderless Telenoid robot illustrates a gender-avoidant, rather than a gender-aware, approach to design. Telenoid™ : Osaka University and ATR Hiroshi Ishiguro Laboratories. Photo by Kate Davis

Another example comes from the REELER research: As illustrated in the story above, the robot developer describes the educational social robot as *gender-neutral* or only *a bit masculine*. Yet, some of the related promotional materials that are available online refer to the robot as 'he' (in addition to calling the robot 'it'). Also, even in the situation of deliberate efforts made to avoid adding any gender-specific features to robots, it may be affected stakeholders themselves who may bring gender stereotypes to their interactions with robots that robot developers will need to face. In most cases, it is the male perspectives that will be imposed to women (see 'Story from the Field on the 'universality' of male perspectives').

All in all, from the ethical perspective, the explicit attribution of gender to robots, be it in the way we design robot hardware and software or how people interact with robots, may be highly problematic. At the same time, such a situation creates the opportunity to uncover existing gender bias and address them. It is important to note that robotics technologies and robot developers who work on them have a real potential to challenge existing gender inequality. The ultimate question and the challenge we need to collectively address is always about the kind of society we want to live in.

11.4 Concluding remarks on Gender Matters

The REELER team decided to include this chapter on gender after analysing the gender issues emerging as a pattern across the 11 cases. While the chapter on Inclusive Design directly addresses the robot developers and suggests ways to obtain a more ethical and inclusive design in general (*see 5.0 Inclusive Design*), this chapter addresses the well-known, yet still relevant, general gender imbalance found in REELER as well as in many of the studies referenced in this chapter. We do not believe this problem can be solved just by bringing more awareness about gender issues in engineering education for instance. Here we are faced with a deep and fundamental problem, that needs a societal solution. In design work it may be an impossible task to create completely gender-neutral robots. However, much more diversity and acknowledgement of other values and life experiences can surely be more prevalent in robot design – and awareness of gender issues may help acknowledging diversity.

A perspective on gender is, as also mentioned in feminist studies, namely not just about a predominantly male normativity that spills out and forms our society and its potentials. The gender perspective also points to that it is a *particular* male gaze and vision, that also excludes other male as well as female gazes and visions. The males encountered in REELER research in general shared the culture of the *inner circle* (*see Collaboration in the Inner Circle, 3.0*) as well-educated engineers or similar academic educations, predominantly white

and between 30 and 50 years of age, with life experiences tied to the work with technology and collaborations with other robot makers. They do not try to exclude women or other males' perspective from their work. On the contrary, some of them express a need for a more holistic and realistic understanding of the world in which their robots are to work. However, it is hard for them to break out of normativity without help. To bridge the gap between these males and their normative culture, and the rest of the male and female needs and values found in our societies, REEER therefore suggests the need for a new type of education that ensures we have alignment experts (*see Human Proximity 12.0*). An important part of their job will be to remedy the gender imbalance.