Integrating Inclusion into Technologies – Practical Insights from two case studies in VR-Technology and E-Mobility

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Abstract
For most of us today, using technologies often is not optional anymore. However, inclusivity and a user-centred approach are still not the default in technology development. There remains a lot to learn on how to apply technologies to different contexts and for diverse user groups. Using two examples of FEMtech research projects (VR4Care on the use of virtual reality in nursing homes and FEMCharge on the development of charging infrastructure for e-cars), we want to give practical insights into two research projects which specifically tried to consider sex and gender in an intersectional way when developing new technologies. In both, we were able to identify relevant insights for the future development of technologies with approaches geared towards more inclusion using focus groups, usability tests, interviews and intersectional analysis of the obtained data. In these two research processes, we were able to witness that while looking at sex and gender as a variable remained relevant, other dimensions of diversity and/or their intersection also caused large disparities. It therefore was elementary to take these into account, as they often turned out to carry more weight than sex or gender. We concluded that it is not enough to consider gender as an isolated variable, but that a user-centred approach needs to be an intersectional approach. Research practice shows us, that there are many limitations and challenges associated with these kinds of research processes. In the conclusion, we therefore also outline our thoughts on the practical challenges we encountered.

1 Introduction

We are not alone in the belief that technology should work equally well for everyone and treat everyone the same. In reality however, this is often not the case. Speech-recognition software tends to work better for male than female voices. Face recognition works best for white males and worst for black female-read persons. Usability tests, voice-activated virtual assistants like Alexa and Siri, as well as video games and translation software often feature gendered aspects, such as voice, looks or learned

behaviours, which reinforce gender norms and stereotypes (for more information and examples see https://genderedinnovations.stanford.edu/Criado Perez 2019).

One of the reasons for this is so-called "I-methodology". With “I-methodology" developmental processes are described in which researchers, designers and engineers see themselves as typical users and develop products based on their own peer-groups needs (see Akrich 1995; Oudshroon et al. 2004). This is problematic because researchers have a special "insider relationship" to technology, which distinguishes their worldview from that of other users. This is due to the fact, that a majority of staff in departments for technological development are white male employees, who are at risk to have a biased perspective of the world and technology (Eurostat 2021; Franklin 2021). As a result, the worldviews and circumstances of females, gender-diverse, disabled, seniors and BIPoCs (and their intersections) are often not represented and considered. From a methodological point of view, it is therefore obvious that so-called "I-methodology" can lead to the development of technology that is not ideal for a diverse range of target groups. One way of tackling this, is increasing the diversity in technical development teams. However, this alone is not enough, as developers tend to have a very specific relationship with technology. Therefore, "user-centered technology development" or "user-centered design" is necessary to ensure the highest possible usability for the broadest possible user group. This is achieved by placing the future users of a product at the centre of the development process (Schraudner et al. 2013).

User orientation is mainly dealt with in two different contexts or discourses:

(1) In industry and business, there is a long tradition, e.g. in the form of usability engineering in the IT sector or the usability of medical technology products in the form of standards (cf. Sarodnigg/Brau 2011; Backhaus 2009; Maramba et al. 2019; Curcio et al. 2019).

(2) As Londa Schiebinger (2008) describes, gender and diversity research has evolved from the question of the representation of women in research to the question of taking diversity dimensions into account in research. "Fixing the knowledge" is now also implemented in funding guidelines of the European Commission (2014; 2021), while gender and diversity dimensions are also integrated into scientific and technical research projects in Austria, often in the form of an increased user orientation (BMBWF/BMVIT/BMDW 2019). While ‘gender blindness’ often leads to neglecting relevant social dimensions, gender awareness can open up research for other relevant social parameters beyond gender. Including a gender perspective can thus increase the quality of research and its relevance for society (EIGE 2021).

While the interest in usability has increased in agile software development, difficulties remain in applying methods to synthesise these research findings, as there is no agreement on how user-centred methods should be incorporated (Curcio et al. 2019). According to Rommes (2014) participatory designs that more closely involve users have now been introduced into the development process in the IT-sector. However,

this is rarely the case at the beginning of development processes. Mostly, prototypes or final products are tested on users (cf. also Sarodnick/Brau 2011). Even then, diversity is seldomly taken into account in the selection of test persons. More often, such tests take place online and in the confines of a tech-savvy community, which is easy accessible and has a high willingness to take part in testing these products. Little attention is paid to how representative these tests subjects are. Similarly, testing for research purposes is usually carried out using students, simply because they are available (Rommes 2014).

Due to a lack of comprehensive methodological knowledge, standardized usability tests in the form of questionnaires are often used to record user orientation. These are commonly not adapted to the specific research context and qualitative methods are rarely used to either interpret quantitative results or adapt quantitative instruments to the requirements of the research (Ohl/Schade 2015). Questionnaires are also the most widely used method for assessing usability of eHealth applications and while they provide a general measure of usability they do not help in identifying problems that may need to be addressed (Maramba et al. 2019).

Experiences with usability research also show that users often find it difficult to explain and express their wishes and needs. This "tacit knowledge", von Hippel calls the problem of "sticky information" (Von Hippel 2005, 67). The targeted involvement of users in the development process and the use of qualitative and creative methods can help to solve this problem and make "tacit knowledge" usable. Overall, there is a lot to be gained from user orientation in the development of technologies.

In this paper, we would like to describe two research projects for the purpose of this argument, which were both funded through the FFG FEMtech projects funding scheme[26]. In both, we have applied a user-centred approach in order to improve the usability and increase the benefits of specific and more diverse target groups.

- The aim of the **VR4Care project** was to develop a gender-sensitive VR application to increase motivation, activation and improve the overall quality of life for residents of long-term care facilities. As the project did not have a medical background or goal, it exclusively focused on VR as a form of leisure activity. Based on the results of focus groups conducted by our project partner the Medical University of Graz and a first round of evaluation with residents of a nursing home, a VR-App including some specialised content were developed. Its usability was then tested in a second evaluation round, together with relatives and caregivers who had helped the residents in using the VR-App. In this paper, we will now focus on the methodology used, the results of the two rounds of evaluation, as well as the literature review.

[26] The two projects were funded under the funding scheme FEMtech Projects by the Austrian Research Agency FFG with the following project numbers: VR4Care (FFG Project Nr. 873757) and FEMCharge (FFG Project Nr. 873011).

- In **FEMCharge**, a decision-analysis-tool for the future expansion and design of e-charging infrastructure was developed. The role of JOANNEUM RESEARCH Policies and thus the authors of this article was to bring in the user perspective. Using interviews and focus groups, we investigated the usage habits and needs of e-car drivers regarding charging stations and their usability.

After describing our methodological approach, we will then focus on the results of these two research projects and thereby investigate which benefits there are in considering gender when developing technologies and why it is not enough to just look at gender as an isolated variable. Finally, we reflect on our methodological findings and discuss how the dimensions of gender diversity and other aspects of diversity were taken into account in developing these technologies, what limitations were encountered and how these might be addressed in the future.

2 Case study 1: VR4Care - Gender-sensitive virtual technologies for the activation of seniors in long-term care

Methodology[27]

At the beginning of the project we conducted a literature review in order to identify how sex, gender and other diversity dimensions such as educational background or age might play a role when it comes to VR technology and the residents of nursing homes. Within the framework of the evaluation, there were two waves of data collection, which will be described separately:

The first wave of data collection was focused on the **residents' experience of VR technology** and took place from September to October 2020. The virtual reality (VR) scenarios[28] had already been identified in previous focus groups (Schüssler et al. 2021) and had subsequently been implemented in a first VR-prototype. These were then tested in a nursing home in Styria with 20 test subjects[29], half of which were men and women respectively. Similarly, half of the test participants were in wheelchairs. 11 of the test subjects had only completed compulsory education, while 9 subjects had

[27] More detailed information about the methodological design see: https://www.researchgate.net/publication/363567239_Gender-sensible_Virtuelle_Technologien_zur_Aktivierung_von_Seniorinnen_in_der_Langzeitpflege_D72_Ergebnisse_der_ersten_Evaluierungsrunde_FEMtech_Projekt_VR4CARE

[28] In order to get a clearer picture how these scenarios looked like, we will give two examples. In one scenario, the camera was put on the head of a person and this person walked through a forest, filming a walk in nature. In another scenario, the camera was put statically on the top of a vineyard, showing the view on other vineyards and hills (incl. a “Klapotetz”, a typically Styrian scarecrow).

[29] The test persons already had the opportunity to get familiar with the VR technology a few months earlier.

completed some form of higher education. Individuals with severe visual and hearing impairments, neurological disorders, moderate and severe dementia, reflex epilepsy, severe physical limitations, and severe medical conditions were excluded from the study. The aim of this specific user-test was to find out how the 360° photos and video clips would be received by residents and which content-related and technical improvements as well as other further development were necessary. Each subject selected five scenarios of interest for testing in advance using a catalogue of 20 360° photos and video clips. The first week of testing was conducted by researchers together with members of the staff of the nursing home. Afterwards, the technology remained in the nursing home and was made available to residents for four weeks for further use, which was aided and documented by the staff. Subjects were able to select 5 scenarios per week to view. The following data was collected:

- *SSQ questionnaires (n=40):* The Simulation Sickness Questionnaire measures whether the VR application has an effect on the physical well-being of test subjects. For this purpose, the questionnaire was filled out by researchers together with the test subjects, before and after the user-test in the first test week.
- *Observation sheets (n=20)*: These sheets were filled out by researchers during the user-tests. Statements and reactions of residents during the use of the VR-application were noted.
- *Interviews (n=20):* researchers conducted interviews with subjects about the perception of the technology and the scenarios, as well as possible complaints or wishes. Finally, one interview was conducted with the nursing staff, who aided and documented the VR application for another 4 weeks. The interviews were recorded on audio.
- *Documentation from the nursing home (n=78)*: During the 4 weeks in which the VR technology was used in the nursing home, a member of the nursing staff documented whether and why the technology was used or why it was rejected, which scenarios were in demand, etc. This documentation was forwarded to the researchers after the end of the test phase.

Following the test phase, the manually completed questionnaires, documentation, observation sheets and audio tracks were digitalised or put into writing and analysed using the MAXQDA software. In data analysis, an emphasis was placed on gender- and diversity-related aspects as well as their intersections in order to make the technology and its contents suitable for all possible users. The results were shared with our project partners in order to inform the further development of this technology.
The second round of data collection focused on secondary end-users, such as nursing home staff and relatives and the usability of the VR-application. In June 2021, the prototype, developed in a previous work package was tested for usability at the same nursing home with five caregivers and five relatives. The aim of this evaluation was to find out how well the caregivers and relatives could handle the technical solution and

to what extent it should be better adapted to their needs and if these two target groups find that the VR application has potential for use beyond the scope of the experiment. This evaluation was co-prepared by staff of the nursing home and carried out by researchers. The following data was collected:

- *Observation questionnaires (n=10):* These were filled out by researchers during the usability test. User's statements and general behaviour during the use of the application were recorded and even more details were added afterwards, since the screen itself was also recorded during the test.
- *Interviews (n=10):* Researchers conducted interviews with the test subjects about their perception concerning the usability of the VR application.
- *Questionnaires (n=10):* These questionnaires were filled out by test subjects together with researchers and recorded some personal characteristics such as gender, age, education and former occupation, as well as their familiarity with computers and frequency of computer usage.

After the test phase, questionnaires, observation sheets and audio tracks were digitalised and subsequently analysed, again using the MAXQDA software. Analogue to the first round, a conscious emphasis was placed on gender- and diversity-related aspects as well as their intersections in data analysis, in order to make the technology and its contents suitable for all possible users.

The pre-emptive literature review[30] had indicated that gender and other diversity dimensions could play a role in VR-usability. On the one hand, the effects of gender and age can be observed in the use of many modern technologies and a so-called digital divide can be identified for both. This means that although older people are increasingly using these technologies, their level of use and added-value tends to be lower and their perspective is more negative than that of younger people (Cai et al. 2017; Eurostat 2016; Niehaves/Plattfaut 2014; Peek et al. 2014; Teo 2010).

A similar digital divide is observed in gender-sensitive analysis: Social gender - especially certain ideas about masculinity - is an important key-moderator in relation to attitudes towards technology and related behaviour. In regard to intersectionality, older women tend to have a more negative and reserved attitude towards technology than men of the same age and use it less as well as with some time delay (Hergatt Huffman et al. 2013; Lafontaine/Sawchuk 2015; Ma et al. 2015; Nayak et al. 2010; Polizäus-Hoffmeister 2015; Reußer et al. 2015; Sáinz/López-Sáez 2010; Wang/Wang 2010). The fact that societal gender roles prove persistent even among those with dementia (Boyle 2017) underlines the relevance of intersectional approaches for our project.

In the context of VR technology, there already exist concrete indicators for the inclusion of gender. Firstly, the variety of body-types needs to be taken into account when

[30] As the literature research was conducted in the beginning of the project, it does not represent the current state of the art.

designing VR-equipment and other hardware: Ideally, the lens of VR goggles needs to be centred directly in line with the eye's cornea. However, interocular distance varies based on sex, age and ethnicity and therefore, VR-glasses should be individually adjustable (LaValle 2017; Gewickey et al. 2018). In terms of content adjustment, there is less need for change pertaining to the user's body and more need for adaptation pertaining to gender (Weiss et al. 2004). The leisure activities of older people are usually shaped by their different individual interests, which are in turn shaped by gender-specific socialisation, the formatted gender roles and expectations resulting from role affiliation among other things. Additionally, it can be assumed that even visually, interests diverge based on gender in regard to VR (Brockmann 1998; Dathe 2011; Hollneck 2009; Lothwesen 2014; Oesterreich/Schulze 2011).

Luckily, this circumstance has already been successfully countered with the development of virtual environments that are as gender-neutral as possible (Eisapour et al. 2018). We also learned, that when introducing people to VR, it is important to bear in mind that getting used to virtual space takes a different amount of time from person to person and that it can have a variety of side-effects (LaValle 2017).

One of the major issues is so-called cyber sickness, which, in contrast to travel- or sea-sickness is not necessarily stronger in women, but tends to occur more frequently with them (McGee 1998; Mourant et al. 2000; Zacharias 2014). Because of this, including approaches that can mitigate cyber sickness and observing it from a gender perspective is in order (Becker/Ngo 2016; Keshavarz/Hecht 2016). Furthermore, first signs have emerged that men tend to experience virtual reality as more immersive in physical interactions, while the use of virtual reality is most attractive to women when it comes to visual stimulation lacking physical interaction and movement (Felnhofer et al. 2012; Kothgassner et al. 2013).

The findings of the literature review were considered in compiling the sample and collecting and analysing the data. What follows are the results of the two rounds of data collection we conducted in VR4Care:

Following the goal of better tailoring VR-technology to the needs of the target groups such as nursing home residents, their caregivers and relatives, this evaluation was able to provide insights regarding VR-content as well as the physical design of the application. However, this article will mostly focus on those results related to gender and diversity.

For the user-tests with nursing home residents, 20 360-degree images and videos were selected, based on the focus group's desired content. Each test subject was able to choose 5 scenarios to try out during the user test. Particularly popular were vineyards, an alpine hut, gardening, a cow pasture and singing in the mountains. Regarding the subsequent individual rating of the content, we were able to identify only slight differences dependent on gender, most of which did not fit a specific pattern. Overall, nature-related scenarios users had a personal connection to, as well as scenarios, which included moderate amounts of movement and audio, were among

the best received. In general, a combination of scenarios that offered a certain variety, but also put users in familiar environments and locations seemed to be important. However, with regard to subject's educational background, we found that people with higher levels of education were more willing to switch between the 20 scenarios on offer and view multiple scenarios over the course of the 4-week test period, when they had the option to use the VR-app once a week. People with lower levels of education tended to select the same scenarios to look at and switched less frequently. When asked about **additional desired content**, the difference between genders was small - women seemed to mention motives related to family somewhat more, while nature and foreign settings were somewhat more in demand among men. It was however noticeable that women, regardless of their educational background - showed a higher level of insecurity or even a negative attitude when asked about their wishes. Although, this reaction was not exclusive to female test subjects and also seemed to correlate with the level of care needed, it definitely seemed to be more pronounced with female users than male ones.

While it was always intended to obtain results on the perceived quality of the content, we also were able to obtain results on the **cinematic realization of VR scenarios**, which we did not foresee. Important factors here were the positioning of the camera (e.g. not too high or too close to objects, people, precipices), the speed of movement (not too fast). A majority of the comments on the level cinematic realization came from men.

Similarly, men commented more about the speed of the movement being too fast and complained about resulting dizziness, while women expressed slightly more anxiety about heights or steep slopes. The latter also seemed to be somewhat amplified with wheelchair users. Women with a low level of education also found it more difficult to state a critical perspective, while men expressed their opinion more freely, independent of their level of education.

Regarding the **physical effects of VR-technology**, men more often reported a slight strain on the eyes, while a feeling of pressure in the head was reported by only two of the female test subjects. Other problems, such as an increased difficulty focusing the eyes, mild fatigue, an upset stomach etc. were either relatively balanced between genders or did not occur at all.

During the second round of tests with relatives and caregivers on the **usability of the developed app**, the evaluation provided information on how to improve the user-interface, as well as recommendations for additional functionality. One example of features proposed, was being able to view what the user is seeing with the VR-goggles on a separate screen, so they have the possibility of talking about the content during the session. Contrary to the learnings from the literature review, female subjects coped better with using the VR-app in the usability test, than male test subjects. However, these differences might be attributable to age and experience with computers, as the female test subjects were younger on average and had more computer experience;

these two characteristics correlated in our study. Overall, the VR application was operable across all groups, with somewhat varying levels of support needed, which can be compensated through increased familiarization and a user-manual.

3 Case Study 2: FEMCharge – Gender- and diversity-appropriate positioning and equipment of e-mobility charging infrastructure

Methodology

As in the VR4Care project, a literature review was conducted for FEMCharge at the beginning of the project, to find out how gender and other diversity dimensions such as education or age might play a role in the use of e-mobility.
The data basis of the usability analysis were several online focus groups, as well as written responses to a set of interview questions and individual telephone interviews. In total, 16 people participated in the evaluation of the e-mobility charging infrastructure. Conducting focus groups was challenging due to coinciding with the COVID-19 pandemic. It was, thus especially difficult to reach a sufficient number of female e-car drivers for the sample. Therefore, individual telephone interviews with female customers of the Styrian energy provider Energie Graz were conducted. Through this, an equal number of female and male participants could finally be achieved. For our purposes, this deliberate diversification of the sample by way of including female and male, younger and older e-car owners as well as ones from economically different regions of Graz, seemed elementary to encompass a diverse range of perspectives, which might have remained partially hidden otherwise.
The resulting focus group data and interviews were recorded, put into writing and analysed qualitatively with the MAXQDA software.

Results

Our literature research[31] had shown that mobility has to always be considered embedded in existing societal structures, such as gender relations (VCÖ 2009). A variety of studies have similarly shown that women and men differ in their mobility behaviour (BMVIT 2016; Martens/Pauls 2001; Knoll 2013; 2016; CIVITAS; Muhr 2014; Amt der Steiermärkischen Landesregierung 2009; Glantschnigg/Hoser 2017; Peters 2013; Rasmussen 2009; Unbehaun et al. 2014a; 2014b; VCÖ 2009; 2015). This is mainly due to the distribution of labour that is part of traditional gender roles in relation to childcare, the care of relatives and working hours. Differences relating to gender can be found within the number of average journeys, the distance and duration of these journeys, the purpose of these journeys, the choice of transportation, the frequency of

[31] As the literature research was conducted in the beginning of the project, it does not represent the current state of the art.

accidents, and the general interest in e-mobility. On average, men also show a tendency for less complex mobility patterns with fewer, but longer journeys with less stops than those of women (Knoll 2013; Glantschnigg/Hoser 2017; Unbehaun et al. 2014b). While men and women without children primarily commute to work or to leisure activities, women with children do more service routes, e.g. driving the children. (Martens/Pauls 2001; Amt der Steiermärkischen Landesregierung 2009).
Similarly, women use a personal car less often and use public transport or walk instead (VCÖ 2018; Amt der Steiermärkischen Landesregierung 2009; Knoll 2013). Particularly young men are also more often involved in traffic accidents (Kuratorium für Verkehrssicherheit (KFV) 2017; Amt der Steiermärkischen Landesregierung 2009) and make up a higher percentage of traffic deaths (Das Land Steiermark 2019). According to a study from Germany, women are less likely to own an e-car (Cerbe/Machledt-Michael 2018). That there are gender differences in mobility behaviour seems obvious, however, these must be considered in the context of the living- and family-situation, phase of life, age, place of residence, socioeconomic position and cultural as well as ethnical background (Segert et al. 2017). Barriers to gender-responsive transport planning present as outdated concepts of transportation (Peters 2013), including male-dominated design of transportation-infrastructure (Rasmussen 2009; Pilz/Jauk 2005; Amt der Steiermärkischen Landesregierung 2009) and a lack of awareness when planning (Höller/Slamanig 2009; Unbehaun et al. 2014a, 2014b; Peters 2013).
As a consequence, marginalised groups have fewer opportunities for participation in urban planning (Martens/Pauls 2001), more anxiety and stress (Irschik 2013) and are more dependent on a car or another person with a car (Amt der Steiermärkischen Landesregierung 2009). The key to socially sustainable mobility is to ensure sufficient accessibility to relevant destinations, such as jobs, educational and supply facilities or leisure facilities for all groups of people (Lindner et al. 2016).
These findings from the literature review were considered in compiling the samples for the focus groups, designing data collection and analysis.
Over the course of FEMCharge, we gathered information on usage habits and factors for conveniently located charging stations, as well as wishes for the expansion of charging infrastructure and suggestions to improve the process of finding a charging station. The stations and charging app were also assessed regarding their user-friendliness.
The results were as follows:
In general, it can be said that the **research effort to find charging stations** and the higher effort for planning the charging activity are still a big challenge compared to the use of combustion vehicles. The use of the charging infrastructure is experienced as complex and non-transparent. In addition, information is often only available digitally, which can be an additional barrier, especially for older people. The high level of complexity also holds the potential to be a barrier for people who do not speak German such as tourists or people who are new to the country, since information was only

available in German. This user group might also lack contacts to other e-car owners to get help. The exchange of information among e-drivers was considered very helpful by the interviewees.

The **charging app** was slightly more popular among male respondents than among female ones. This could also be due to some women not using apps at all, while all male participants already use such apps and start the charging process more often with the app. The reason for this might be gender differences in socialisation, which make men tend to integrate technology more naturally into their everyday lives and have less reluctance than the majority of women.

Studies still show that women and men differ in terms of technology affinity and self-assessed technology competence (Reidl et al. 2020).

The effort involved in finding a free charging station, planning and carrying out the charging activity is also **difficult to integrate into the daily routine of working parents with small children** – here, it is still mostly mothers that shoulder this double burden. In the survey conducted by JR LIFE as part of FEMCharge (Seebauer et al. 2021), it became clear that women in particular, as well as people with lower incomes, are less willing or able to extend the length of stay for charging their car than men and people with higher incomes. It seems reasonable to assume, that this is due to a higher workload including unpaid work. Overall, the expansion of the charging infrastructure at locations central to everyday life as well as at home and a low-threshold provision of information (also offline, e.g. via telephone) would particularly benefit these groups.

The project was also key in identifying **concrete locations where charging stations are direly needed** in order to better integrate charging into a daily routine when there is no charging option at home. Fewer women than men reported being able to charge at work or at home. Here it would be interesting to see whether company charging stations tend to be found more commonly with employers in male-dominated industries and less in female-dominated fields like retail and elderly-care. This assumption is supported by the fact that in large cities more men than women have a parking space available at their place of work (BMK 2016). A focus on charging at the workplace also excludes the unemployed, pensioners, and those on parental leave or with other informal care responsibilities. At the same time, it would be interesting to investigate whether charging at home shows gender-specific differences in addition to differences specific to socioeconomic status. In the survey of JR LIFE within the framework of FEMCharge, it was also found that women are less likely than men to have a parking space at their place of residence or work. People with higher incomes are more likely to have a parking space at their place of work. Similarly, women and lower-income individuals see little or no opportunity to retrofit charging infrastructure at their place of residence. This underlines the assumption that there are gender and class-specific differences and this is a public infrastructure issue.

Additionally, the **costs of charging** was a central topic during the interviews and focus groups. Still, the high financial costs of e-mobility compared to combustion vehicles

represent an essential barrier, especially for people from lower income households. As women have a higher risk of poverty than men do and there is an evident gender pay and wealth gap (Statistik Austria 2020, 2021; Schneebaum et al. 2018), electric mobility is more difficult to afford for women than for men. This barrier mainly concerns the high purchase costs for private e-mobility. This is confirmed by a study from Germany, which shows that private e-drivers are predominantly male and come from educated milieus with a higher income, and are on average 51 years of age (Lenz et al. 2015).

Currently, charging costs are measured on a time basis rather than on a kW basis, which disadvantages certain groups with older, smaller and less expensive cars with lower charging capacities. People who therefore cannot use fast charging stations to their full capacity would like to be able to use them (also in terms of price) as "normal" charging stations. Otherwise, people with cars without the option of fast charging are financially disadvantaged and often have to switch to other “slower” charging stations. The group which did not use fast charging stations consisted exclusively of women. This is not to conclude that these are irrelevant for female e-drivers. However, further research should investigate whether women tend to drive cars with a lower charging capacity and driving range and thus benefit less from the implementation of fast charging stations.

In a study conducted in Denmark, Finland, Iceland, Norway and Sweden, some respondents still associated the size of a car with masculinity, even though this seems to be changing. Furthermore, “women report stronger preferences for environmentally friendly vehicles or those with better safety measures. Women similarly give less importance to acceleration, power, or sound, whereas men emphasize range, supposed sex appeal, and acceleration” (Sovacool et al. 2019). In a study for German market research with 1000 subjects, women showed fewer reservations towards the low range of e-cars (F: 28%, M: 46%) and thus seem to be open-minded towards smaller models with a lower range (puls Marktforschung 2017). Fittingly, female respondents in our study were more satisfied with the space available at the charging stations than men, which also suggests that they often have smaller cars. If this assumption were to be proven true, this means that women would be more disadvantaged by the charging measure based on time as opposed to kW.

4 Discussion and Reflection

The two projects show that we were able to produce gender- and diversity-specific results that are relevant for the further development of both technologies. Conclusively, we would also like to reflect on how this intersectional approach has worked in both projects and what its limitations are.

In VR4Care, the literature analysis showed gender and sex related differences in intraocular distance and other physical and psychological features in VR. Moreover,

gender together with age, education and occupational experience influence the interest to use VR technology (see grey coloured arrows in figure 1). As has been described, we actively tried to consider these dimensions in choosing our samples. This turned out to be quite challenging because of the relatively small number of nursing home residents who were physically, mentally and cognitively able to participate at all. The first round of evaluation confirmed some differences regarding gender, age and educational background, as described above. Moreover, we have found that there are differences in the feeling of safety during VR use between wheelchair users and non-wheelchair users. Additionally, the evaluation revealed that nursing home residents would not be able to use this technology independently.
The second evaluation round with relatives and caregivers showed that experience with computers is a key factor in supporting residents in using VR. This experience is of course a result of education, occupational experience and age (see figure 1).

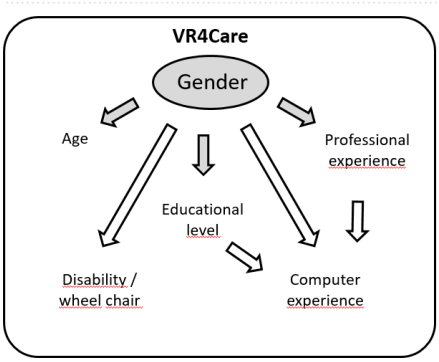

Figure 7: VR4Care - relevant diversity dimensions

In the literature review for FEMCharge, we found that gender specific mobility patterns are an issue, which is often influenced by informal care responsibilities and therefore life phases, but also regions of residence (see grey coloured arrows in figure 2). For this reason, we compiled our samples according to these criteria. In the interviews and focus groups, the usage of the charging app turned out to be challenging, especially for older e-car drivers with less computer experience. Moreover, we could identify discrimination of e-car drivers with cheaper and smaller cars, which are far more likely to be women. Additionally, we found that men were more likely to mention the possibility of charging at work, leading to the suggestion that male-dominated industries may be more likely to provide charging stations.

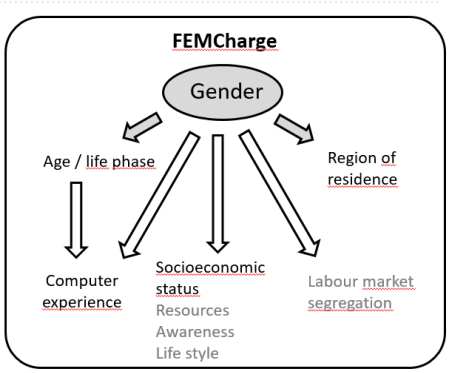

Figure 8: FEMCharge – relevant diversity dimensions

Overall, both projects have allowed us to add new perspectives and knowledge of intersectional contexts in both fields of research - even if these concepts of intersectional contexts remain simplified.

In both projects, the intersectional approaches spanned from the literature review, to the sampling, to incorporating findings from the literature in data collection instruments and data analysis as well as finally developing recommendations for more inclusive technology development. We actively tried to recognize people's multiple, interdependent and overlapping needs and axes of social identity (Crenshaw 2017), such as gender, socioeconomic status, age, disability, technological competence etc. However, due to the projects operating with small samples and on a qualitative basis we could only show which other diversity dimensions might be of relevance but could not investigate their interdependence. Therefore, a quantitative analysis with representative results would be required, which was not possible within the scope of these projects due to resource constraints. Even apart from limited resources, the question arises how to conduct a representative quantitative intersectional analysis and deal with the multidimensionality of diversity.

Our experience in VR4Care and FEMCharge also showed that it can be very challenging to compile diverse samples. In both projects, we were only able to select from a very limited pool of potential participants. Sometimes we had to be glad to get any participants at all. In a next project (FairCom) about using and designing online communication inclusively, where we are currently trying to include a gender diverse group of subjects, recruiting people with a diverse gender identity (e.g. non-binary) turns out to be even more difficult. For example, databases are still mostly created in a gender-binary way, which makes it difficult to address people specifically and correctly.

Especially when using participatory methods in technology development, there is another question of how to avoid involving a majority of extroverts. Introverts or those with sometimes self-perceived lower social-skills or educational distance very rarely come forward to participate in research projects.

In conducting the interviews in VR4Care, we also learned that elderly women with low education levels did not criticize VR technology at all. This leads to the assumption that women with lower education find it harder to criticise and to articulate their needs - perhaps due to gender-specific socialization. It is difficult to deal with this inherited reticence in research projects and not ignore the special needs of this group. Presumably, this would require data collection over a longer period of time by trusted individuals such as caregivers.

It can therefore be assumed that there are more barriers to participation in user-centred studies for (multiply) marginalised groups. For example, a working person with children and distant relatives will have even more limited time resources than a working person with children but sufficient (informal) childcare. Privileged people are more likely to assume that their opinion is relevant and important and should therefore be expressed - this may not be the case for marginalised groups. This is another common way research bias persists. In a current project, we are trying to address this problem by selecting people from observations and asking for support from multipliers. Overall, we face the challenge of developing our recruitment strategies as well as communication and methods to ensure that everyone feels welcome. A financial allowance can also be a way to value the invested time and sharing of negative experiences and knowledge of discrimination.

Overall, we see that an intersectional approach demands engagement, creativity and flexibility and must always be adapted to the specific context. Perhaps we also need the courage to leave gaps in data and set certain priorities, since diversity usually cannot be taken into consideration in its full variety without overwhelming us. Nevertheless, we try to use the results of these projects with their limitations for the benefit of all, to contribute to the development of more inclusive and user-friendly technology.

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