Situated Abilities: Understanding Everyday Use of ICTs

THESIS SUBMITTED FOR THE DEGREE OF PHILOSOPHIAE DOCTOR (PH.D.)

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Abstract

BACKGROUND. Universal Design (UD) refers to the design and development of products and services so that as many people as possible can use them. However, historically, UD was associated with disabilities laws and movements regarding the physical environment. Lately, the UD of digital environments or Information Communication Technologies (ICTs) has been emphasized in several studies. Many studies on UD for ICTs cover research on people with physical or cognitive disabilities, such as studies on people with dyslexia, autism, deaf or blind people. While this thesis recognizes and supports the importance of such research, it emphasizes situations in which fully-abled individuals still encounter challenges in their everyday use of ICTs. Thus, the thesis proposes the concept of situated abilities.

AIM. This thesis aims to introduce, talk about, and discuss situated abilities as referring to human abilities in situations they experience in their everyday interaction with and use of technologies without categorizing people into those who are able or disable.

THEORY. The thesis is theoretically anchored in phenomenology. Specifically, the lens used to reflect upon the conceptual apparatus of situated abilities is the concept of *Befindlichkeit* from Heidegger's existentialism. This can be translated as situatedness.

METHOD. This thesis subscribes to an interpretive paradigm, with critical intent. The methodology adopted is an instrumental collective case study and is represented by two different cases. The first case considers the everyday use of moving technologies, e.g., robots in the homes of elderly and non-elderly participants. The second case considers the everyday use of Digital Learning Environments (DLEs) in Higher Education. Qualitative methods were used for data collection and analysis. The methods include interviews, photos, domestic probes used as participants' diary notes, observations, log reports, document analysis, headnotes, and Story-Dialogue Method (SDM. The data was analyzed through inductive analysis, such as latent and manifest analysis, and Systematic Text Condensation (STC). Other methods used for data analysis are thematic analysis and SDM.

FINDINGS. The general findings from both cases can be summarized as follows: the design of ICTs work for many people, but not for some individuals. Thus, both Case 1 and Case 2 illustrate that current designs may suit some, but not all. The overall findings from both cases demonstrate that most participants encountered challenges in interacting with ICTs, both with the robots and with Digital Learning Environments, regardless of their age, previous experience or exposure to ICTs. However, they were not medically diagnosed with any cognitive disabilities. The participants' abilities in their everyday interaction with and use of ICTs depended on the design of the ICTs and the situations at hand. Although the participants were generally abled in their everyday life, they found themselves less abled in certain given situations when interacting with- and using ICTs. Moreover, many participants were often unable to comprehend how to interact with and use the ICTs due to their design and their own situated abilities. Besides, many of the participants were often unable to manage their interaction with and use with the ICTs. Finally, many of the participants found the everyday interaction and use not meaningful, at times even frustrating, when the interaction with ICTs was neither suitable nor enabling. Finally, the overall key findings from both cases included in this thesis can be summarized in the overall theme and concept of situated abilities.

CONTRIBUTION. The contributions consist of a main- and several smaller contributions. The main contribution is the concept of situated ability that emerged as a response to the findings from both cases. The concept of situated abilities is defined, framed, explained how it emerged, and exemplified with concrete examples in a dedicated chapter. Its anatomy is presented together with the situated ability continuum that includes low- and high-end abilities. The concept is also analyzed through the *Befindlichkeit* concept, but also in terms of Universal Design (UD), Human-Computer Interaction (HRI), Human-Robot Interaction (HRI), and Computer-Supported Cooperative Work (CSCW). In addition, some ethical implications on the concept are also included. At the same time, the smaller contributions consist of a salutogenic approach to design, concept development, introducing qualitative data analysis methods well established in the medical field to the design fields, as well as introducing a new workshop method of both data collection and analysis introduced to the HCI community.

CONCLUSION. Based on this thesis, a shift in perspective from disabilities to people's abilities is proposed in order to be able to design and develop products and services that accommodate human beings' situated abilities. Moreover, the UD discourse ought also to regard the situated abilities of individuals, not only their disabilities. This is a salutogenic approach. Lastly, situated abilities can open up an understanding of the everyday use of digital technologies and systems, including welfare technologies, by promoting understanding the experienced and lived situations of the users as human beings.

FURTHER WORK. This thesis suggests that there is a need for legal frameworks, standards, guidelines, and recommendations for designing and regulating robots to be used in the public sector, including healthcare, homecare, and education. Moreover, this thesis suggests that studies in UD shall also regard the abilities and situatedness of the individuals when using multiples digital technologies or systems and not simply the design and use of single individual digital technologies or systems. Finally, the application of the situated abilities concept can be further explored in philosophical and theoretical questions on the autonomy of human beings and their relationships with digital technologies, along with the development of contemporary technologies, based on Artificial Intelligence and Machine Learning. These may include robots, chatbots, and other digital technologies or systems that can, to some degree, delegate tasks to humans.

KEYWORDS. Two cases, ICTs, everyday technology, everyday experiences, robots, Digital Learning Environments, Universal Design, situated abilities, situatedness.

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Diana Saplacan

Diana Saplacan

Oslo, Norway, 29 September 2020

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List of Abbreviations

Abbreviation	*Explanation*
ABD	Ability-Based Design
CHI	International Conference on Computer-Human Interaction
CSCW	Computer-Supported Cooperative Work
DESIGN	Research Group for Design of Information Systems, at University of Oslo
DfA	Design for All
DLE	Digital Learning Environment
H-A-R	Human-App-Robot
HCI	Human-Computer Interaction
HE	Higher Education
H-R	Human-Robot
HRI	Human-Robot Interaction
ICT	Information Communication Technology refers, in this thesis, specifically to robots used in the home and to Digital Learning Environments used in Higher Education.
IfI	Department of Informatics at the University of Oslo (from Norwegian: Institutt for informatikk)
LEARN	Project application at the Norwegian Center for Research Data (NSD) for conducting the Ph.D. study
LMS	Learning Management System
MECS	Multimodal Elderly Care System
NordiCHI	Nordic Conference on Computer-Human Interaction
NSD	Norwegian Center for Research Data
OK+	Omsorg Kampen+, Bymyssion, accommodation for elderly
ROBIN	Research Group for Robotics and Intelligent Systems, at University of Oslo
RSCW	Robot-Supported Cooperative Work
SDM	Story-Dialogue Method

TSD	Services for Sensitive Data (from Norwegian “tjenster for sensitive data”)
UD	Universal Design
UDFeed	Project on Universal Design in Higher Education
UiO	University of Oslo
UN	United Nations
USIT	IT-Department of the TSD service group at the University of Oslo
WHO	World Health Organization

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Papers that are included in this thesis

Project 1: Papers within Multimodal Elderly Care Systems (MECS) Project

Paper I

(Conference paper, MECS) Saplacan, D., Herstad, J., Pajalic, Z. (2020). An analysis of independent living elderly's (≥65 years) views on robots and welfare technology – A descriptive study from the Norwegian context. *Proceedings of the Thirteenth International Conference on Advances in Computer-Human Interactions (ACHI),* ISSN 2308-4138, pp. 199-208.

Paper II

(Journal paper, MECS) Saplacan, Diana & Herstad, Jo (2019). An Explorative Study on Motion as Feedback: Using Semi-Autonomous Robots in Domestic Settings. *International Journal on Advances in Software.* ISSN 1942-2628. Vol. vol. 12, nr. 1&2, pp. 68- 90.

Paper III

(Journal paper, MECS) Saplacan, D., Herstad, J., Tørresen, and Pajalic, Z. (2020). A Framework on Division of Work Task between Humans and Robots in the Home, *Multimodal Technologies Interactions*, vol. 4, nr. 44, ISSN: 2414-4088, p. 22.

Paper IV

(Journal paper, MECS) Saplacan, D., Herstad, J., Schulz, T. (Accepted 09.11.2020), Situated Abilities within Universal Design – A Theoretical Exploration, *submitted to International Journal On Advances in Intelligent Systems*, vol. 13, nr. 3&4, 2020, ISSN: 1942-2679, p. 14.

Project 2: Papers within Universal Design in Higher Education (UDFeed) Project

Paper V

(Conference paper, UDFeed) Saplacan, D. (2020). Cross-Use of Digital Learning Environments in Higher Education: A Conceptual Analysis Grounded in Common Information Spaces, *In Proceedings of the Thirteenth International Conference on Advances in Computer-Human Interactions (ACHI),* ISSN 2308-4138, pp. 272-281. (Best Paper Award)

Paper VI

(Journal paper, UDFeed) Saplacan, D., Herstad, J, Pajalic, Z. (2020). Use of Multiple Digital Learning Environments: A Study about Fragmented Information Awareness. *Interaction Design and Architecture(s) Journal (IxD&A),* nr. 43, 2019-2020, ISSN 1826-9745. pp. 86-109.

Paper VII

(Conference paper, UDFeed) Saplacan, D. (2020). Situated ability: A Case from Higher Education on Digital Learning Environments, 22nd International Conference on Human-Computer Interaction (HCII 2020), Copenhagen Denmark, 19-24 July 2020, published in Antona M., Stephanidis C. (eds) *Universal Access in Human-Computer Interaction. Applications and Practice, Lecture Notes in Computer Science,* Part I, vol. 12189, Chapter 19. Springer, Cham. https://doi.org/10.1007/978-3-030-49108-6_19, e-ISSN 1611-3349, ISBN 978-3-030-49107-9, p.19.

Papers that are *not* included in this thesis[1]

(Journal paper, MECS) Saplacan, Diana (Second review). The invisible work to make the robot work work: A study about escaping robots, digitalization and automation of homecare services, *submitted for publication to Computer Supportive Cooperative Work, The Journal of Collaborative Computing and Work Practices.* e-ISSN 1573-7551.

(Conference paper, MECS) Saplacan, Diana & Herstad, Jo (2017). A Quadratic Anthropocentric Perspective on Feedback - Using Proxemics as a Framework, in Lynn Hall; Tom Flint; Suzy O'Hara & Phil Turner (ed.), *Proceedings of the 31st International BCS Human-Computer Interaction Conference (HCI 2017)*. British Computer Society (BCS). ISBN 9781906124045, p. 6.

(Conference paper, MECS) Saplacan, D., Herstad, J. (2018). Fear, feedback, familiarity… how are these connected? Can Familiarity as a Design Concept Applied to Digital Feedback Reduce Fear?. *in Proceedings of the Eleventh International Conference on Advances in Computer-Human Interactions (ACHI).* (Best Paper Award), ISSN 2308-4138, pp. 171-179.

(Conference paper, MECS) Newaz, Fahd & Saplacan, Diana (2018). Exploring the role of feedback on trust for the robots used in homes of the elderly, in Tone Bratteteig & Frode Eika Sandnes (ed.), *NordiCHI '18 - Proceedings of the 10th Nordic Conference on Human-Computer Interaction, Oslo, Norway — September 29 - October 03, 2018*. Association for Computing Machinery (ACM). ISBN 978-1-4503-6437-9. Robots and autonomous things, pp. 681 – 685.

(Conference paper, MECS) Saplacan, D., Herstad, J. (2019). Understanding robot motion in domestic settings. In 2*019 Joint IEEE 9th International Conference on Development and Learning and Epigenetic Robotics (ICDL-EpiRob)*, Oslo, Norway, 2019, pp. 67-74.

(Conference paper, MECS). Herstad, J., Schulz, T., and Saplacan, D. (2021 – conference postponed due to Corona, submitted). T-able: An Investigation of Habituating Moving Tables at Home. *Fifth International Conference on Universal Design*, IOS Press.

(Workshop paper, UDFeed) Saplacan, Diana; Herstad, Jo; Mørch, Anders Irving; Kluge, Anders & Pajalic, Zada (2018). Inclusion through design and use of digital learning environments: issues, methods, and stories, in Tone Bratteteig & Frode Eika Sandnes (ed.), *NordiCHI '18 - Proceedings of the 10th Nordic Conference on Human-Computer Interaction, Oslo, Norway — September 29 - October 03, 2018*. Association for Computing Machinery (ACM). ISBN 978-1-4503-6437-9. Workshops. pp. 956 – 959.

(Conference paper, UDFeed) Saplacan, Diana; Herstad, Jo; Elsrud, Marthe & Pajalic, Zada (2018). Reflections on using Story-Dialogue Method in a workshop with interaction design students, in Barbara Rita Barricelli; Gerard Fischer; Daniela Fogli; Anders Mørch; Antonio Piccinno & Stefano Valtolina (ed.), *Cultures of Participation in the Digital Age: Proc. of the Fifth Int. Workshop on Cultures of Participation in the Digital Age: Design Trade-offs for an Inclusive Society co-located with the International Conference on Advanced Visual Interfaces (AVI 2018)*. CEUR Workshop Proceedings. Design Trade-Offs in Education. pp. 34 – 43.

(Conference paper, UDFeed) Saplacan, Diana; Herstad, Jo & Pajalic, Zada (2018). Feedback from Digital Systems Used in Higher Education: An Inquiry into Triggered Emotions - Two Universal Design Oriented Solutions for a Better User Experience, in Gerald Craddock; Cormac Doran; Larry McNutt & Dónal Rice (ed.), *Transforming our World Through Design, Diversity, and Education*. IOS Press. ISBN 978-1-61499-922-5. Studies in Health Technology and Informatics. pp. 421 – 430.

(Workshop paper) Bratteteig, T., Saplacan, D., Soma, R., Oskarsen, S. J., (2020). Strengthening human autonomy in the era of autonomous technology: Contemporary perspectives on interaction with 'autonomous things.' in *NordiCHI'20.* (ACM). Workshops. p. 3.

[1] These papers are outside of the scope of this thesis. However, their findings and learnings contributed to each of the research projects, e.g., MECS and UDFeed and to my understanding of the concept of situated abilities.

Part I Setting the scene

Introduction

Positioning this thesis in design fields

On Universal Design

Theory

Paradigm, methodology, and methods

Chapter 1 INTRODUCTION

"I can't keep up with it, unfortunately!"
— Participant, Interview (Paper I, p. 203)

"*I can't keep up with it, unfortunately!*" – This was the worry voiced by one of the participants who took part in one of the studies that is part of this thesis (Saplacan, Herstad, and Pajalic 2020). He expressed his worry about the fast development of modern and advanced technologies, including the everyday use of smartphones and robots. He felt surpassed, overwhelmed, despised, and somehow ashamed that he could not master these technologies in his everyday interactions and use of them.

Although these feelings are common amongst many of the users of current everyday technology, it is still somehow bizarre that we humans do not put the blame and those feelings on the technology that we interact with– and on its design. If we play a bit with the plasticity of the participant's words and turn them around, he could perhaps have said: "*That technology – it does not keep up with **me**, unfortunately*!". Many of us, human beings, often put the blame, the shame, and all those feelings of inadequacy, on ourselves rather than on the design of the everyday technologies we interact with– or use. It is suddenly our fault that we as human beings cannot master paying our bills through internet banking, buying a digital travel ticket through a smartphone when we do not even own a smartphone, or remembering PIN-codes and passwords for all the websites that the digital society asks us to be part of, including the tax system, the national health system, or the education system. Of course, the list could continue with other similar examples that you might identify yourself with, but I will stop here for now.

These forms of shame, frustration, anxiety, or other feelings reflected by being lower abled in a situation when we interact with or use technology in our everyday lives are, for us, a form of taking responsibility for something that was not well enough designed to accommodate us or our situated abilities. Instead of putting that responsibility on the designer, or why not, on the society itself, we often end up putting it on the weight of our shoulders. We, as human beings, experience all kinds of feelings when we feel less or higher abled. "As Heidegger describes, we are always in some 'mood,' i.e., 'anxiety,' which is associated with something subjective. Subjectivity can also feel respected or humiliated, proud, indifferent or ashamed, elated or depressed, etc. – something objects do not." (Østerberg 2011, p. 105, own translation from Norwegian). As the author says, the objects do not have these feelings. So why not saying then: "*That technology – it does not keep up with **me**, unfortunately*!". In that way, we can put the responsibility on the objects representing the technology, and their (bad) design. However, the design is usually made for the "average user" although the "average user" does not exist. As Story, Mueller, and Mace (1998) say, we are all unique human beings. Another approach to design is to design products and services that suit a wide range of people, including people of all ages, children, young and old, and people of all abilities or for those "inconvenienced by circumstance" (Story, Mueller, and Mace 1998, p. 2). Such design is defined as Universal Design.

Historically, Universal Design was often associated with the dichotomic pair of abilities vs. disabilities of human beings. Several legislative changes and disability movements stand at the basis of Universal Design such as the U.S. federal legislation, the Civil Rights Movement in the 1960s, the barrier-free movement in the 1950s, the American Standards Associations that pledged to make buildings accessible for the disabled, the accessibility legislation later coming into force during the 1970s, and the Architectural Barriers Act in 1968 (Story, Mueller, and Mace 1998). Moreover, at the basis of Universal Design also stands The Rehabilitation Act (1973), The Education for Handicapped Children Act (1975), The Fair Housing Amendments Act (1988), The Americans with Disability Act (ADA) (1990), and The Telecommunications Act (1996) (Story, Mueller, and Mace 1998). However, these movements are related mainly to the physical environment. The term of Universal Design was later defined by R. Mace as "*the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design*" (emphasis added) (Story, Mueller, and Mace 1998, p. 2). The Universal Design term was used to describe the idea of "designing all products and the built environment to be aesthetic and usable to the greatest extent possible by everyone, regardless of their age, ability, or status in life" (Center for Universal Design, North Carolina State University 2008). As the authors say, Universal Design respects human diversity and promotes the "inclusion of all people in all activities of life" (Story, Mueller, and Mace 1998, p. 2).

Although, historically, Universal Design was associated with disability laws and movements regarding the physical environment, lately, a focus on the Universal Design of digital environments or Information Communication Technologies (ICTs)[2] has been emphasized in several studies (see Fuglerud 2014; Begnum 2018; Begnum 2019; Vavik 2009; Bai et al. 2016; Fuchs and Obrist 2010).

Moreover, R. Mace, in his last speech, at *Designing for the 21st Century: An International Conference on Universal Design*, in 1998, explained that Universal Design broadly defines the user, explaining that the focus of Universal Design is *not* on *people with disabilities*, *but* on *all people* (Center for Universal Design, North Carolina State University 2008). It can also be observed that in his definition, R. Mace never mentions *disabilities.* He advocates for the idea that we, the human beings, are all disabled in some way, or become disabled with age (Center for Universal Design, North Carolina State University 2008), as was illustrated in his last public speech: "Universal Design broadly defines the user. It's a consumer market-driven issue. Its focus is not specifically on people with disabilities, but all people. It actually assumes the idea that everybody has a disability, and I

[2] ICT is defined as the technology for gathering, storing, retrieving, processing, and analyzing and transmitting information, according to (ISO/IEC 2019)

feel strongly that that's the case. We all become disabled as we age and lose ability, whether we want to admit it or not. It is negative in our society to say 'I am disabled' or 'I am old.' We tend to discount people who are less than what we popularly consider to be 'normal.' To be 'normal' is to be perfect, capable, competent, and independent. Unfortunately, designers in our society also mistakenly assume that everyone fits this definition of 'normal.' This just is not the case." (Excerpt from R. Mace last speech, at *Designing for the 21st Century: International Conference on Universal Design*, June 19, 1998. Edited Text by J. Reagan, August 1998. Emphasis added).

Along the same lines, questions may be posed, such as: what happens when a human being's situation changes, such as a new moving object, say a robot, is introduced to the home? What happens when a human being's situation changes, such as a webpage interface changes its layout, and the user cannot find their way around it anymore? What happens when the human being's context is virtually distributed on several online platforms, or when the user needs to distribute their attention between all of these new digital forms?

Similar to R. Mace's view and the original definition of Universal Design, this thesis talks about the concept of *situated abilities*, without dividing human beings into *abled* and *disabled*. Specifically, the focus in this thesis is situations experienced in our everyday lives that en-able our interaction with and use of technologies or those that make us feel less abled.

Thus, the *phenomena* under the study in this thesis are *situations* and *abilities*, or, in other words, the *situatedness of our abilities* when we interact with and use everyday technology. The unit of analysis is represented by situations from human beings' everyday lives when they interact with and use technology. The human beings' situated abilities can be experienced as lower or higher abilities on an ability continuum.

One example of such experienced *situated abilities* is, for instance, when one experiences oneself as less able to borrow a book from the library via a digital system, e.g., an e-library system, rather than going to the library desk and asking for it from the library personnel (Saplacan, Herstad, and Schulz 2020). Another example is when a person is asked to use an Ubuntu Operating System based computer when the person is used to either using a Mac or a Windows computer. He or she will, at the start, feel less abled in using that specific computer, experiencing low situated ability. A third example is when a person is asked to use internet banking when the person is not used to using an online payment service. Even in this case, the person will feel less abled, experiencing a lower situated ability than if he went to a bank and got help directly from the bank personnel with his errands.

Thus, the *aim* of this thesis is to introduce, talk about, and discuss *situated abilities* as a form of abilities in situations that are experienced by human beings in their everyday interaction with and use of technologies. The concept adds a new dimension to look at the abilities of human beings, a positive laden, a salutogenic one, where the focus is on the abilities of the human beings, rather than their disabilities. Moreover, the thesis moves away from the dichotomy of abled vs.

disabled people, illustrating that all human beings may experience themselves as less or more abled in certain situations, in their everyday interactions with and use of technologies. An ability/disability view is indirectly pathogenic since it also focuses on the disability of human beings. However, many of us human beings are not necessarily medically diagnosed as disabled – however, we still encounter challenges in our everyday interactions and use of technologies. This is often encountered not necessarily because we are disabled, but because of the design of the technologies themselves.

Hence, this salutogenic approach is adopted as a way of enabling us to talk about these forms of situated abilities from a salutogenic perspective. It is not a "real-world" problem to be solved per se, but it is a way for us, researchers in design, designers, and human beings, to understand our interaction and use of digital technologies from a different perspective, without categorizing the human beings into those that are able and those that are disabled. The specific thesis grounding this work is that we, researchers in design and designers, should aim for universally designed products and services that can be used by as many people as possible, without further adaptation or customizations. Thus, this thesis is anchored in R. Mace's original definition of Universal Design, without focusing on the disabilities of the human being.

Further, I have illustrated this through two different cases in this thesis to understand everyday situations and human beings' abilities to interact with and use technology in their everyday life. *Case 1* is about understanding everyday interaction with and the use of robots in the home. *Case 2* is about understanding everyday interaction with and the use of multiple Digital Learning Environments (DLE) in Higher Education. These two cases are contrasting: while *Case 1* focuses on things that are quite novel for the majority of users (semi-autonomous moving objects in the home, e.g., robots), *Case 2* focuses on online DLEs that may seem more familiar to us, since we are more used to desktop interaction. These two cases are illustrative for semi-autonomous *moving things* (Case 1) and respectively, for the *desktop metaphor* (Case 2). I have used both cases instrumentally to understand everyday interaction and the use of these ICTs.[3] However, my intention was never to compare these two in the way an experimental study would do by applying the same parameters to both cases. Instead, both of the cases are instrumentally used to understand everyday situations on interaction with and use of technologies, and how these lived experiences are understood by human beings. Although each of the cases is so different from the other, we can still learn from each of them. The concept of *situated abilities*, or the situatedness of the human beings' abilities, emerged as a finding from these two apparently different cases – however, both cases illustrate situations when the participants, although not medically diagnosed as disabled, regardless of their age, interest, skills, or experience with ICTs still experience *situated abilities* in their everyday interaction with and use of ICTs.

[3] From now on, throughout the thesis, I will refer to the collection of interfaces used in Case 1, robots used in the home, and Digital Learning Environments (DLE) from Case 2, as ICTs.

1.1 Motivation – abilities in design fields[4]

The notion of ability dates back to the 14^{th} century, from the French ableté; however, it originates from the Latin habilitatem (Oxford English Dictionary, 2020). The antonyms unability and inability were later introduced during the 14^{th} and 15^{th} centuries (Oxford English Dictionary, 2020). The notion of disability was formed only during the 16^{th}-17^{th} century, with the meaning of "loss of power" or having incapacities in the front of the law (Oxford English Dictionary, 2020). In design studies, with the focus on Universal Design, many discourses about (dis)ability studies have their point of departure in the dichotomy pair of abilities-disabilities.

Further, several researchers write about Universal Design and abilities-disabilities dichotomic pair, in one or another form. Some have focused on inclusion, others on the diversity of people, others on the available legislation concerning Universal Design and accessibility. For instance, Fuglerud (2014) wrote her Ph.D. thesis on the inclusive design of ICTs and the challenge of diversity. Her Ph.D. thesis covers cases on inclusive design in ICT services, buildings, products, and services. Berget and Sandnes (2016), and Berget, Herstad, and Sandnes (2016) focused instead on dyslectic students. Begnum (2019) focused on the legislation concerning the implementation of the Universal Design of ICTs. She wrote several papers talking about experts' views on the Universal Design of ICTs (Begnum 2016b; Begnum 2017; Begnum 2016a; Bue Lintho and Begnum 2018). Some have written about designing for capabilities of individuals, without entering the polemics of Universal Design, but rather from a Participatory Design perspective. For instance, Joshi (2017) has written his Ph.D. thesis on this topic. He wrote several papers on designing for experienced simplicity (Joshi 2015) and the prolonged mastery of the elderly (Joshi and Bratteteig 2016).

A few others have elevated the idea of designing for abilities in different forms. For instance, Frauenberger (2018) talks about designing for different abilities. However, some of his work focuses on designing for the abilities of medically-diagnosed individuals, such as designing for the abilities of autistic children (Frauenberger 2015; 2007). Thus, the dichotomy of abilities-disabilities is indirectly present by indirectly adopting a medical model perspective.

At the same time, others talk about situational impairments or situational induced impairments (see Jupp, Langdon, and Godsill 2007; Macpherson et al. 2018; Mott and Wobbrock 2019; Sarsenbayeva 2018; Tigwell, Flatla, and Menzies 2018a; 2018b; Wobbrock 2019; Wolf et al. 2019). These studies focus on the impairments experienced by users induced by a situation when they interact with digital technology. This refers indirectly to a pathogenic view.

However, others adopt a salutogenic view and talk about Ability-Centered Design (ACD) (Evenson, Rheinfrank, and Dubberly 2010), or Ability Based Design (ABD) (Wobbrock et al. 2011). For instance, Wobbrock (2017) introduced the idea of ABD as an alternative way of designing for disabilities. He has written about ABD in several publications (see Wobbrock et al. 2011; 2018).

[4] Text adapted from (Saplacan 2020b; Saplacan, Herstad, and Schulz 2020)

Ability Based Design refers to designing for the abilities of people, rather than their disabilities. Wobbrock et al. (2011) described the concept of ABD by framing a set of principles and supporting it with examples. Wobbrock and colleagues argue that one cannot have disabilities as one cannot have “dis-height” or “dis-money” (Wobbrock et al. 2011, p. 91). ABD systems are systems that focus on what an individual can do, where the system is somehow aware of the user’s abilities, such that it can adapt and accommodate the individuals’ abilities (Wobbrock et al. 2011). The challenge with the ABD systems is, according to them, that there is a high variation in the abilities of the users. However, as an ideal, such systems should be able to adapt and re-configure themselves to its users' abilities, shifting the responsibility to the designer of the systems, and to the system themselves, not the other way around, to the users (Wobbrock et al. 2018). Further, they mentioned that ABD is an ideal, where any individual could interact with any given system, at any time, based on his or her “situated abilities” (Wobbrock et al. 2018, p. 3). Such a perspective would require a Global Public Inclusive Infrastructure, according to Vanderheiden and Treviranus (2011) and Vanderheiden et al. (2014). Along the same lines, Vanderheiden, in his latest talk during the 22nd International Conference on Human-Computer Interaction (HCII) 2020, brought to light the idea that it is more and more usual for individuals to have a low digital affinity, which he describes as an inclination or talent to use digital technologies (Vanderheiden 2020). He argues that this is different from digital (i)literacy: people with low digital affinity are those who cannot understand technology, although they try to understand it. Also, Wobbrock and colleagues argue that disabilities reside in the disabling environment and situations, rather than within the individual himself (Wobbrock et al. 2018). Although the term “situated abilities” was mentioned in the authors’ work (ibid, p.3), it was never defined, framed, explored, or further anchored. Thus, this thesis sheds light on the concept of situated abilities, by revitalizing it, defining, and framing it.

1.2 Empirical contexts

The proposed thesis includes two cases. Each of the cases is carried out within the framework of two different research projects. Both of them are briefly explained next.

Case 1, presented in this thesis, *Understanding everyday use*[5] *of robots in the homes*, was conducted within the framework of the Multimodal Elderly Care System (MECS) project. MECS is a project funded by the Research Council of Norway and the IKTPluss Program (reference number 247697), and it took place between 2016 and 2019 (currently prolonged to February 2021). Omsorg Kampen+ (OK+), an accommodation facility for independently living elderly people in Oslo, Norway, is amongst the project partners representing the public sector. Xcenter AS and Noveldata AS, working with sensor technologies, as well as the previous robot companion company Giraff Technology AB (Sweden), are amongst the partners representing the private sector. The Norwegian

[5] I will refer to *use* throughout this thesis as both with the sense of *use* and with the sense of *interaction*.

Center for Integrated Care and Telemedicine is representing the collaboration with research institutions. Other international collaborations are the Adaptive System Research (ASR) at the University of Hertfordshire (UK), the Intelligent Systems Research (ISR) Lab at the University of Reading (UK), and Technological University of Eindhoven (Holland). The manager of the project is Professor Jim Tørresen at the University of Oslo (UiO). The project was conducted through internal cooperation at the University of Oslo, between the Research Group for Robotics and Intelligent Systems (ROBIN), with Professor Jim Tørresen as the project manager for the ROBIN group, and the Research Group for Design of Information Systems (DESIGN), with Associate Professor Jo Herstad as the project manager for the DESIGN group. The overall aim of the MECS project was to "*create and evaluate multimodal mobile human supportive systems that are able to sense, learn, and predict future events*."[6] The project was organized into five (5) Working Packages (WP) on Sensor Systems (WP1), User-Centered Design (UCD) (WP2), User Testing (WP3), Behavior Modeling (WP4), and Detecting and Predicting Behavior (WP4). My main focus was in WP2 and WP3. Specifically, WP3 was concerned with the type of robots that the elderly wished to have in their homes, especially for those not interested in such technical solutions. WP3 was concerned with testing technological prototypes before implementing technical solutions with the elderly at OK+. The proposed thesis contains four papers (Papers I-IV) on behalf of the MECS project and as part of *Case 1: Understanding everyday use of robots in the home,* presented in this thesis. An extensive description of *Case 1* is available in Part II, Chapter 6.

Case 2, presented in this thesis, *Understanding everyday use of Digital Learning Environments in Higher Education*, was conducted within the framework of the UDFeed Project. The project entitled "Universal Design in Higher Education" (UDFeed) is a qualitative pedagogical project at the University of Oslo (UiO), Faculty of Mathematics and Natural Sciences, Institute of Informatics (Ifi). The project was funded by Universell ("Universell" 2017), the National Coordinator of Accessibility of Higher Education in Norway (reference number: 2017/22876). On behalf of the Norwegian Ministry of Education and Research and the Norwegian Royal Ministry of Children and Equality, Universell allocates incentive funds annually to increase competences about Universal Design as a concept within Higher Education (HE). UDFeed is one of the projects that got external funding in December 2017 and was implemented during 2018. The project manager for this project was Associate Professor Jo Herstad, whereas the project coordinator was the Ph.D. Candidate, Diana Saplacan. The overall aim of the project was to develop knowledge on Universal Design within Higher Education, to create an arena for new interdisciplinary collaborations, and to increase awareness of Universal Design in Higher Education. The proposed thesis contains three papers (Paper V-VII) on behalf of the UDFeed project. An extensive description of each of the

[6] Source: Project Description in the MECS Official Project Proposal

studies makes up part of Case 2 *Understanding everyday use of Digital Learning Environments in Higher Education* and is available in Part II, Chapter 7.

1.3 Research questions

The research questions that are asked lead the researcher to collect relevant data material. However, the research process is much more complex, and often, the initially stated research questions may change along the way, be re-formulated, re-iterated, and re-thought. In qualitative research, the initial research questions are "to orient" the researcher towards the field of research (Holter and Kalleberg 1996, p. 34). In the same way, the research questions addressed initially in this research have changed along with the research process and have been re-iterated. Different papers which make up part of this thesis answer parts of the research questions, or their answers helped to build the research. In this section, I explain the research questions addressed in the research presented and how they were answered.

One may address three different types of research questions. These are descriptive-/constative, normative/critical, and constructive research questions (Kalleberg, 1992; Holter and Kalleberg, 1996). The descriptive research questions are addressed when one wishes to describe the conditions or situations, and explanations of how something changes or stays the same when one wishes to document something, explain, tell, and present, and interpret something (Kalleberg 1992). For instance, descriptive research questions are illustrated through *how* the reality is for someone, and what the elements are that build it. The normative questions are evaluating or criticizing an existent reality (Kalleberg 1992). These point out equalities and inequalities, justice and fairness, and are strongly connected to values (Kalleberg 1992). These questions may be *why*-questions, challenging existing values, and pointing to power balance. Finally, constructive questions point out alternatives to a present situation or phenomenon, and they often focus on transitions (Kalleberg 1992). These questions are *what*-questions focusing on improvements (Kalleberg 1992).

This thesis explores two main research questions (RQ). Each of these questions is stated below and explained thereafter in the next sections.

> ***RQ1:*** *How do human beings understand and experience situations from their everyday use of ICTs?*

> ***RQ2:*** *How can human beings' abilities and their relation with ICT's design be defined and talked about without focusing on human beings' disabilities?*

1.3.1 RQ1: How do human beings understand and experience situations from their everyday use of ICTs?

The first research question is a descriptive one and has two other sub-questions. Each of the sub-questions is connected to a specific case: Case 1 and Case 2, respectively. These are:

> ***SRQ1:*** *How do human beings understand and experience situations from their everyday use of a domestic robot in the home? (Case 1)*

> ***SRQ2****: How do human beings understand and experience situations from their everyday use of Digital Learning Environments in Higher Education? (Case 2)*

The first main question is an abstraction of the two sub-questions. The first sub-question (SRQ1) focuses on investigating the interaction and use of domestic robots in the home. The second sub-question (SRQ2) concentrates on investigating the interaction and use of multiple Digital Learning Environments in Higher Education. By asking these descriptive questions, I am trying to understand, qualitatively, the phenomena surrounding individuals in specific situations. The answers to these questions are illustrated through the empirical findings from each of the cases reported in the papers included in this thesis. The answers to these sub-questions are illustrated in this thesis in Ch. 6, on Case 1, and Ch. 7, on Case 2. While reading the findings from the two cases in each of these chapters may seem to only make sense for each of the individual cases, the findings from both of the cases put together resulted in the overall theme and the concept discussed in this thesis, namely, of *situated abilities*. The understanding from both cases is fused into the overall theme of *situated abilities,* which is described in a dedicated chapter, Ch. 8.

1.3.2 RQ2: How can human beings' abilities and their relation with ICT's design be defined and talked about without focusing on human beings' disabilities?

The second research question is formulated as descriptive, but it is inherently critical and constructive, meant to explore the human being's relations with *things*, with ICTs, based on how one finds oneself in a situation, depending on one's experienced abilities in relation to the world. As McGrath (2005) says, interpretive research may produce critical elements, but critical work can produce less interpretive elements. Along the same lines, the research conducted, as part of this thesis, is interpretive. However, the outcome, especially the answer to the second research question, is critical. The second research question is inherently critical because it looks at the idea of the Universal Design of digital technologies and our relations with these ICTs. Universal Design is inherently critical, stemming from disability studies, feminist, or the queer movement. The question can also be described as constructive since it searches for alternatives. If so far, Universal Design was often associated with pathogenic values and disability studies, by moving its focus from the core values of Universal Design, I wished to anchor such a question in a salutogenic approach, focusing on the abilities of human beings. However, through this question itself and its answers, I wish to shift the focus of design and Universal Design towards abilities. Thus, the question is also inherently constructive because it tries to look for alternative ways of talking about design, focusing on the *situated abilities* of human beings instead of their disabilities.

Moreover, the question itself and the concept of situated abilities introduced in the question is anchored within Heidegger's *Befindlichkeit* (Heidegger 2010) philosophical concept. Heidegger's *Befindlichkeit* is about being *situated* and *situatedness* (Gendlin 1978; Ciborra 2006).

The second research question, as opposed to the first main research question, does not limit itself to a specific case, but it explores human beings' relations with things. This is not only a theoretical question but a philosophical one. The value of posing and exploring the question in this thesis is that human beings' abilities and our *being-in-the-world*, to use Heidegger's words, can be better understood concerning design. Theoretical concepts, described in Case 1 and Case 2, cannot do this work as a philosophical concept can, according to Gendlin (1978). However, they can help our understanding of our relations with ICTs.

Lastly, situated abilities anchored in Heidegger's *Befindlichkeit* philosophical concept is an answer to a theme that emerged from both cases. The theme emerged was that of *situated abilities* of users as human beings' everyday interaction with and use of ICTs. Therefore, I also consider it a finding. A dedicated section on this can be found in Ch. 8, where I explain this conceptual apparatus of *situated abilities*, which is then further discussed in Ch. 9, as this is also the main theoretical contribution of the thesis.

1.4 **Adopting an eclectic view**

Along with this thesis and the cases included in this thesis, I have learned that research should do more than just fitting its context or discipline: the research and the knowledge generated through the carried research should be transferrable. To do this, I have adopted an eclectic way of carrying out research, i.e., by bringing inspiration from different fields. Along the same lines, Walsham (2012) argues that a field needs interdisciplinarity and methodological pluralism. For instance, he argues that some fields, such as information systems, are already interdisciplinary as they are; it is not possible to isolate the topics in a field since the issues discussed are "inextricably interlinked," and that we have a lot to learn from working with other disciplines (p. 90). I also subscribe to this way of thinking and doing research about design – not because I am against the traditional way of subscribing to single disciplines or their sub-disciplines, and not because I do not think that the traditional way of carrying out research and a thesis is "good enough." I subscribe to this interdisciplinary way of researching because I identify myself with this eclectic way of thinking and approaching research. It comes naturally to me. I understand it. It challenges me and my intellectual curiosity. Along the same lines as Walsham (2012), McGrath (2005) supports this approach. She cites Walsham (1993, p. 6) in her work and says that "theory is both a way of seeing and a way of not-seeing" (McGrath 2005, p. 91), meaning that when we limit ourselves to one theory or one way of seeing things, we might miss out on other ways of seeing things. The value of seeing things through multiple angles and perspectives is that we can find out things that we would not find out otherwise. Thus, understanding the everyday interaction and use of ICTs through multiple angles, interdisciplinarity, and methodological pluralism helped me compress the findings, bring out the essence, and look at them from a new perspective, namely *situated ability*. This interdisciplinarity and methodological pluralism are visible throughout the papers I have included in this thesis, and respectively through the thesis itself. Moreover, McGrath (2005) also suggests that "deep understanding and rich descriptions can only take us so far" (p. 98). She means that while interpretive research can help us to document and map out a complex understanding of a state of affairs, it does not address or pursue change, retarding further development. Thus, the value brought by this thesis relies upon: first, documenting the state of affairs through the first research question, e.g., Case 1 and Case 2; and second, looking for alternatives as an answer to the second research question, which brings in some critical elements.

1.5 Limitations

This thesis presents situated abilities as a salutogenic alternative to discussing Universal Design. However, the thesis does not focus on Web Content Accessibility Guidelines (WCAG) or on the ergonomics of robots.

1.6 Contributions

This thesis consists of seven papers, four belonging to the first case, while three belong to the second case. These are listed below. Table 1-1 at the end of this section shows an overview of the contributions with their corresponding papers and the research questions they answer.

1.6.1 List of papers

(Case 1) **Paper I.** (Conference paper, MECS) Saplacan, D., Herstad, J., Pajalic, Z. (2020). An analysis of independent living elderly's (≥65 years) views on robots and welfare technology – A descriptive study from the Norwegian context, in *Proceedings of the Thirteenth International Conference on Advances in Computer-Human Interactions* (ACHI), ISSN 2308-4138, pp. 199-208.

(Case 1) **Paper II** (Journal paper, MECS) Saplacan, Diana & Herstad, Jo (2019). An Explorative Study on Motion as Feedback: Using Semi-Autonomous Robots in Domestic Settings. *International Journal on Advances in Software*. ISSN 1942-2628. 12(1&2), pp. 68- 90.

(Case 1) **Paper III** (Journal paper, MECS) Saplacan, D., Herstad, J., Tørresen, and Pajalic, Z. (2020). A Framework on Division of Work Task between Humans and Robots in the Home, *Multimodal Technologies Interact*., vol. 4, nr. 44, ISSN: 2414-4088, p. 22.

(Case 1) **Paper IV** (Journal Paper, MECS), Saplacan, D., Herstad, J., Schulz, T. (Submitted), Situated Abilities within Universal Design – A Theoretical Exploration, submitted to *International Journal On Advances in Intelligent Systems*, v 13 n 3&4 2020, p. 14

(Case 2) **Paper V.** (Conference paper, UDFeed) Saplacan, D. (2020). Cross-Use of Digital Learning Environments in Higher Education: A Conceptual Analysis Grounded in Common Information Spaces. In *Proceedings of the Thirteenth International Conference on Advances in Computer-Human Interactions* (ACHI), ISSN 2308-4138, pp. 272-281. (Best Paper Award)

(Case 2) **Paper VI.** (Journal paper, UDFeed) Saplacan, D., Herstad, J, Pajalic, Z. (2020). Use of Multiple Digital Learning Environments: A Study about Fragmented Information Awareness. *Interaction Design and Architecture(s) Journal* (IxD&A), nr. 43, 2019-2020, ISSN 1826-9745. pp. 96-109.

(Case 2) **Paper VII.** (Conference paper, UDFeed) Saplacan, D. (2020). Situated ability: A Case from Higher Education on Digital Learning Environments, 22nd International Conference on Human-Computer Interaction (HCII 2020), Copenhagen Denmark, 19-24 July 2020, published in Antona M., Stephanidis C. (eds) *Universal Access in Human-Computer Interaction. Applications and Practice, Lecture Notes in Computer Science, Part I*, vol. 12189, Chapter 19. Springer, Cham. https://doi.org/10.1007/978-3-030-49108-6_19, e-ISSN 1611-3349, ISBN 978-3-030-49107-9, p.19.

The overall contribution of this thesis is the proposed concept of situated abilities and its ability continuum, anchored in Heidegger's *Befindlichkeit*, and the work of Antonovsky (1996). The papers' individual contributions can be structured into four contributions: a salutogenic approach, concept development, analysis, and a new method introduced to the HCI community. I explain each of these contributions as follows.

1.6.2 A salutogenic approach

The shift in focus from a pathogenic approach to a salutogenic approach, i.e., from what users cannot do to what users can do, is illustrated in several of the papers included in this thesis (Paper I, Paper IV, Paper VII). This shift of focus is inspired and anchored in the work of Antonovsky (1996). His work has inspired, amongst others, the idea of situated abilities that this thesis brings to the foreground.

1.6.3 Concept development

Throughout the papers belonging to each of the cases, some small contributions were made to concept development. For instance, feedback, one of the main HCI concepts, has been explored and investigated, and new classifications and attributes of the feedback were found, such as motion as feedback (Paper II). Other concepts belonging to the CSCW field were explored on behalf of the cases, such as work tasks, fragmented information awareness, or common information spaces (Paper III, Paper V, Paper VI). Further, the concept of situated ability has been proposed as a new concept in the area of a salutogenic approach towards the debate of Universal Design, shifting the Universal Design focus from disabilities to abilities (Paper IV, Paper VII). This is also the main contribution of this thesis.

1.6.4 Analysis

Different analysis methods have been described in detail across different papers. While some of the analysis methods were familiar within the design communities this thesis addresses, others were not. Some of these qualitative analysis methods were inspired by the medical field. The medical field is not only known for its rigor in analyzing data and reporting results, but it has already developed a range of methods that it is proved through this thesis, can be applied even in the design fields. Nevertheless, McGrath (2005) argues that many papers are not transparent enough about their methods. She also encourages the transparency of these methods. For instance, the reader can find the following methods presented in detail in a range of papers: manifest and content analysis (Graneheim and Lundman 2004) (Paper I), thematic analysis (Braun and Clarke 2006) (Paper III), and systematic text condensation (Malterud 2012) (Paper V, Paper VI, or in Paper VII).

1.6.5 New method introduced to the HCI community

A new method was introduced to the HCI community, namely the Story Dialogue Method (Labonté 2011a; Labonte, Feather, and Hills 1999). This method is both a data collection and analysis method, which is different from classic data collection only, or data analysis only methods. The method was presented in one of the papers included in this thesis (Paper VI) and proposed as a workshop method in a workshop proposal for NordiCHI 2018 (Saplacan, Herstad, Mørch, et al. 2018).

Table 1-1 Overview of relations between the contributions, papers, and research questions

Contribution	Paper	RQ1		RQ2
		SRQ1	SRQ2	
A salutogenic approach	Paper I	X		X
	Paper IV	X		X
	Paper VII		X	X
Concept development	Paper II	X		
	Paper III	X		
	Paper IV	X		X
	Paper V		X	
	Paper VI		X	
	Paper VII		X	X
Analysis	Paper I	X		X
	Paper II	X		
	Paper V		X	
	Paper VI		X	
	Paper VII		X	X
New method introduced to HCI	Paper VI		X	

1.7 Thesis design

The thesis is structured from two cases, each of them having three main phases: analysis, understanding, and respectively framing the main contribution of this thesis, the concept of situated abilities. For the initial research questions, RQ1 drives the cases, whereas the second, RQ2, helps with positioning the concept of situated abilities in design fields. An overview of how the cases and their corresponding papers hang together, as well as how the cases and the research questions are integrated into this thesis, is given in Figure 1-1.

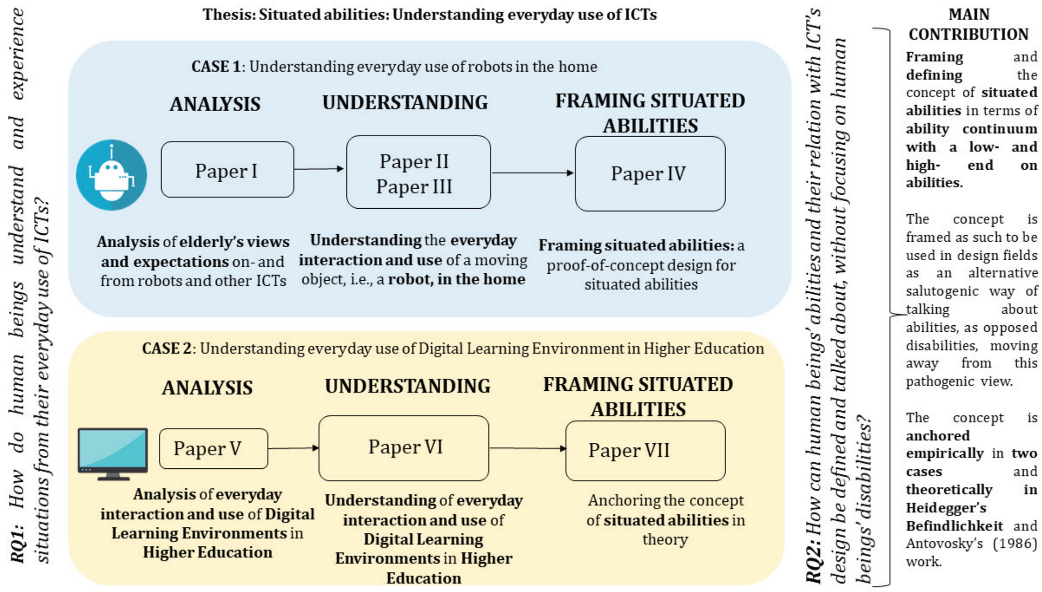


Figure 1-1 Thesis design – overview

1.8 The intended audience for this thesis

This thesis addresses academics in the field of design, with the purpose of bridging the distance between Human-Computer Interaction (HCI), Human-Robot Interaction (HRI), Computer-Supported Cooperative Work (CSCW), and Universal Design (UD) academics and designers. The proposed concept of situated abilities sews together and bridges the gap between these fields.

1.9 Outline of the thesis

The thesis is divided into IV main parts. Each of these is introduced below.

Part I: Setting the scene (Chapters 1-5) – In this part, the thesis is introduced, and the positioning of the thesis is presented as a background chapter. Thereafter, a chapter on Universal Design is included. Afterward, the theory chapter explains how theory is used in this thesis. The method chapter covers the paradigm, methodology, data collection and analysis methods, ethical considerations, and positionality of the researcher.

Part II: Presentation of cases (Chapters 6 and 7) **–** This part presents two of the cases described in this thesis. This part includes details about each of the cases, in two separate chapters, each one being dedicated to a single case. Each of the chapters contains sections covering the background of that specific case, the study design for each of the specific cases, and the specific methods used in each of the specific cases. A summary of papers is included in each of the chapters. Findings and a short discussion belonging to each of the cases are also described.

Part III: Putting things together (Chapters 8-10) **–** From the diffractive view that was taken on in Part II where I gave rich details on each of the cases, in Part III, I converge back to the main part of this. Specifically, this part of the thesis steps again outwards the cases themselves and is dedicated to the thesis' proposed concept of situated abilities. Then it continues with a discussion on how each of the research questions was answered. Nevertheless, the discussion also reflects on areas brought into the discussion in the background of the thesis, e.g., the fourth wave of HCI, Universal Design. It also includes a discussion on implications stepping outside of the design fields. This part is closed then with the conclusion, including a summary, final conclusions, and some suggestions for further work.

Part IV: Publications – This last part, including all the papers belonging to this thesis.

1.10 Writing style and recommendations on how to read the thesis

The thesis has a realistic account style of writing. A realist account pretends to describe the world as it is, indicating that "knowledge involves perfect, omniscient sight" (Crang and Cook 2007, p. 153). This realist account can be encountered, especially through the papers included in this thesis. The majority of the papers, and even this thesis, have a positivist flavor in terms of how the thesis is structured, the tables and diagrams that are included, and the rigor of the methods. However, neither the message of the papers nor the thesis is positivistic but rather interpretive with perhaps, at times, a critical intent (specifically, when answering the second research question).

The papers were mainly written through writing-through-codes (Crang and Cook 2007a), using Graneheim and Lundman (2004) and Braun and Clarke (2006) for writing up the findings from the data, and montage writing, especially when using Malterud (2012) to analyze and report on the findings. Montage writing refers to a fragmentary understanding that is put together. Montage writing was even used for this thesis: by first understanding the findings from Case 1 and Case 2, and only then putting the main findings of the thesis together.

The thesis is also written analytically, and richness of details can be observed throughout the thesis. I have used the writing in the papers I have written so far to sort out my thinking and understanding of the fields. Or, as van Manen (2006) says, "writing creates a space that belongs to the unsayable" (p. 718). He continues: "Like Orpheus, the writer must enter the dark, the space of the text, in the hope of seeing what cannot really be seen, hearing what it cannot really be heard, touching what cannot really be touched. Darkness is the method" (p. 719). In the same way, I have, perhaps at times, lost myself in writing, but I have eventually seen the light. This thesis is written to shed light on what I have seen, and hopefully, it will not bring you to the darkness where I was at times. I also hope you can find my writing as an anamnesis, and not as a hypomnesis, to use the words from Derrida and Ferraris (2001) in van Manen (2006, p. 719). You can also find my personal touch of writing, especially in the Paradigm, methodology, and methods chapter, Ch. 5, where I dedicated an entire section to the reflexivity and positionality of the researcher, e.g., myself.

The thesis in itself is built from several independent or semi-independent parts. I recommend, therefore, the following alternatives for reading the thesis:

(1) Read the thesis from Part I to Part III through a single read. You may have to make some stops and also read the papers at some point, which can be found in Part IV.

(2) Start with reading Part II, Case 1, and then Case 2. You can read Case 1 first and its corresponding papers, and then Case 2 and its corresponding papers. The papers are available in Part IV. Only then turn back to Part I, and thereafter read Part III – if you are still interested.

(3) Read Part I and Part III to get an idea of the thesis. You can opt thereafter to read each of the cases in detail, in Part II, and its corresponding papers that can be found in Part IV.

Chapter 2 POSITIONING THIS THESIS IN DESIGN FIELDS

"Nothing in life is to be feared; it is only to be understood. Now is the time to understand more, so that we may fear less."

—Marie Curie (1867-1934)

This chapter gives an overview of the design fields addressed by the papers included in this thesis: Human-Computer Interaction (HCI), Human-Robot Interaction (HRI), and Computer-Supported Cooperative Work (CSCW). [7]

2.1 Human-Computer Interaction (HCI)

The field of Human-Computer Interaction (HCI) is defined as the "discipline concerned with the *design*, *evaluation,* and implementation of interactive computing systems *for human use* and with the *study of major phenomena surrounding them*" (Hewett et al. 1992, p. 5, emphasis added).

The field has evolved over time, shifting slightly its focus from the "*interaction as a form of man-machine coupling"* to "*mind and computer as coupled information processors,"* to *"interaction as phenomenologically situated,"* where the researcher focused on meaning-making of the situation of use (Harrison, Sengers, and Tatar 2007, pp. 3-8). These different ways of knowing are referred to in the philosophy of science as paradigms, i.e., in Kuhn's (1970) work on structures of scientific revolutions, or as generative metaphors in Agre's (1997) theory. Following Kuhn (1970), such a paradigm is characterized by specific ways of knowing. Paradigm shifts occur due to crisis, while changes in the world views emerge, as scientific revolutions (Kuhn 1970). In this absolutist view, the new ways of knowing to replace the old ways of knowing (Kuhn 1970). Agre (1997) has a slightly different view. His approach supports the idea that different paradigms may co-exist at the same time.

Similarly to Agre's (1997) approach, HCI can also be divided into different paradigms (Harrison, Sengers, and Tatar 2007) or, as Bødker (2015) calls them, waves. In HCI, we can identify three such paradigms or waves. Recent research indicates that a fourth wave is on its way (see Frauenberger 2019; Ashby et al. 2019; Forlizzi 2018). Along the lines of Agre's (1997) approach, Bødker (2006; 2015) and Duarte and Baranauskas (2016) argue that although the HCI waves are characterized by different attributes and elements, they should not be ignored or forgotten when a

[7] Universal Design is addressed later in a dedicated chapter, namely Ch. 3.

wave transcends to a new one, but rather their attributes should co-exist, or be inherited into the next wave. In the next subsections, I give an overview of the current HCI waves.

2.1.1 First wave

The early field of HCI stemmed from engineering (Duarte and Baranauskas 2016) and emerged along with the field of human factors and ergonomics, in the 1980s (see Figure 1 in Grudin, 1994, p. 21), following the development of data processing management in information systems in the 1960s, and software engineering development in office automation, in the 1970s. The field focused on the interaction between the individual and the product, e.g., PC application. The field was driven by experiencing critical incidents. Such an example evolved within the Air Forces when they realized that they needed to gain the pilot's attention in case of an error. Since the pilots at the time were males, they introduced the female voice as the "emergency voice" for gaining the pilots' attention (Harrison, Sengers, and Tatar 2007, p. 10).

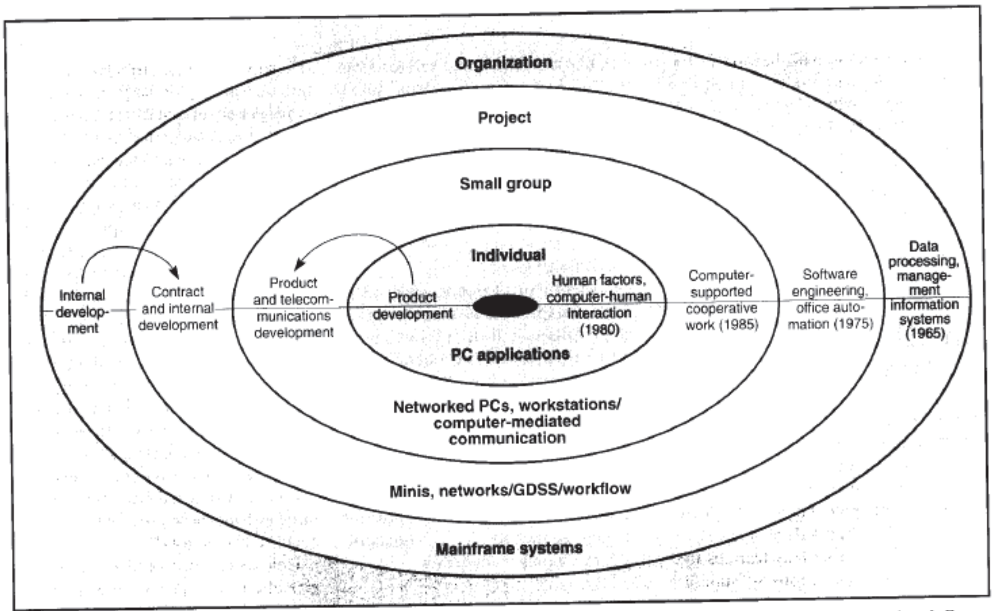


Figure 1. US research and development contexts for computer-supported cooperative work and groupware. Each ring defines a work level (organization, project, small group, or individual) and its corresponding systems (listed directly below the hub of the figure) and software development (left) and research (right) areas.

Figure 2-1 Overview over the fields - from Grudin (1992, p. 21)

Further, during the time, the interaction was perceived as a form of "man-machine coupling" (Duarte and Baranauskas 2016, p. 1; Harrison, Sengers, and Tatar 2007, p. 3). This first HCI paradigm took a pragmatic approach to understand the meaning of interactions (Harrison, Sengers, and Tatar, 2007). However, by the end of the 1980s and the start of the 1990s, Bannon (1989; 1992) criticized the perspective on the human part of the HCI, where the human is seen as a part of a computer system, rather than individuals as actors, with their agency, who are not passive 'components' of a computer system.

Moreover, this first wave of HCI focused on cognitive science and human factors and ergonomics. It embedded rigorous methods, and the human being was studied through formal and systematic methods as a 'subject' (Bødker 2015). Besides, the first wave is characterized by measurements, such as measuring the efficiency of the interaction (Ashby et al. 2019). In other words, the hallmark of the first HCI wave was experimental HCI (Bannon 1992). The wave can be framed within the positivism and post-positivism movement, following Duarte and Baranauskas (2016), while its theoretical foundation in the early days of HCI, in the 1980s, relied upon information processing and cognitive psychology (Kaptelinin et al. 2003). However, some of the limitations of this approach were illustrated in Suchman's (1987) work on *Plans and Situated Actions*, and in Winograd and Flores's (1986) work on *Understanding Computers and Cognition*. The first wave moved slightly forward to a second wave, towards the cognitive science revolution (Duarte and Baranauskas 2016).

2.1.2 Second wave

The metaphor describing the second wave is *"mind and computer as coupled information processors"* (Harrison, Sengers, and Tatar 2007, p. 3, emphasis in original). The focus during the second wave was mainly on user-centered design (Forlizzi 2018), investigating what happens in the human minds when interacting with machines (Duarte and Baranauskas 2016). During this wave, mind models were developed (Duarte and Baranauskas, 2016). For instance, Gibson's (1979) work was used to understand interaction through the concept of affordance. However, the second wave also focused on the groups and their interactions within communities of practices (Bødker 2015).

Moreover, during this wave, researchers from the HCI field noticed that interaction with computers was often not limited to interacting with a single computer (see, for instance, Bellotti and Bly, 1996), but one had to interact with multiple digital artifacts to perform the work (Bødker 2006). Hence, during this phase, attempts were made to divide the work between humans and machines (Bannon 1992).

Specific theories for studying the interaction between humans and computers were activity theory and distributed cognition (Bødker 2006), phenomenology (Winograd and Flores 1986), ethnomethodology (Suchman 1987), but also Norman's (2013) *Design of everyday things.* Moreover, during the second wave, a lot of focus was concentrated on context (Bødker 2006).

Methodologically, the focus in the second wave was on "participatory design workshops, prototyping, and contextual inquiry" (Bødker 2015, p. 1), and on groups (Bødker 2006). Other fields, such as Participatory Design (PD) and Computer Supported Cooperative Work (CSCW), developed during the second HCI wave (Bødker 2015).

The second wave can be framed as positivist and positivist-post-positivist, but also as constructivist-interpretive movements, floating between those, following Duarte and Baranauskas (2016). However, since PD emerged during the second wave, the wave also has some critical-ideological elements.

2.1.3 Third-wave

The third wave's focus is on *situated perspectives* while recognizing the subjectivity of the researchers, i.e., the relation between the *researchers* and the *researched* (Harrison, Sengers, and Tatar 2007). The third wave focused on the spread of technology from the workplace into the home environment, into the everyday lives of individuals, and culture (Bødker 2015), within the public and private spheres (Bødker 2006). The third wave started with questioning participatory design methods, opting for new forms of participatory methods such as cultural probes (Gaver, Dunne, and Pacenti 1999), seeking new ways for the users to contribute to the design and the design process.

In other words, the third wave's focus was mainly on User Experience (UX) (Forlizzi 2018), trying to reintroduce the humanities into HCI (Duarte and Baranauskas 2016). Affective computing (see Picard 1995) evolved into new forms of approaching emotions and HCI, such as positive computing (see Calvo and Peters 2014). Moreover, the third wave can be characterized as having its focus on consumer technology, participation, and sharing (Bødker 2015). Culture, emotion, experience, and reflexivity are a few of the elements included in HCI studies during the third wave (Bødker 2006). The third wave is also portrayed by new forms of interaction with technologies, such as those covered by pervasive computing, augmented reality, or tangible interaction (Bødker 2006), embodiment, or somaesthetics (Höök 2018). Finally, the third wave can be framed within the critical-ideological and constructivist-interpretive movements, following Duarte and Baranauskas (2016).

2.1.4 Fourth wave

Whether or not a fourth wave was on its way five years ago when Bødker (2015) wrote about the third wave during the CHI 2015 conference was not clear by then. She instead encouraged others to investigate the question (Bødker 2015). During the Halfway to the Future (HttF) Symposium in 2019, Ashby et al. (2019) took on Bødker's (2015) challenge to identify the fourth HCI wave. The fourth wave is described as value-laden rather than value-neutral as the previous waves were, according to Ashby et al. (2019). The authors also argue for pushing harder beyond the institutional changes and criticism, while shifting its focus to "activism at all levels," the covered aspects including accessibility and diversity (Ashby et al. 2019, p. 1). The fourth wave encourages being thoughtful about the design, but also about its implications, pledging for activism towards positive change within HCI while addressing large political issues and embedding values and ethics (Ashby et al. 2019).

Along the same lines, Forlizzi (2018) argues that HCI moved beyond the user-centered design and User Experience (UX), and its focus is rather on stakeholder-centered design instead, where the focus is moved from developing products to developing complex services for the use of multiple stakeholders. She continues saying that both laws and policies should be taken into account, beyond the technology systems, and the stakeholder and individual users (Forlizzi 2018).

Further, Frauenberger (2019) proposes the “entanglement HCI” as the nexus wave. He addresses the issue of the relations between humans and machines becoming diffused with the development of social robotics, artificial intelligence, virtual technology, or self-driving cars, challenging the HCI field and its current boundaries (Frauenberger 2019). He argues that the third wave with its “situatedness, values, and embodiment” is, in a way, “ill-equipped” for dealing with these complex technologies (Frauenberger 2019, p. 21). The author calls for more philosophical debates on what he calls the ‘homo digitalis,’ but also on ethics and responsibility (Frauenberger 2019, p. 2). Since humans’ relations with such digital technologies become more complex and entangled, he suggests that entanglement theories can tackle the moral and ethical challenges that come along with the complex relations we develop with these advanced digital technologies (Frauenberger 2019).

2.1.5 Epistemological commitments of the HCI waves

I have merged the information above and created the table below to give an overview of the epistemological commitments of the HCI waves. This representation is mainly based on the earlier work of Frauenberger (2019), Harrison, Sengers, and Tatar (2007), Bødker (2006; 2015), and Ashby et al. (2019).

	First wave	Second wave	Third wave	Fourth wave
	Human Factors, Ergonomics (Grudin 1994)	Cognitive revolution	Situated Perspectives	Entanglement HCI
Interaction	Man-machine coupling (Duarte and Baranauskas 2016, p. 1; Harrison, Sengers, and Tatar 2007, p. 3)	'mind and computer as coupled information processors' (Harrison, Sengers, and Tatar 2007, p. 3)	Phenomenological views on situated perspectives (Harrison, Sengers, and Tatar 2007)	Entaglement HCI? (Frauenberger 2019)
Interaction goal	Optimization and measurements of efficiency (Ashby et al. 2019). Testing the interaction. Problem solving.	Optimizing the interaction. Focus on the improvement of the interaction. Focus on the improvement of the interaction. Hypothesis testing, rather than problem solving (Harrison, Sengers, and Tatar 2007). The work was divided between humans and machines (L. Bannon, 1992).	Consumer technology, participation and sharing (Bødker 2015). Construction of the situation for successful interaction. Pervasive computing, augmented reality, or tangible interaction (Bødker 2006). Identifying design tensions and practical trade-offs (Harrison, Sengers, and Tatar 2007). Embodiement, or somaaesthetics (Höök 2018).	Social robotics, artificial intelligence, virtual technology, or self-driving cars (Frauenberger 2019). Focus on service design. Focus on interdisciplinary and understanding interaction from multiple disciplines views.
Scientific movement	Positivism and post-positivism (Duarte and Baranauskas 2016).	Floating between positivist and positivist—post-positivist movements, but also within constructivist-interpretivist movements, according to Duarte and Baranauskas (2016). The wave has also some critical-ideological elements.	Critical-ideological and constructivist-interpretivist movements, according to Duarte and Baranauskas (2016).	Critical and constructivist-interpretivist. (?) Wave anchored in philosophical concepts. (?) Crosscutting boundaries of different disciplines.
Theories	Cognitive psychology (Kaptelinin et al. 2003). Phenomenology as in Winograd and Flores (1986).	Affordance concept from Gibson (1979). Activity theory and distributed cognition (Bødker 2006). Phenomenology inspired from Winograd and Flores (1986). Theoretical behavioral science theories.	Phenomenology. Situatedness. Positive computing (see Calvo and Peters 2014).	Entanglement theories, such as socio-materiality (Frauenberger 2019). Theories stemming from universal design?
Methodology and methods	Focus on programming and ergonomics. Experiemental HCI (L. Bannon 1992). Formal and systematic methods. Engineering methods.	Ethnomethodology inspired by Suchman (1987). Norman's (2013) Design of everyday things. Focus on context (Bødker 2006). Participatory design workshops, prototyping, and contextual inquiry" (Bødker 2015, p. 1). Laboratory experiments. Evaluation methods.	Ethnography, action research, interaction analysis. Empirical based research and thick descriptions. New methods of participation, such as cultural probes (see Gaver, Dunne, and Pacenti 1999). Positionality of the researcher.	Ethnographic methods, service design.
Relation between the human and the computer	The individual was "the subject" researched. (Bødker 2015). Focus on objective details.	User-centered design (Forlizzi 2018). Interaction with communities of practices, not only with one individual user. Bødker 2015).	Exploring the relation between the researcher and the researched (Harrison, Sengers, and Tatar 2007). User experience (Forlizzi 2018)	Philosophical questions. Moving beyond user-centered design, focus on stakeholder-centered design (Forlizzi 2018). Focus on complex relationships between humans and computers. Focus on cooperation between different stakeholders within society, including academia and industry.
Values and questions	Solving critical incidents. See the Air Force example described in Harrison, Sengers, and Tatar (2007).	Improving the communication between humans and computers. Creation of models for better efficiency. Generalizibility. Structure design.	Intellectual questions. Focus on culture, emotion, experience, and reflexivity. Appropriation of technology.	Focus on situatedness, values and embodiment is no longer enough (Frauenberger 2019). Focus on activism at all levels, pushing beyond institutional levels (Ashby et al. 2019). Focus on accessibility and diversity, policies and laws (Ashby et al. 2019). Ethics, individuals' and society's responsibilities (Frauenberger 2019).

Table 2-1 Epistemological commitments of the HCI waves. The Fourth Wave included.

2.2 Human-Robot Interaction (HRI)

HCI is both dynamic and an interdisciplinary field, with the researchers subscribing to the field having different backgrounds, including Computing, Industrial Design, Psychology, and others (Duarte and Baranauskas 2016). The plurality of the field allows for a certain openness for new fields to immerse into it, or to give birth to new fields that inherit some of HCI's characteristics. One such field is Human-Robot Interaction (HRI). HRI is defined as the field "dedicated to understanding, designing, and evaluating robotic systems for use by or with humans" (Goodrich and Schultz 2007, p. 204). The central notion in HRI is a *robot.*

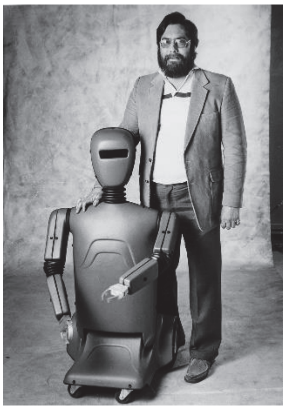
HRI research was interesting for the HCI community since robots occupy the physical space, hence offering to the HCI community new challenges and opportunities for studying the interaction that the desktop metaphor cannot offer (Goodrich and Schultz 2007). Besides HCI, there are also other fields contributing to HRI, such as human factors, natural languages, robotics, telerobotics and teleoperation, automation science, aviation and air traffic control, intelligent vehicle systems, artificial intelligence and cybernetics, haptics and telemanipulation, cognitive psychology, and design (Goodrich and Schultz 2007). The field started to emerge in the 1990s and early 2000s (Goodrich and Schultz 2007). An elegant view of the key themes and challenges of HRI is given by Goodrich and Schultz (2007).

2.2.1 Defining what a robot is

The central notion of HRI is the notion of a *robot.* In general, the definition of a robot has evolved.

The notion dates back to the Czechoslovakian *robota*, which means *work* or *forced labor* (OED 2017). The word was introduced along with the science fiction *Rossum's Universal Robots* (R.U.R., original title *Rossumovi Univerzální Roboti*) Karel Ĉapek's play (Goodrich and Schultz 2007). Further, the first HRI principles were introduced by Isaac Asimov's early works on science fiction (Goodrich and Schultz 2007). However, a reference to human-like machines, without the use of the term *robot*, dates back to Leonardo da Vinci's mechanical man in 1495, and even further back in time, to the concept of *automata* and other mechanical creatures from antique Egypt, Greece, and China (Goodrich and Schultz 2007).

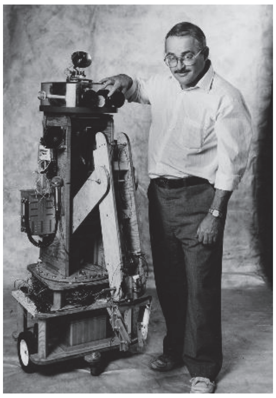
Further, robot technology was mainly born in the 20th century (Goodrich and Schultz, 2007). Amongst the robots developed were the Electric Dog robot from 1923 meant to be used during World War II, the Shakey robot, and later during the 1980s, several robotic applications were developed, including NASA robot platforms and the Soviet lunar robots within the Soviet Lunokhods robotic program (Goodrich and Schultz 2007). Some illustrative examples of early robots since the '80s are illustrated in the *Me & My Robot* project, from Mikkel Aaland, a Norwegian photographer. (see Figure 2-2).



Purists don't consider radio-controlled Arok a true robot, but Ben Skora (spell it backwards) has used his invention to entertain at bar mitzvahs and weddings for 14 years.

Nolan Bushnell, the founder of Atari. "The robot that tells the best joke wins."

Stephen Powers built this radio-controlled robot to help teach traffic safety to grade schoolers. "Kids, Powers observes, "aren't' so impressed by policemen anymore."



Richard Prather built this robot for a role in a feature film, which also stars Mariel Hemingway and Peter O'Toole. The robot has a gripper strong enough to juice an orange.

"In the old days," says robot designer Ray Spears, "when you told a robot to move forward three feet, the only thing you could be sure of was that it wouldn't move forward three feet."

Joseph Bosworth sold computers before he started RB Robot Corp. "Walk into a bar," he says, "and the hard hats wouldn't know what to do with a computer; they'd have fun with a robot."

Figure 2-2 Photos with their original captions from (Aaland 2018) [8]

International Standard Organization (ISO), founded in 1947, worked more than 30 years to establishing standards regarding robot development. ISO 8373:2012 defines the robot as "an actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment to perform intended tasks" (International Organization for Standardization 2017). According to the standard, a robot should include a control system and an interface to control the robot. ISO classifies the robots into industrial robots or service robots (International Organization for Standardization 2017). The standard defines service robots as "robots that perform useful tasks for humans or equipment excluding industrial automation application." (International Organization for Standardization 2017). Others define a *robot* as a programmable machine that can conduct a

[8] Mikkel Aaland, (2018). It's all an adventure. Photoblog. Me and My Robot project. https://www.mikkelaaland.com/me---my-robot.html, last accessed 15.03.2020. Copyright (c) All rights reserved. Permission was obtained (13.03.2020) from the photographer before using these photos in the thesis.

complex set of actions on its own (Oborn, Barrett, and Darzi 2011), or simply as intelligent machines that can "attain the general abilities of the normal two-year child" (Suchman 1987, p. 14). However, since the 1980s, robots can get as complex as Sophia-the first-ever robot citizen.[9]

Finally, a domestic robot is a form of welfare technology (Nordic Centre for Welfare and Social Issues n.d.), along with safety alarms, robot vacuum cleaners, smart home environments, safety alarms connected to a healthcare system, mobile care systems, automation solutions, and games consoles used for rehabilitation and physical therapy.

2.2.2 HRI waves or paradigms

There are not so many debates on the HRI waves as in HCI. HRI can, however, be divided into *programming based interaction* and *modern HRI.* The former one refers to studies in the lab, whereas the latter one refers to efficient and dynamic interactions, where the robot is as autonomous as possible. An attempt to debate the HRI waves, similar to the HCI waves, was done by Fernaeus et al. (2009) during their NordiCHI 2008 workshop. According to the authors, HRI seems to share the same themes with those covered in the waves of HCI (see also Table 2-1).

Moreover, HRI themes such as technology covering zoomorphism, humanoid robots, systems as tools for supporting human activities, de-contextualization of systems, etc. encounter challenges (Fernaeus et al. 2009). Other themes covered in HRI are autonomy, information exchange between the human and the robot(s), the structure of the team where the team includes robots, adaptation and learning of the robots, and robot tasks (Goodrich and Schultz 2007).

However, HRI seems to be divided into two paradigms that talk about either *remote* or *proximate* interaction (Goodrich and Schultz 2007). Remote interaction refers to the human and the robot not being co-located, i.e., being separated in space and even time. This type of interaction usually requires teleoperation and supervisory control (Goodrich and Schultz, 2007). Such an example is the Mars Rover robot. The proximate interaction refers to the human and the robot being co-located in space and time. Examples of such robots are robot assistants, companion robots, or service robots (Goodrich and Schultz 2007).

2.2.3 HRI frameworks

In general, robots can be classified based on their application domain. Currently, there are several robot classification frameworks available.

For instance, Goodrich and Schultz (2007) indicate that the main influential areas where robots are used are within robot-assisted search and rescue situations, where assistive robots are used, and in space exploration. For instance, the robot-assisted search and rescue area includes

[9] Sophia the robot was declared as the first-ever robot citizen in Weller 2019; "Meet Sophia, the Female Humanoid Robot and Newest SXSW Celebrity" 2016; "Ben Goertzel: Here's How Sophia the Robot Works" 2018; "Saudi Arabia Bestows Citizenship on a Robot Named Sophia | TechCrunch" 2019).

robots that can do work which can be hazardous for humans. Such robots are used during natural disasters, such as earthquakes, or in collapsed buildings, for searching for humans, such as the Urban Search and Rescue (USAR) robots used during the collapse of the World Trade Center twin buildings. Other such robots are used in chemically polluted areas, such as in the case of Chernobyl, where a German robot was used to navigate the highly nuclear-polluted environment, unsafe for humans to enter. Other examples are the Unmanned or Uninhabited Air Vehicles (UAVs), which are remote-controlled by humans. Assistive robots can be used to assist the elderly, disabled, or for instance, hospital personnel with transporting medications across different departments. These kinds of robots usually need to be designed for close proximity and long-term interaction. Such examples are the edutainment robots used in classrooms or museum, and the therapeutic or educational or social robots, such as those used in training of persons with severe autism with an autism spectrum disorder. Space robots are robots that may assist astronauts in space or robots that are remote-controlled by a team at the ground-base (Goodrich and Schultz 2007).

Thrun (2004) did a similar classification of robots to Goodrich and Schultz (2007). Thrun (2004) classified the robots based on the UN classification, by distinguishing amongst three different types of robots: industrial, professional service robots, and personal service robots. The industrial robots include robot-assisted search and rescue robots, earlier mentioned. Professional service robots include robots used in a hospital, for transporting goods or medicines, similar to the assistive robots from Goodrich and Schultz (2007). For some examples of the use of hospital robots, see the work by Oskarsen (2018), Søyland, and Søyseth (2017), Ozkil et al. (2009), and Ljungblad et al. (2012). Finally, personal service robots refer to robots used for personal use, usually used in the home. Amongst such robots are the robot vacuum cleaners, lawnmowers, robotic wheelchairs, robotic toys, but also assistant robots for the elderly and people with disabilities (Thrun, 2004).

However, in this thesis, I am interested in talking about deployed robots, such as domestic robots, in domestic settings, and how humans "partner" up with robots to achieve a common goal. According to the existing literature, it seems that deploying prototypes of robots *in situ* is quite difficult because of "the complexity of the resources needed to build" the robots and "the costs/sophistication of the materials" (Fernaeus et al. 2009, p. 294). Lately, it has been a trend to deploy off-the-shelf products, such as robot vacuum cleaners, which I also did in studies for part of this thesis. In general, the research shows that several studies investigating the use of robot vacuum cleaners in the home were undertaken (Forlizzi and DiSalvo 2006; Sung et al. 2007; Forlizzi 2007). Such *in situ* studies seem to be of particular importance and relevance in HRI (Fernaeus et al. 2009), especially for the academic discourses on human-robot cooperation, human-robot collaboration, and division of tasks between humans and robots. Along the same lines, several HRI studies have focused on task-collaboration between humans and robots. For instance, the seminal work of Hoffman (2007) has focused on how humans work with robots and on the human-robot fluent collaboration (Hoffman 2015). However, fewer studies are available investigating the work that needs to be performed by humans when introducing robots in their homes. This work is more suitable for discussion from a CSCW perspective instead. In the next section, I introduce the CSCW field.

2.3 Computer-Supported Cooperative Work (CSCW)

CSCW stands for Computer-Supported Cooperative Work, and it should support cooperative work via computers, independently of the current or future technology (Schmidt and Bannon 1992, p. 10). The first use of the term CSCW appeared in Irene Grief and Paul Cashman (1984), in a workshop. Across time, the field was defined in different ways (see, for example, Grief 1988; Bannon & Schmidt 1989; Suchman 1989). The field is also sometimes known as *groupware*, but the *groupware* term is mostly associated with "software that supports group work" (Schmidt and Bannon 1992, p. 9). However, the acronym has, at times, been criticized, as cooperative work is considered to be a "goal" rather than a "reality" (Grudin 1994, p. 20).

In the 1970s, software engineering and OA focused on computer support for extensive projects and groups (Grudin 1994). Grudin (1994) explains that the field emerged from Office Automation (OA) studies. He also argues that focusing only on the technology behind OA was not sufficient; instead, researchers had to focus on the technology used and how it affects the work of its users (Grudin 1994). Thus, the field sprang from multiple disciplines, including social psychology, anthropology, organizational theory, education, and economics – mainly fields that could help to understand group work (Grudin 1994). Some of the early applications studied within the field are videoconferencing, email, online meeting rooms, collaborative authorship applications, CAD/CAM and CASE systems, distance learning, computer-assisted software engineering, etc. (Grudin 1994).

2.3.1 Defining CSCW

Grief (1988b, p. 5) in Schmidt and Bannon (1992) defined CSCW as: "an identifiable research field focused on the role of the computer in group work." Bannon & Schmidt (1989) in Schmidt and Bannon (1992) defined it as: "an endeavor to understand the nature and characteristics of cooperative work with the objective of designing adequate computer-based technologies." Suchman (1989, p. 1) in (ibid) defined it as: "the design of computer-based technologies with explicit concern for the socially organized practices of their intended users."

However, as a response to unclear boundaries of the field, Schmidt and Bannon (1992) tried to: define those, find a common reference point, and define the questions that the field asks and/or answers. Moreover, Schmidt and Bannon (1992) tried, through their article, to set a framework for the field, which according to them, "should be concerned with the *support requirements of cooperative work arrangements*" (Schmidt and Bannon 1992, p. 7, emphasis in original). They defined CSCW as "*an endeavor to understand the nature and requirements of* *cooperative work with the objective of designing computer based technologies for cooperative work arrangements*" (Schmidt and Bannon 1992, p. 7, emphasis in original). Grief (1988a, in Schmidt and Bannon 1992, p. 14) defines CSCW as: "an identifiable research field focused on the role of the computer in group work." In other words, the CS part of the CSCW is the field that tries to both understand and study how current or future technologies are designed to support cooperative (group) work, which is a specific type of work. Technologies (computers, robots, etc.) are seen here as artifacts.

However, systems that support communication in a cooperative ensemble can be considered CSCW systems. Further, according to the authors, there have been debates and dilemmas regarding the use of the phrase *cooperative work:* should it be called collaborative work, group work, coordination work, or collective work? Cooperative work is work that requires cooperation amongst individuals, and it has some sort of interdependence between them, in the sense that the quality of the work of the individual *A* highly depends on the quality and timeline of the individual *B*'s work (Schmidt and Bannon 1992, p. 13). Cooperative work is not only about exchanging information but rather about closely working together on activities that relate to content and in the process of producing a product or service. Cooperative work can be roughly defined as the process of coming together with the aim of working towards producing a product or service (Schmidt and Bannon 1992, p. 15).

Cooperative work also includes activities of coordination work, planning, and scheduling, decision making, task and resource allocation and shared responsibilities, etc. Cooperative work does not necessarily need to be linear, conflict-free, or fully aligned with the formal boundaries of an organization.

Cooperative work takes place in cooperative ensembles (Schmidt and Bannon 1992). Cooperative ensembles are large or embedded within a large ensemble. These are often transient formations emerging to handle a particular situation, after which they dissolve again. Membership of cooperative ensembles is not stable and often even non-determinable. Cooperative ensembles often intersect. The pattern of interaction in cooperative work changes dynamically with the requirements and constraints of the situation. Moreover, cooperative work is distributed physically in time and space. Cooperative work is distributed logically, in terms of control, in the sense that agents are semi-autonomous in their partial work. Cooperative work involves incommensurate perspectives (professions, specialties, work functions, responsibilities) as well as incongruent strategies and discordant motives (every actor acts semi-autonomously in the system, but none of the actors can conduct the work on their own). There are no omniscient agents in cooperative work in natural settings, i.e., no cooperative "worker" has full power (Swedish "fullmakt").

Cooperative work requires other types of facilitation work that make possible the co-operation. This type of facilitation work is called *articulation work*. Articulation work is not part of the main type of work, but it is somehow *additional work* that one of the group has to do to achieve the main goal: “Articulation consists in all the tasks involved in assembling, scheduling, monitoring, and coordinating all of the steps necessary to complete a production work” (Gerson and Star, 1986 p. 266 in Schmidt and Bannon 1992, p. 22). Moreover, cooperative work is work that is distributed and cannot be otherwise achieved individually (Schmidt and Bannon, 1992, p. 18). However, the agents that take part in cooperative work, be they humans or machines may act, to some degree, semi-autonomously. However, since the work is distributed, articulation of the distributed activities has to be done (Schmidt and Bannon 1992, p. 18). Articulation is some kind of “supra-type of work” (Strauss, 1985, p. 8, in ibid., p. 18). Furthermore, articulation work may sometimes require other or additional articulation work: sometimes, CSCW systems do not support all the necessary interaction for achieving a goal (e.g., production of a product or service). Therefore, additional interaction mechanisms are needed: planning and scheduling, procedures, schemes, protocols, formal structures. These are used to reduce the complexity of cooperative work. In their turn, sometimes, these interaction mechanisms require articulation work (Gerson and Star, 1986, p. 266 in Schmidt and Bannon 1992, p. 19). Articulation work can refer to two aspects: “the workflow, and the construction and management of a ‘common information space’” (Schmidt and Bannon 1992, p. 22).

2.3.2 CSCW traditions

Grudin (1994) differentiates between two CSCW continental traditions: the US and the European tradition. The US CSCW tradition often focuses on “experimental, observational, and sociological data” with an empirical approach (Grudin 1994, p. 22). In the last decade, the US CSCW tradition focused on online ethnographies, i.e., focusing on the use of social media.

The European CSCW, also known as the ECSCW tradition, is anchored in philosophical and sociology, economy, or political theory or questions reflecting cultural norms, laws, trade unions, or social welfare systems (Grudin 1994). Scandinavian tradition, with its participatory design, approaches subscribes to the ECSCW tradition. This thesis subscribes to the European CSCW tradition.

Other CSCS traditions are the UK CSCW and the Japanese CSCW tradition. The UK CSCW tradition bridges the US and the ECSCW one, “due to shared language and culture” (Grudin 1994, p. 23). One of the UK’s CSCW seminal works is from Heath and Luff (1991), on the London Underground case. Japanese CSCW tradition focuses on workflow management systems and the idea of the “software factory.” Amongst the known CSCW contributions from Japan are studies from Toshiba.

2.4 Positioning this thesis within scientific design fields[10]

As several researchers (see Frauenberger 2019; Forlizzi 2018; Ashby et al. 2019) have pointed out, design fields should move beyond the user-centered design, *focusing on the complex relations between humans and computers and between different stakeholders within society*. We should ask philosophical questions that do not limit themselves to the questions asked during the third wave regarding situatedness, values, and embodiment (Frauenberger 2019) but push beyond the institutional limits, focusing on accessibility, diversity, policies, and laws (Ashby et al. 2019). Questions regarding ethics, and an individual's and society's responsibilities, as well as activism, should be in focus (Frauenberger 2019). This thesis contributes to the understanding of these relations between humans and computers, systems, and the use of various interfaces, by going beyond the desktop metaphor, moving beyond the concept of robots used in the lab, or analyzing interactions with individual learning management systems.

To understand some of these complex relations that we develop or have with digital technologies, I include in this thesis two cases to illustrate this. Thus, this thesis positions itself at the cross-section between HCI, HRI, and CSCW, with some Universal Design elements. Universal Design is described in Ch 3. Table 2-2 below indicates the positioning of each of the papers written as part of Case 1 and Case 2.

Table 2-2 Positioning this thesis across design fields

Case	Paper	Field of contribution
(MECS Project) Case 1: Understanding everyday use of robots in the home	Paper I	HCI, HRI
	Paper II	HCI, HRI
	Paper III	HCI, HRI, CSCW
	Paper IV	HCI, HRI, UD
(UDFeed Project) Case 2: Understanding everyday use of digital learning environments in Higher Education	Paper V	CSCW
	Paper VI	HCI, CSCW, UD
	Paper VII	HCI, UD

Figure 2-3 below shows the positioning of this thesis across HCI, HRI, CSCW, and Universal Design (UD). Although the two cases presented later in Ch. 6 and Ch. 7 may seem different at first sight, both cases are anchored within HCI and CSCW. Universal Design is not necessarily an independent field; it is, in a way, similar to ethics – it is orthogonal to the other fields, as you can also see in the figure that I borrowed from Grudin (1994, p. 21) and slightly modified to map my research towards the fields.

[10] Text adapted from (Saplacan, Herstad, and Pajalic 2020)

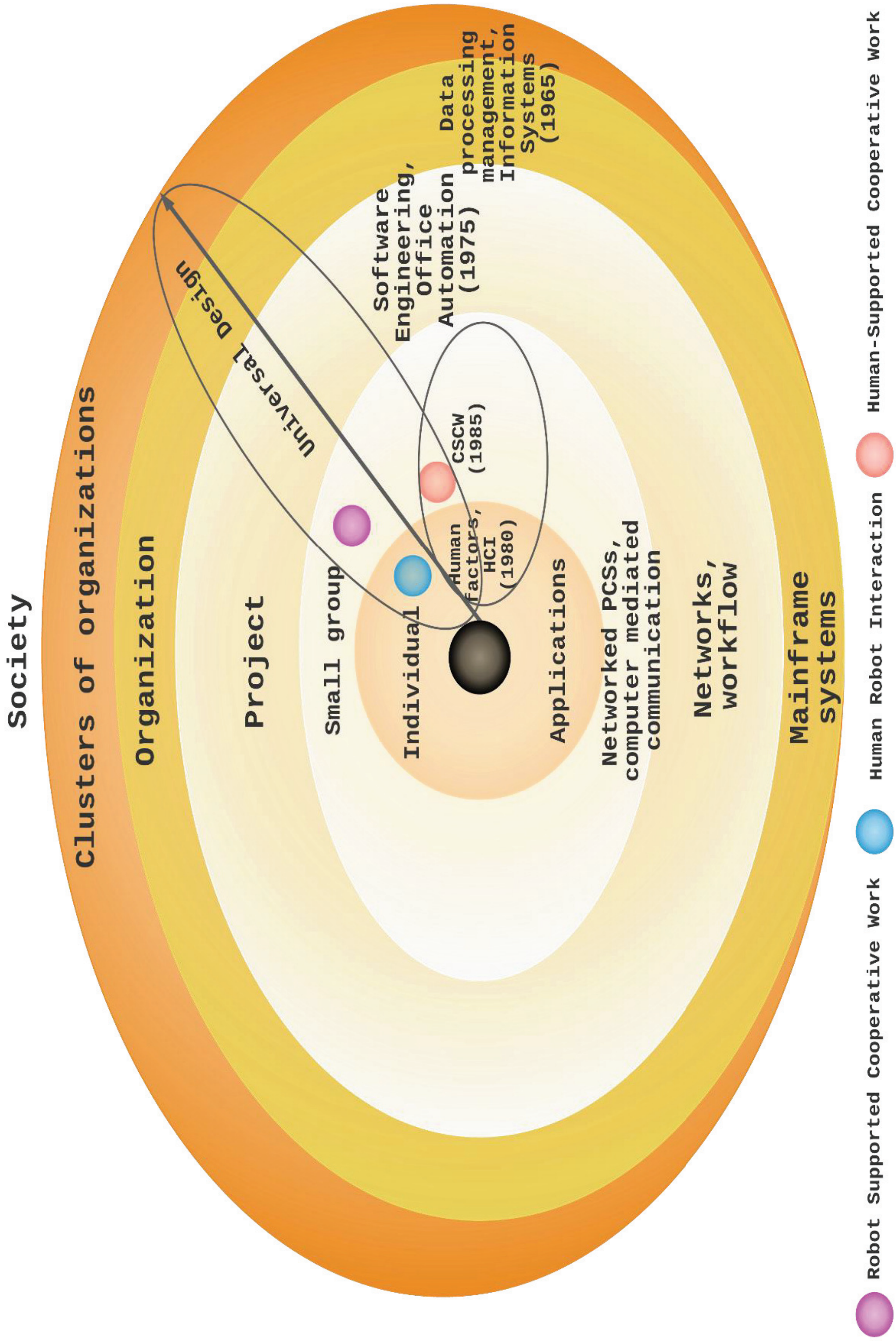


Figure 2-3 Positioning this thesis across different design fields - Adapted figure based on Grudin (1994, p. 21)

Chapter 3 ON UNIVERSAL DESIGN

About Universal Design: "designing all products and the built environment to be aesthetic and usable to the greatest extent possible by everyone, regardless of their age, ability, or status in life."

— Ronald Mace (1941-1998)

This chapter introduces and describes Universal Design, its history, definition, and focus. Besides, the chapter explains some of the adjacent fields to Universal Design, including barrier-free design, assistive technologies, inclusive design, and design for all, which often are interchangeable with the term of Universal Design, although they are slightly different from Universal Design. Moreover, the chapter explains different models that are adopted in Universal Design studies. Finally, the chapter gives an overview of the current Norwegian laws and regulations concerning Universal Design, followed by a description of how Universal Design is used in this thesis.

3.1 Universal Design: history, definition, and focus

R. Mace (1941-1998), a nationally and internationally recognized design pioneer, product designer, architect, and educator, coined the term Universal Design (Center for Universal Design, North Carolina State University 2008). R. Mace graduated in 1966 from North Carolina University in the US, receiving a Bachelor's degree in architecture. Only four years after that he tried to establish the first accessibility building code. In 1973, the code was adopted and implemented in the North Carolina State. In 1988, the Fair Housing Amendments Act was introduced, and only two years after the Americans with Disability Act (ADA) was established. He has also established the national and international research center and resource for Universal Design, namely The Center for Universal Design, at the School of Design at North Carolina State University, in the US.

The term *Universal Design* was defined by R. Mace as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design." (Story, Mueller, and Mace 1998, p. 2) The term Universal Design was used to describe the idea of "designing all products and the built environment to be aesthetic and usable to the greatest extent possible by everyone, regardless of their age, ability, or status in life" (Center for Universal Design, North Carolina State University 2008). In his last speech, at *Designing for the 21st Century: An International Conference on Universal Design*, in 1998, he explained that Universal Design largely defines the user, explaining that the focus of Universal

Design is not on people with *disabilities*, but on *all* people (Center for Universal Design, North Carolina State University 2008). It can also be observed that in his definition, R. Mace never mentions *disabilities.* He advocates for the idea that we are all disabled in some way, or become disabled with the age (Center for Universal Design, North Carolina State University 2008), as was also pointed out in the first chapter of the thesis.

Further, Universal Design embeds seven principles: 1) equitable use, 2) flexibility in use, 3) simple and intuitive, 4) perceptible information, 5) tolerance for error, 6) low physical effort, and 7) size and space for approach and use (Center for Universal Design, North Carolina State University 2008). An overview of the Universal Design principles is illustrated in Table 3-1.

Table 3-1 Universal Design principles and examples (Saplacan, Herstad, and Schulz, forthcoming)

#	Universal Design Principles	Example from objects in everyday use
1	Equitable use	Use of a ramp for getting into a bus: it provides equal ability to step onto a bus for both people in a wheelchair and without a wheelchair, such as a woman with a stroller.
2	Flexibility in use	The use of a table with an adjustable height is good for both people for abled people, people with back problems, people sitting in wheelchairs, or children.
3	Simple and intuitive use	An iconic example is the iPhone design, with its buttons in the same place in different versions.
4	Perceptible information	Consistency in using symbols for volume or radio buttons, send icons, or save icons on buttons.
5	Tolerance for error	The undo button provides reliable feedback. Another example is the oven lock button for children's safety.
6	Low physical effort	The height of ATMs provides easy access and low physical effort for people of different heights, including children and people sitting in a wheelchair.
7	Size and space for approach and use	The gates of a metro-station or security control at the airport should be large enough to accommodate individuals of different sizes, or people sitting in a wheelchair.

Universal Design, as such, is an ideological point of view, a strategy or an approach to design that is orthogonal to many fields and disciplines, integrated within architecture, product design, information design, service design, design of ICTs, web pages, etc. (Vavik 2009). However, from Universal Design, new adjacent areas related to Universal Design stemmed, which may give a slightly different focus.

3.2 **Adjacent fields to Universal Design**

Over time, several movements towards the rights of people with disabilities were associated with Universal Design. Thus, several adjacent areas emerged, such as barrier-free design, assistive technologies, inclusive design, and Design for All (DfA).

Barrier-free design started as an accessibility movement for people with disabilities. It is related to the Americans with Disabilities Act (ADA) standards introduced in 1990 and later updated during 2010. It is also worth saying that ADA is a law, a disability mandate, and it is not to be confused with Universal Design (Center for Universal Design, North Carolina State University 2008). Barrier-free design is a portion of ADA, focusing on removing architectural barriers for people with disabilities (Center for Universal Design, North Carolina State University 2008).

Compared to barrier-free designed technologies, assistive technologies are not consumer products, compared to Universally Designed products (or services) that aim at being consumer products. Assistive technologies focus on designing for *some* individuals, compensating for disability, and helping one to function in a specific environment (Center for Universal Design, North Carolina State University 2008). The devices designed as assistive technologies are usually devices for personal use. Some examples of such assistive technologies are a Text-to-Speech (TTS) software reader, and other screen readers, screen magnifiers, Braille displays, other input or output devices for impaired users, wheelchairs, eyeglasses, oxygen systems, or other medical equipment helping one to function in an environment or a given situation. Assistive technologies are also sometimes known as adaptive technologies and are defined as: "...products, devices or equipment, whether acquired commercially, modified or customized, that are used to maintain, increase or improve the functional capabilities of individuals with disabilities..." (C. Stephanidis 2020). The public law 105-394 regarding the Assistive Technologies Act came into force in 1998 in the US (US Government 1998).

Another term often associated with Universal Design is inclusive design. Inclusive design refers to "the design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible, without the need for special adaptation or specialised design," according to The British Standards Institute (2005) (University of Cambridge 2017). This view contradicts, in a way, the Universal Design mantra of "one size fits all." The inclusive design approach argues that it is not possible to design for an entire population, and therefore it is recommended to design instead, what they call, a family of products (University of Cambridge 2017). According to the inclusive design approach, each product or service should be designed with a target population or user in mind, giving the user flexibility of use in different situations. Such an example of inclusive design is, for instance, a digital tablet designed for children with perhaps a hardcover and less software installed on the tablet, vs. a digital tablet designed for the elderly with a handgrip designed for elderly users, or perhaps hands-free standing support for holding the device.

Finally, the Design for All (DfA) term is the established term for talking about universal design in Interaction Design (C. Stephanidis 2020). Stephanidis (2020) describes DfA as an umbrella term covering design approaches, methods, and techniques, as well as tools that address a wide range of users' needs for designing interactive artifacts. The term was introduced in HCI in the late 1990s originating from three traditions: 1) from user-centered design; 2) from accessibility and assistive technologies designed for disabled people, and 3) from Universal Design (C. Stephanidis 2020). DfA was defined by Stephanidis et al. (1998) in Stephanidis (2020) as subsuming or being synonymous with accessible design, inclusive design, barrier-free design, or universal design. DfA aims to design ICTs in such a way that it will not be necessary for additional adaptations or specialized design post-design (C. Stephanidis 2020).

3.3 Universal Design models

Several Universal Design models have been developed across time that enable us to talk about Universal Design or Universal Design-related issues. Some of these models are the medical model, social model, relational model, expert model, empowering model, charity model, and economic model. Each of these is briefly described in the next paragraphs. However, many of these models are strongly connected to disability studies, although Universal Design in its core does not focus on disabilities, but on designing for as many people as possible.

For instance, the medical model is one example of a model emerging from disability studies. The model focuses on the disability of the individual. Disability, in this sense, is viewed as a problem owned by the individual that needs to be corrected (Lid 2013). According to the definition of the WHO, the medical model sees disability as “caused by a disease, trauma or health condition, which requires medical care in the form of individual treatment by professionals” (World Health Organization 2001, p. 20). The medical model is sometimes seen as the personal tragedy of the individual (Grue 2011). Moreover, this model argues that the disabled person benefits from the medical treatment of intervention (Begnum 2016b).

Another model is the expert model. The expert model is also sometimes called the professional model, referring to disability as identified by an expert, a professional (Begnum 2016b). This model is similar to the medical model, where professionals need to identify the disability of the individual. This model suppresses the individuals' power to take their own decisions, not trusting the individuals' abilities (Begnum 2016b).

Some talk about the charity model. The charity model is similar to the medical and the expert model, seeing the disability of the individual as a personal tragedy (Begnum 2016b). The individuals are seen with pity as victims (Begnum 2016b). This model is often used by non-disabled individuals to talk about disabled people (Langtree, 2010 in Begnum, 2016).

Further, the social model is another model used in disability studies. The social model sees Universal Design from a social perspective, i.e., the environment must be corrected because it disables and oppresses the individual (Lid 2013; 2014). In other words, the disability is socially created (Begnum 2016b). As we can see, this model shifts the focus from the individuals' disabilities to the disabling environment. However, this approach seems to neglect the individual's experiences (Lid, 2014). The social model demands political responses to address the issues created by a disabling environment (World Health Organization, 2001).

A similar model to the social model is the socially adapted model. The model is a combination of the social and the medical model, but disability is less polarized in this model (Begnum 2016b). The model sees individuals' disability as possibly limiting the individual to take part in the activities of the non-disabled individuals (Begnum 2016b). The model itself, similar to the social model, sees the individuals' environment as the main factor disabling the individual, rather than the disability itself (Begnum 2016b).

A more recent model is the relational model used in Scandinavian countries. The relational model is also one of the models used in disability studies. Lid (2014) criticized the medical and social models, saying that these models either focus on the individual or the environment. She argues that a model should focus on the relations between both, such as the relational model does (Lid 2014). This model is also sometimes known as the Scandinavian model or the GAP model (Lid 2013). According to her, disability should be viewed as a human condition, since disability is not something that a human has, but something that may emerge in a given situation (Lid 2013). She is against the division of individuals as abled and disabled, acknowledging human diversity and individual experiences (Lid 2013). According to her, disability emerges from the social and material factors, and disability is an embodied experience lived in certain situations or contexts by individuals (Lid 2013).

The socio-relational model is a combination of the social and the relational model. Lid (2014) talks about this model as the model where disabilities are theorized; the model is anchored in Carol Thomas's (1999) work on *Female forms.* The idea of the socio-relational model is that disabilities are experienced by an individual in the environment s/he is part of. However, disabling mechanisms part of the environment can be avoided or removed through different measures, including social, political, and physical ones (Carol Thomas 1999 in Lid 2014).

A better model than the medical and the social one is the biopsychosocial model, according to WHO (World Health Organization 2001). Disability in this model is related to both biological, psychological, and social factors (Begnum 2016b). This model focuses on "the interaction between a persons' health conditions and the contextual factors and the environments they are living in" (pp. 2-3). This model is also the one preferred by WHO when talking about disabilities (World Health Organization 2001).

The empowering model, also sometimes called the customer model, is opposite to the medical, the expert, and the charity models. This model empowers the individual, instead of suppressing him as the other models do. The model trusts the individuals' autonomy, decision power, and control, and the professionals come in only as advisors rather than experts (Begnum 2016b). The model sees instead the individual himself as the expert on his own body; he is the one deciding for appropriate measures of treatment (Begnum 2016b).

Further, the economic model defines an individual's ability or disability based on his ability to work (Begnum 2016b). This model seems to be used by policymakers for regulating the state welfare payments (Begnum 2016b).

All the above UD models are illustrated in Table 3-2. In addition to the above-mentioned models, Begnum (2016) also talks about the existence of the following models: legitimacy model, spectrum model, right-based model, rehabilitation model, interface model, and moral or religious models.

Table 3-2 Overview of some of the Universal Design models

Universal design model	The specificity of the model
Medical model	Focuses on the disability of the individual, a problem owned by the individual and needs to be corrected (Lid 2013)
Expert model (also known as the professional model)	Disability as identified by an expert, a professional (Begnum 2016)
Charity model	The disability of the individual is seen as a personal tragedy (Begnum 2016)
Social model	The social model sees Universal Design from a social perspective, i.e., the environment must be corrected because it disables and oppresses the individual (Lid 2013; 2014)
Socially adapted model	The model sees individuals' disability as possibly limiting the individual to take part in the activities of non-disabled individuals (Begnum 2016)
Relational model (also known as the Scandinavian or GAP model)	Disability should be viewed as a human condition since disability is not something that a human has, but something that may emerge in a given situation (Lid 2013)
Socio-relational model	Disabilities are theorized; the model is anchored in Carol Thomas's (1999) work on *Female forms*
Biopsychological model (the model preferred by WHO)	Disability in this model is related to both biological, psychological, and the social factors (Begnum 2016); this model focuses on "the interaction between a persons' health conditions and the contextual factors and the environments they are living in" (pp. 2-3)
Empowering model (also known as the customer model)	The individual is seen as an expert on him- or herself
Economic model	An individuals' ability or disability is defined based on the ability to work (Begnum 2016)

3.4 Norwegian laws and regulations with regard to Universal Design

Norway is one of the most advanced e-government countries, being amongst the most digitalized countries in the world (#8 in 2012, and #13 in 2014), according to a report from the United Nations (2014) in Begnum (2019, p. 44). Moreover, Norway was placed second amongst the Scandinavian countries, after Finland, in 2014, in the E-Government Development Index (Begnum 2019, p. 44). Also, the digitalization of the Norwegian public sector was put on the digitalization agenda 2019-2025 of The Norwegian Ministry of Local Government and Modernization. The agenda aimed to improve the efficiency of the public sector, supporting its digital transformation (Ministry of Local Government and Modernisation 2019). The strategy is a follow-up of the earlier White Paper Meld. St. 27 (2015-2016) (Kommunal-og moderniseringsdepartemenet 2016) that had, amongst its main objectives, the focus on the user, and efficient public administration, and inclusion. According to the White Paper, the Norwegian government offered digital services that had a 235% increase in their use between 2010 and 2015 (p. 13). Currently, Difi, The Norwegian Agency for Public Management and eGovernment, together with Altinn and with Brønnøysund Register Center, form the Norwegian Digitalization Agency, as of January 1, 2020. The Norwegian Digitalization Agency is also the one responsible for auditing Universal Design for ICTs in Norway. The agency is also responsible for the digitalization and management of e common IT solutions in the public sector.

However, Norway, as a highly digitalized country in terms of its ICT solutions in the public sector, encounters challenges, such as the digital exclusion of its citizens and inhabitants in several sectors, including education and employment, the consumer market, and also citizenship ICT solutions (Begnum 2019). If these sectors do not reach out to all their users with their digitalized ICT solutions, this can have huge consequences for society. In order to counter-encounter these challenges, Universal Design is essential and an absolute necessity for the development of ICT solutions.

3.4.1 Laws and regulations on Universal Design of ICTs in Norway

In Norway, a regulation on Universal Design for ICTs solutions was introduced in 2013, as part of the Norwegian law (Kommunal- og moderniseringsdepartementet 2013). The regulation was anchored in an earlier law introduced in 2008 on the prohibition of discrimination on the grounds of disability, also called The Discrimination and Disability Act. The regulation aims to ensure the Universal Design for ICTs solutions, without putting a burden on the operation of the organization. The regulation explains Universal Design as “the design or facilitation of the main ICT solution, in such a way that the organization’s main function can be used by as many as possible” (Kommunal- og moderniseringsdepartementet 2013) (own translation into English from Norwegian). The regulation was later updated in 2017, entering into force from 1st January 2018. The updated regulation says that Universal Design shall be applied to ICT solutions that underpin the organization's general functions, and which are the main solutions aimed at or made available to the public. The regulation also specifies that it applies to all ICT solutions in all areas of society, including the education and training sector. However, the regulation is limited to online solutions, including digital teaching aids and vending machines, and they do not apply where the design of ICT solutions is regulated by other legislation, such as in Svalbard and Jan Mayen, to installations and vessels operating on the Norwegian continental shelf or to Norwegian ships and aircraft wherever they are located. Moreover, the regulation does not currently apply to robots.

Specifically, the regulation of universally designed ICT solutions covers ICTs, vending machines, web solutions, digital teaching aids, main solutions, new ICT solutions, user interfaces, and standards. The regulations clearly define these terminologies. For instance, ICT is defined as "technology and systems of technology used to express, create, transform, exchange, store, reproduce and publish information, or otherwise make information usable" (Kommunal- og moderniseringsdepartementet 2013) (own translation into English from Norwegian). A vending machine is defined as a "machine or other device that the user operates alone to buy an item or have a service performed" (Kommunal- og moderniseringsdepartementet 2013) (own translation into English from Norwegian). The web solution refers to the "dissemination of information or service that is available in a web browser or equivalent, accessible via a URI (Uniform Resource Identifier) and which uses the HTTP protocol (Hypertext Transfer Protocol) or equivalent to make content available" (Kommunal- og moderniseringsdepartementet 2013) (own translation into English from Norwegian). The digital teaching aids refer to "online tools that can be used in pedagogical work, and that have been developed to support learning activities" (Kommunal- og moderniseringsdepartementet 2013) (own translation into English from Norwegian). The earlier definition of the main ICT solution in an organization was complemented by the additional text: the "main solution in the education and training sector [refers to] network solutions that are an integral part of the organization's teaching or information dissemination, and over which the organization has influence" (Kommunal- og moderniseringsdepartementet 2013) (own translation into English from Norwegian).

The new ICT solution refers to "the total replacement of a technical solution, version upgrade, replacement or major change of source code and major change of appearance or design, or gradual changes over time, which together constitute a change. These can also be regarded as a new ICT solution" (Kommunal- og moderniseringsdepartementet 2013) (own translation into English from Norwegian).

The user interface was defined as "the meeting point between human and machine, and the part of the machine the user comes into direct contact with, including physical hardware and logical software components" (Kommunal- og moderniseringsdepartementet 2013) (own translation into English from Norwegian).

Finally, standards were defined as a “normative document, including specifications, guidelines, and recommendations (Kommunal- og moderniseringsdepartementet 2013) (own translation into English from Norwegian).

However, a lot of focus, so far, in Norway and abroad, has been put on the Universal Design of the individual web solutions, but not on how these should work together, or on other ICT solutions, such as robots. According to paragraph §4 of the regulations, on web solutions, they “shall be at least designed in accordance with the standard for web content accessibility guidelines 2.0 (WCAG 2.0) /NS /ISO/ IEC 40500: 2012, at levels A and AA except for the success criteria 1.2.3, 1.2.4 and 1.2.5, or similar to this standard” (Kommunal- og moderniseringsdepartementet 2013) (own translation into English from Norwegian).

Some other standards refer to the design of the identification card systems (e.g., NS-EN 1332-1:2009), but also the ergonomics of the human-computer interaction (e.g., NS-EN ISO 9241-20:2009), to the ease of operation of everyday products (e.g., ISO 20282-1:2006), but they also cover the ergonomics of products and services to address the needs of older persons and persons with disabilities (e.g., ISO/TR 22411:2008).

Besides this, the regulations require that an organization that has obligations following these regulations must ensure that new ICT solutions are universally designed no later than 12 months after these regulations have entered into force, namely from 1st January 2019. Educational organizations and the training sector have a duty to ensure that new ICT solutions are universally designed no later than 12 months after 1 January 2018. Existing ICT solutions must be universally designed by 1 January 2021.

3.4.2 Web Content Accessibility Directive (WAD) in Norway

At the European Union level, directive 2016/2012, paragraph §12 refers to the accessibility of websites and mobile applications for public services (EUR-LEX 2016). The directive stipulates that the ICT solutions should, at least, comply with the minimum standards and accessibility guidelines, enabling as many people as possible to use these products or services, without the need for special or individual adjustments (EUR-LEX 2016). Specifically, paragraph §46 indicates that websites or mobile applications should include feedback mechanisms that facilitate user feedback, i.e., the user should be able to provide feedback in case the website or the mobile applications does not comply with the accessibility requirements. Further, a specific directive formulated in 2018 and that is relevant for Norway is the Web Accessibility Directive (WAD), covering the EN 301 549 v2.1.2 standard and the Web Content and Accessibility Guidelines (WCAG) version 2.1 (CEN, CENELEC, and ETSI 2018). In Norway, there were some ongoing discussions on how this should be adopted and what the socio-economic consequences are, because of the introduction of new requirements for accessibility of webpages and mobile applications (Haavardsholm, Vennemo, and Kessel 2018). According to a recent post from the Norwegian government, Norway fulfills many of the requirements that the WAD imposes already (Kommunal-og moderniseringsdepartementet 2019; Kulturdepartementet 2020). The requirements that are new for Norway are:

1) Requirements for visual interpretation of multimedia content (video)
2) Requirements for an accessibility declaration and user feedback functions
3) Requirements for universal design of new intranet- and extranet- portals (Kulturdepartementet 2020) (own translation into English from Norwegian).

However, it was not clear whether the proposed WAD requirements would apply to all public and private organizations that have more than 50 employees. The new WAD standard also includes the WCAG 2.1 guidelines, which contain 12 new success criteria that must be applied for websites and mobile applications for them to be universally designed. The new guidelines will replace the current ones (WCAG 2.0). However, in a hearing in 2019 (Kommunal-og moderniseringsdepartementet 2019), it was stated that "when the regulations update the reference to the new guidelines, the guidelines shall apply to all the subjects of duty under the right law, i.e., to the entire public and the entire private sector" (own translation into English from Norwegian).[11]

Further, in the same hearing, The Norwegian government stated that WAD would take effect from 1st July 2020, with a transition period of six months, i.e., the organizations would fulfill the requirements at the latest by 1st January 2021. However, in a later post from 31.03.2020, the government decided that longer transition periods should be given to organizations to adapt their ICT solutions to WAD. Currently, it is not certain when the directive will take effect, but clarification on the timeframe needed will be proposed by the European Economic Area (EEA) countries, which includes Norway, for the European Union.

3.5 Universal Design in this thesis

Universal Design can be described from a macro-, mezzo-, or micro-level (Giannoumis 2016). The macro-level is represented by studies on the legal framework that regulates Universal Design aspects of the physical or virtual environment. The mezzo-level is represented by studies on informatics, computer science, or engineering that investigate the use of technology as a mechanism of participation, at an organizational level. The micro-level is typically represented by HCI studies examining individuals or groups in Universal Design to understand human characteristics.

In the previous sections, I have described Universal Design at a macro-level. From a legal framework perspective, based on the previous section overview on the Universal Design laws and

[11] The original Norwegian text says: "Når forskriften oppdaterer henvisningen til de nye retningslinjene, vil retningslinjene gjelde for alle pliktsubjektene etter gjeldende rett, dvs. hele offentlig og hele privat sector." (Kommunal-og moderniseringsdepartementet 2019).

regulations in Norway, the conclusion is that the Norwegian regulations regarding the Universal Design of ICT solutions cover:

1) Mainly web solutions and WCAG, but no other ICT solutions such as robots (Case 1 in this thesis)
2) Mainly individual web solutions – however, the user is sometimes asked to use some ICT solutions that are universally designed but can also use some that are not (Case 2 in this thesis)

At the same time, I had an interest in Universal Design from the start of this thesis. However, although I did not know how to include Universal Design, I knew what I did not wish to focus on disabilities when I talk about Universal Design. I did not wish to focus on “disabilities” or “disabled people,” nor on WCAG or ergonomics. I did not wish to focus on “disabilities” or “disabled people” not because I do not think the subject is important enough, but because I wished to go back to the core definition of Universal Design, as defined by R. Mace. This was my point of departure. At the same time, I admit that WCAG is important, but it only focuses on web solutions.

Thus, Case 1 in this thesis is about robots, so WCAG is not applicable. Ergonomics may have been suitable for Case 1 on robots, but my interest in the design of robots was more focused, at the time, on the interaction between the human and the robot, rather than on the robots’ ergonomics. All in all, it was difficult to include and talk about Universal Design in Case 1, which is about robots.

Hence, I have therefore used Case 2, which focuses on web interfaces, to understand more about Universal Design, to be able to come back to Case 1, and reflect on Universal Design and robots. However, I was clear from the start that I wanted to focus on Universal Design without focusing on "disabilities" or "disabled people." This was a clear starting point for me. Instead, I wanted to be able to talk about Universal Design and abilities.

Moreover, during Case 1 on robots, I came across the work of Antonovsky (1996) on health and ease/dis-ease, which has also partially inspired my view on Universal Design, from the perspective of human beings’ abilities. Thus, some of the questions that I asked myself concerning Universal Design were: What about people that change contexts? What about people as human beings who get old? What about interfaces that are always changing, updating? What about getting cognitively overwhelmed by using multiple systems at the same time – when many of them are not universally design? What about a lack of standards that goes beyond the technical WCAG standards and focuses on the abilities of people rather than on their disabilities? What about design standards for robots in the home that go beyond ergonomics? At the same time, WCAG standards apply only to individual websites. In this thesis, Case 2 presents individuals’ experiences when they have to use several platforms or webpages, where not all of them are universally designed.

Finally, this thesis answers some of these questions throughout Case 1 in Ch. 6, and Case 2 in Ch. 7, but also through this thesis itself and the emergent concept of situated abilities presented in Ch. 8.

Chapter 4 THEORY

"In our field, theory is like the public library. If asked, most of us would say that we are glad that it is around—but few of us actually go there. Most see it as a haven for the old, the unemployed and the eccentric "
— Paul Dourish,, Where the Action Is: The Foundations of Embodied Interaction (2001, p. 1)

Theory refers to "the conceptual basis of a subject or area of study" and is "contrasted with practice*,"* following the Oxford English Dictionary (2020). The theory is also defined as "an approach to the study of literature, the arts, and culture that incorporates *concepts* from disciplines such as philosophy, psychoanalysis, and the social sciences; esp. such an approach intended to challenge or provide an alternative to critical methods and interpretations that are established, traditional, and seen as arising from particular metaphysical or ideological assumptions" (Oxford English Dictionary 2020b). Thus, this chapter's focus is on presenting the theory in this thesis.[12] First, the chapter describes phenomenology, its definition, and its history. Thereafter, the chapter continues with phenomenology in design. A whole section is then dedicated to Heidegger's phenomenology, followed by its concept of *Befindlichkeit*. A section on the relations between *Befindlichkeit* and situatedness is explained thereafter, followed by a section that explains how *Befindlichkeit* is used in this thesis. The chapter ends with a reflection on theoretical challenges and advantages in an interdisciplinary thesis.

4.1 Phenomenology: definition and history

Phenomenology was introduced by Georg W. Fr. Hegel through his writing on *The Phenomenology of Spirit* (German: *Phanomenologie Des Geistes*, 1807) (Lübcke et al. 1996). Phenomenology, a primal science (Ciborra 2006, p. 135), as an expression, refers to the concept of method, and it can be translated into the maxim "To the things themselves!" (Heidegger 2010, pp. 26, 32). Epistemologically, phenomenology originates from the Greek term *phainomenon*, which means to show itself, and *logos*, which means to study (Lübcke et al. 1996). In other words, phenomenology is the philosophical study of experience, focusing on first-person experiences (Gallagher 2012), or the science of phenomena (Heidegger 2010, p. 27). Sometimes, phenomenology is also referred to as the "science of the being of beings – ontology" (Heidegger 2010, p. 35). The Greek term phenomenon derives from a verb with the meaning "to show itself," self-showing, manifesting itself, bringing to (day-)light, visible in itself, or being brought to light (Heidegger 2010, p. 27). In a way, phenomenology is a way to access ontology, while "*ontology is possible only as phenomenology*" (Heidegger 2010, p. 33).

[12] The concepts chosen and explored in the papers included in this thesis are described in detail in each of the papers included in this thesis.

During the 20th century, Edmund Husserl gave a special meaning to the word phenomenology, focusing on intentionality, and how phenomenology can support our understanding of the structure of the consciousness (Lübcke et al. 1996). Amongst the adopters of phenomenology are Martin Heidegger, Hans-Georg Gadamer, Jean-Paul Sartre, Merleau-Ponty, Jacques Derrida, and Hubert Dreyfus. I summarize some of their work in the next paragraphs. However, the focus of the theoretical concept adopted in this thesis is on the work of Martin Heidegger. A whole section is dedicated to explaining his work later in this chapter (Section 4.3).

Husserl's work is framed within phenomenological reduction, within transcendental-idealist philosophy (Lübcke et al. 1996). Husserl, with his phenomenological view on the structure of consciousness, argued that consciousness is characterized by intentionality and that it is about something. In his explanations, he adopted two Greek philosophical notions, noesis and noema. Noesis or the noetic aspect of the consciousness refers to the mental act of consciousness that may involve a complex process of perception, thinking, judgment, desire, and/or intention simultaneously, or modulating between these (Gallagher 2020). Noema or the noematic aspect of the consciousness refers to the individual's experience about something. The noematic aspect has a noematic nucleus that can include conceptual or visual appearances about something, from the perspective of the individual him- or herself. Further, Husserl distinguishes also between an inner and an outer horizon of the object or concept in the consciousness. The inner horizon refers to the object itself, how it appears, or how it is manipulated by the individual, whereas the outer horizon of the object refers to how the object appears in relation to other things in its nexus environment (Gallagher 2020). Furthermore, Husserl's phenomenology does not limit itself to the notions of noesis and noema, but it goes further in the temporal and aesthetic aspects of the experience of the objects in the consciousness, to structure the objects phenomenologically in the consciousness.

However, one of Husserl's students, Martin Heidegger, introduced a new way of looking at phenomenology. While Husserl was looking at the basic structure of consciousness through phenomenology, Heidegger was focusing on the human being as part of the world, trying to understand the human experiences through the lived body, feelings, and affect. I describe Heidegger's phenomenology in detail, in Section 4.3, since this thesis adopts his approach.

Further, Sartre, on the other hand, focused on consciousness intentionality (Lübcke et al. 1996), arguing that the design specifics of objects do not resume to only how we use them, but we also encounter *others* through these designs (Gallagher 2020). He introduced the idea of Vorhanden and Zuhanden, where the designer should treat his/her products as something that facilitates function, respectively, as something that best suits the use of human agents (Gallagher 2020).

Merleau-Ponty focused on embodiment, arguing that we make sense of the world through our bodies and our bodily actions (Gallagher 2020). He distinguished between the notion of Leib, meaning the lived body or the body as a subject, and Körper, the objective body, or the body as an object (Gallagher 2020).

Dreyfus adopted the view from Heidegger and Merleau-Ponty in his phenomenological work focused on developing a critique of the artificial intelligence of machines that aim to act with human-like intelligence (Gallagher 2020). He argued that we could not look at the computer's intelligence like the human brain, because this would undermine human cognition: human cognition is much more complex, and it cannot be reduced to a set of formal rules (Gallagher 2020). His work focuses on AI, cognition, and embodiment in robots, social affordances, and robotic design (Gallagher 2020).

As we can see, phenomenology has evolved. However, researchers in design fields have adopted different phenomenological perspectives, following specific phenomenologists. I continue further by giving some examples of how phenomenology was used as a philosophical grounding in design fields.

4.2 **Phenomenology in design fields**

Various phenomenological perspectives were adopted in different design fields by different authors. For instance, Winograd and Flores (1986) anchored their work on *Understanding Computers and Cognition* (1986) within phenomenology as a philosophical way of investigating the foundations of human experiences and actions. According to the authors, the phenomenological tradition emerged from humanistic studies and is concerned with studying the individual's experiences in the context where the individual lives, emphasizing the importance of human experience (Winograd and Flores 1986). They have mainly concentrated their work on the previous work of Gadamer and Heidegger, for several reasons: 1) Gadamer's work focused mainly on the problem of language and its interpretation, whereas 2) Heidegger argued that cognition is not resumed to "systematic manipulation of representations" (Winograd and Flores 1986, p. 10). The authors' focus in their work was on dealing with questions about cognition and the nature of language for understanding computers. Thus, the work of Gadamer and Heidegger was relevant for their work.

Further, more recent work from Turner (2008a; 2013) has focused on understanding *familiarity* as a concept. The author has adopted a phenomenological perspective anchored in the work of Heidegger on *being-with* and in the Dreyfus (1991) commentary on Heidegger's work. His work has also crossed the boundaries of familiarity as a phenomenological concept, and focused on the anatomy of engagement with technology, as opposed to interaction with technology (Turner 2010), on intuitiveness (Turner 2008b), and appropriation of technology (Turner 2011). Some of his work has even focused on the phenomenological perspective on familiarity and universal design (Turner and Walle, 2006). Along the same lines, Herstad and Holone (2012) have also focused on the phenomenology of familiarity as a concept for designing universally designed tangible co-creatives.

However, some design researchers have focused on the interaction between humans and machines as embodied interaction, anchored in Heidegger's work and his "being-in-the-world." One of them is Dourish (2001) with his work on *Where the action is: the foundations of embodied interactions*. He framed the concept of embodied interaction as "the creation, manipulation, and sharing of meaning through engaged interaction with art[i]facts" (Dourish 2001). His work criticized how much of the literature available on HCI and CSCW is not very theoretically anchored when addressing the complexity of cooperative systems, their structures, and their use (Dourish 2001). He argues that many technologists focus on the technology itself; however, one needs theoretical abstraction and a conceptual grounding to be able to address the complexity of the technology as part of cooperative systems. Specifically, he talks about tangible and social computing, framing accessible theory for technologists, grounded in phenomenology, and Heidegger's "being-in-the-world" and "readiness-to-hand." He also draws on Merleau-Ponty's phenomenology of the lived body and Wittgenstein's philosophy of language. Dourish's work spans both the HCI and CSCW fields. Similarly, Robertson (2002), in CSCW, has used Merleau-Ponty's phenomenology to study shared work practices.

Along the same lines as Dourish's work, some researchers have focused their work on tangible interaction and the experience of the lived body, anchored in the work of Merleau-Ponty's (1962) *Phenomenology of Perception* (1962). For instance, Svanaes's (2000) Ph.D. thesis focuses on understanding interactivity, from a phenomenological perspective, anchored in Heidegger's and Merleau-Ponty's works. In one of his later works, he then gives an elegant illustration of the implications of Merelau-Ponty's phenomenology (Svanæs 2013). Similarly, Joshi (2017) dedicated his Ph.D. thesis to adopting Merleau-Ponty's phenomenological approach to designing for the capabilities of elderly users. Some of his work presents designing for simplicity (Joshi 2015) and prolonged mastery (Joshi and Bratteteig 2016).

Also, in Interaction Design, the work of Fällman (2003) is significant in designing mobile information technology, anchored in a phenomenological approach. He also explored the philosophy of technology, talking about Borgman's' device paradigm and Ihde's non-neutrality of technology, both being anchored in the work of Dewey and Heidegger (Fallman 2011). Similarly, the more recent work by Höök (2018) has focused on the phenomenological idea of *designing with the body,* through an experiential, felt, soma-aesthetic experience, as also the title of is book denotes: *Designing with the body-Somaesthetic interaction design.*

Frauenberger, whom I have mentioned in the positioning of this thesis (Ch. 2), and his paper on entanglement HCI (Frauenberger 2019), has previously argued for the importance of phenomenology as a philosophical discipline that equips the designer with a theoretical framework for studying the human experience when interacting with the things surrounding him (Frauenberger, Good, and Keay-Bright 2010). Moreover, Frauenberger and colleagues have argued for the critical role that phenomenology plays, in, for instance, participatory design studies (Frauenberger, Good, and Keay-Bright 2010). The authors say that phenomenology has implications for both the technological artifacts produced as a result of the participatory design process, but also during the process of design, by providing those involved in the design process with valuable insights (Frauenberger, Good, and Keay-Bright 2010). One of his research projects is ECHOES (Frauenberger, Good, and Keay-Bright 2010; Frauenberger 2015), focusing on designing technologically enhanced learning environments for children with autism or Asperger Syndrome. During the ACM's conference on Interaction Design and Children (IDC'18), he was even the editor of a special session on designing for different abilities (Frauenberger 2018). Besides, in his recent work on entanglement HCI, as the next HCI wave, Frauenberger (2019) suggested that perhaps entanglement theories may take further the idea of embodiment, proposed during the third HCI wave by Dourish (2001). As shown earlier in this section, several design researchers have explored the idea of embodiment. However, Frauenberger (2019) suggests that entanglement theories may take the question on the relation between humans and things, and their agency, further. He says that the focus on situatedness, values and embodiment is no longer enough (Frauenberger 2019).

However, although many design researchers have adopted phenomenology as a philosophy for thinking, reflecting upon, discussing design, or designing, Heidegger's concept of *Befindlichkeit*, with the meaning of situatedness, is still underexplored in design fields. For instance, if we look at the work of Ciborra (2006), he argued that the meaning of situatedness is used differently than the one from Heidegger across the available literature. For instance, he gives the examples of the importance of situation mentioned in Winograd and Flores (1986), "situated change" from Orlikowski (1996), "situated nature of knowledge" from Schultze & Leidner (2002), Haraway's (1991) "situated knowledges," or Suchman's (1987) "planned and situated actions," in Ciborra (2006, pp. 129-130). He also refers to the "situated process" from Lave & Wenger (1991), "situatedness of experience" from Wenger (1998), and "situated cultures" in Artificial Intelligence literature (Clancey, 1977), or "situated learning" debated in Contu & Willmott (2003), in Ciborra (2006, pp. 129-130). Besides, he recalls the importance of the idea of situatedness in CSCW and Dourish's (2002) more recent idea of "situated perspective" in Ciborra (2006, pp. 129-130). Further, Ciborra (2006) argues that the notion of situatedness is often taken for granted, it is implicit, and it is assumed to refer to phenomenology, through ethnomethodology (Ciborra 2006, p. 130).

As this thesis frames, defines, and investigates the concept of situated abilities through a phenomenological perspective, I argue that it is necessary to go back to the original idea of situatedness, as described in Heidegger's work. This thesis argues that we should do this before we can move on to what Frauenberger (2019) means when saying that we should rather focus on the human relations with things as forms of entanglements while stepping away from the idea of situatedness, values, and embodiment. But for being able to talk about situatedness, and the original concept as defined in Heidegger's phenomenology, I need first to give a brief description of Heidegger's work, since I will be using some of his notions further in the thesis. Thus, in the next section, I present Heidegger's phenomenology, before I continue thereafter with his concept of *Befindlichkeit*.

4.3 **Heidegger’s phenomenology**

Heidegger laid the foundation for a philosophical revolution (Heidegger 2010). He proposed an ontological view of human experiences and existence, as “being-in-the-world” (German: *In-der-Welt-Sein*) (Heidegger 2010). He argued that the question of *being* is an ancient ontological question illustrated in the work of Plato and Aristotle, but it ceased in the later works of the contemporary philosophers (Heidegger 2010, p. 1). He argued that we could not understand the world without a pragmatic view of it, i.e., by being part of it. One of his arguments was that our intentionality is illustrated by our orientation to action, i.e., we see things as “ready-to-hand” (German term: *Zuhanden*) or as “present-at-hand” (German term: *Vorhanden*) (Heidegger 2010). His canonic example is illustrated through the use of an object, the hammer, which is “ready-at-hand” when the human being experiences it as somehow transparent, when the hammer works (Heidegger 2010). In this case, the hammer is a piece of equipment, a tool, or an instrument that facilitates the human being’s experience, and supports its “being-in-the-world” through a transparent experience (Heidegger 2010). However, when an object does not work, the object becomes “present-at-hand” (Heidegger 2010). For instance, when the hammer used as a piece of equipment, instrument, or tool does not work or creates a breakdown situation for the human being, the relations of the human with the world changes, the human noticing his or her experience as “present-to-hand.”

Figure 4-1 A representation of Heidegger’s classic example of the hammer as "ready-to-hand" or "present-at-hand"

Further, Heidegger criticized other philosophers and scientists, suggesting that they were mainly looking at the objects in the world, including the human being, as “present-at-hand” and trying to adopt an objective perspective. He argued instead that the human being, as he calls it *Dasein*, cannot be viewed separately from the world, it cannot be reduced to a thing, but it can only be viewed and understood in relation to the world, as *being-in-the-world* (Heidegger 2010). He argued that the question of being [*Sein*] was no longer in focus; however, the question of what it means “to be” or “not to be” is what defines us (Heidegger 2010, p. xviii). *Dasein*, translated as *being-here* (Gendlin 1978, p. 4), “the being concerned with its own being” (Heidegger 2010, p. xviii), the human existence can only be understood and discovered through inter-subjectivity, through its encounter with others, through specific circumstances and moods, dispositions, and its *throwness* in the world, its *situatedness*, namely what Heidegger named *Befindlichkeit* (Heidegger 2010). In the next section, I go deeper into Heidegger’s concept of *Befindlichkeit*.

4.4 Heidegger's concept of Befindlichkeit

The concept of *Befindlichkeit* was first introduced in Heidegger's dedicated lectures on Aristotle, on Nichomachean Ethics and Rhetorics, where he chose *Befindlichkeit* to define situatedness, according to Ciborra (2006, p. 136). Heidegger based his *Befindlichkeit* concept on the idea of *pathos*, from Aristotle, to capture the non-cognitive aspects of *Dasein* in a situation, as "points of access to life," according to Ciborra (2006, p. 136).

Befindlichkeit is a philosophical concept and one of Heidegger's neologisms (Heidegger 2010). According to Gendlin (1978), philosophical concepts are positioned at a higher level than the scientific concepts, since philosophy is considered to be more abstract than science. The word emerges from the German *sich befienden*, which has the meaning of being, existing, or finding oneself in a situation. In everyday German, *wie befienden Sie sich* would translate as '*How do you find yourself?'* (Gendlin 1978), with the meaning of '*How are you doing?'* (Heidegger 2010, p. xxiii), or with the meaning of *'How do you feel?'* (Gendlin, 1978, p. 2; Ciborra, 2006, p. 130). However, the German neologism of *Befindlichkeit* has no direct translation into English – if it was to be translated, it would as the English "how-are-you-ness" or as "self-finding" (Gendlin 1978, p. 2). The term denotes one's passive experience of the situation one experiences (Lübcke et al. 1996). Moreover, the neologism denotes a general ontological term for one's openness and understanding of its own existence and experiences in a given situation (Lübcke et al. 1996). However, the authors point out that the term *Befindlichkeit* as such does not reduce itself to an existence of only consciousness, but also other forms of sensorial experiences, everyday experiences with objects of use, etc. (Lübcke et al. 1996). At the same time, some translate it as *attunement* (Heidegger 2010, p. xxv). *Befindlichkeit* is also a way of being *there*, described as the most familiar in everyday life, a "*mood*," which is fundamental to the existence of the being, as explained in Heidegger (2010, p. 130).

4.5 Befindlichkeit and situatedness

Gendlin (1978) explains the concept of *Befindlichkeit* as a bodily-experiential dimension. He argues that the concept is often misunderstood; however, it should be regarded as one of Heidegger's ground parameters of human existence (German *Existenziale*), along with *understanding* and *speech*, included in many of Heidegger's concepts (Gendlin 1978). *Befindlichkeit* can be defined as the *beings* of human beings, how they are in certain situations, with all their "moods, feelings, or affects" (Gendlin 1978, p. 1).

Sich befienden, translated as finding oneself, has several meanings: (1) the reflexive meaning of finding oneself, (2) the meaning of feeling, and (3) of being situated (Gendlin 1978, p. 2). All these meanings of the concept are interconnected. On the one hand, the reflexive meaning of (1) finding oneself has an outward meaning and is illustrated in terms of how "*we sense ourselves in situations*" (Gendlin 1978, p. 2). On the other hand, the meaning of (2) feeling has an inward meaning, and own understanding of the *being* (Gendlin 1978, p. 2) instead. However, the human being finds him- or herself always in situations and *in* relation to others. The human being cannot be detached from the world s/he is situated in. The being of the human being is always situated in the world, as in "being-in-the-world." Further, *Befindlichkeit* is both an interactional and an intrapsychic concept, according to Gendlin's (1978) reading of Heidegger, arguing that humans are "their living in the world with others," they are "living-in" and "living-with" (Gendlin 1978, p. 2). The lived situations of the *Dasein*, the existence of the human being, is not detached from the *Dasein* itself: *Dasein* is part of these situations, and therefore only *Dasein* can have an understanding about the own being in the lived situations (Gendlin 1978, p. 2). As explained by Gendlin 1978, p. 2), this understanding is an implicit one, not a cognitive one: it is lived, sensed, felt, without being separated from the body, into cognitive structures (Gendlin 1978, p. 2) (compared to Husserl's structure of consciousness, where these are separated, investigated and understood as objects separated from the body).

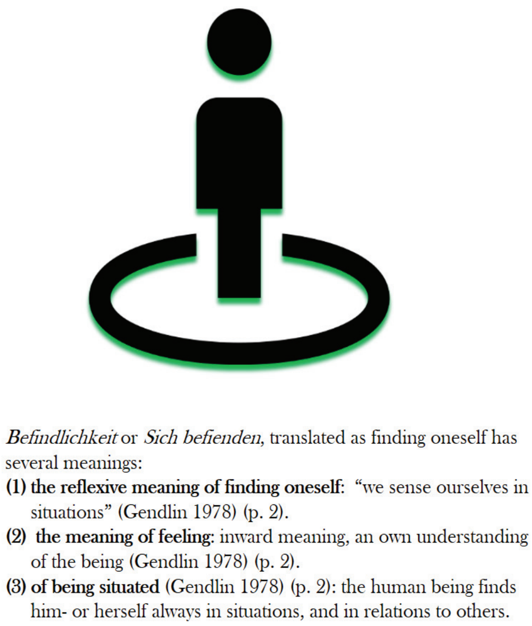


Figure 4-2 *Befindlichkeit* or *Sich befienden* and its three meanings

As may be observed, the philosophical concept of *Befindlichkeit* eliminates the dichotomy between the inward/outward world of the *Dasein* and between the self- and others, altering the affective/cognitive part, losing its distinction across time and space (here/there), and past/present/future, according to Gendlin's (1978, p. 4) understanding of Heidegger's work. Gendlin (1978) closes his understanding of *Befindlichkeit* as being linguistically structured, in the way that we are always living in situations, and our *Befindlichkeit* emerges from these "living-in our contexts" or situations (Gendlin 1978, p. 20).

Further, as I previously mentioned, although situatedness has often been used in design research, Ciborra (2006) argues that the notion is not well anchored in the original definition from

Heidegger. He finds the concept of situatedness both interesting and relevant for understanding the human lived experience. The author sheds light on the idea of situatedness as originally understood, through Heidegger's *Befindlichkeit*, criticizing how the idea of situatedness is often shallowly understood and used in its limited sense. He argues that one should go back to the original definition of *Befindlichkeit*, where *befindlich* in German means "situated," whereas he translated *Befindlichkeit* as "situatedness" (Ciborra 2006, p. 130). In other words, he tries to restore the meaning of situatedness, as originally used by Heidegger in his *Befindlichkeit* concept. According to him, the way the human being, the *Dasein*, understands the world is situated. Similarly to Gendlin's (1978) understanding of *Befindlichkeit*, Ciborra (2006) agrees that situatedness is both "the ongoing or emerging circumstances of the surrounding world" and the inner world of *Dasein* (Ciborra 2006, p. 130). Further, he argues that although references to phenomenology are often made across the literature when talking about situatedness, these are never explored in-depth, i.e., the authors do not allocate sufficient time and space to anchor their idea of "situatedness" in the original concept as described by Heidegger (Ciborra 2006, pp. 131-133). He continues by explaining two cases: first, the case of the photo-copying machine described in Suchman (1987), and her situated actions; and second, the idea of situatedness, from Heidegger. He argues that Suchman's (1987) and others' views on situatedness are interpretive, while Heidegger's connects to phenomenology (Ciborra 2006, p. 138). In Ciborra's (2006) understanding of Heidegger's work, the "I," the *Dasein*, cannot be removed from the situation (Ciborra 2006, p. 135). He continues by describing the initial work from Heidegger using the term *I-situation*, and *I-in-the-situation*, arguing that this should be in the focus of the human's reflection (Ciborra 2006, p. 135). The situation is always the situation of *someone*. A situation cannot exist without the belonging of the situation to someone. Moreover, talking about a situation removes the barrier between the dichotomy between subject-object, that "depriv[es] the lived experience of any life," capturing, in a way, several meanings, as he says (Ciborra 2006, p. 135). A situation includes the "I", the *Dasein*, "being-in-the-world". Finally, a human being lives a situation, or works her way towards a situation (Ciborra 2006).

4.6 How is Befindlichkeit used in this thesis?

I have presented, in this chapter, phenomenology as a philosophical perspective to understand the world and, thereafter, phenomenology in design. Phenomenology is extensively used in design fields as a way of seeing the world, in many ways. Many of Heidegger's earlier concepts are used; however, I could not find much literature on the use of the *Befindlichkeit* concept.

Befindlichkeit is used in this thesis with the meaning of situatedness, for explaining the idea of *situated abilities*. I chose to follow Heidegger's idea of situatedness defined as *Befindlichkeit* after reading Ciborra's (2006) article, a critique of the literature addressing situatedness. As Ciborra (2006) argues, many researchers talk about situatedness, without anchoring it within the core concept and the original one, from Heidegger, namely *Befindlichkeit*. Moreover, Heidegger's phenomenology is not only used to define the concept of situated abilities. His phenomenology is also used as a theoretical lens to analyze, interpret, discuss, and reflect upon my findings from the two presented cases while framing the idea of situated abilities.

Thus, in order to be able to talk about situated abilities, it is necessary to go back to the original definition of situatedness, from Heidegger.

4.7 Reflection on theoretical challenges and advantages in an interdisciplinary thesis

While classic or traditional theses apply one theory to a thesis, I have applied multiple theoretical concepts instead of different papers, borrowed from different fields. However, the concepts were carefully chosen to fit each of the studies. In other words, I have dived into the sea of the unknown. Each time when I thought that I had a grasp and understood the depth of my data through a concept, I found new ways of exploring new or old data through *new* concepts. On the one hand, I have perhaps failed to embrace one theory and limit myself to that one for each paper written. On the other hand, I have trained my eyes to see and manage concepts from different theories and fields, to be able to mold, analyze, and reflect on my data with the help of these concepts, not only for one case but across the two cases. I fed my intellectual curiosity by reading HCI, HRI, and CSCW literature, theories, and concepts. I drew parallels between fields, borrowed concepts from one field, and perhaps applied those to another field. Thus, I explored and challenged the boundaries of these fields – in my own way, and through my own understanding. McGrath (2005) supports this idea of embracing several theories. She says that if we limit ourselves to single theories or concepts, we perhaps limit ourselves in terms of seeing things from multiple angles.

Along the same lines, Walsham (2012) talks about the importance of using a multi-pluralistic methodology and interdisciplinary views. I argue that I found out things that I would not have found out if I had applied a single theory and concepts from one single theory. Moreover, some of the concepts from one theory may not fit with the data or the findings. Therefore, it is better, at times, to step outside a field and borrow other concepts that fit and help to understand phenomena during the analysis of the data and findings. I am open to the idea that this might be criticized by some, while appreciated by others. It might be safer to sail on safe waters, subscribing to certain ways of doing things – but this will take us only so far, and we might lose out on seeing things from different perspectives. Sailing on "unsafe waters" might be more dangerous, but we learn more. This thesis subscribes eventually to the latter way of doing things, which I personally found more challenging but also more rewarding.

Further, the ontological assumptions of the papers included in this thesis refer to the nature of reality. I based the "existent reality" of each of the papers in the existing literature on the studied topic. According to Heidegger, an ontic view can be understood through ontology, but ontology can be understood only through phenomenology.

Thus, I have adopted a phenomenological approach in this thesis, as explained in this chapter. Finally, the papers included in this thesis, as you will able to see in the next chapters, can be framed in the concept of situated abilities, which is in itself both the main finding of this thesis and the main contribution of this thesis.

Finally, the epistemological assumptions of the papers included in this thesis refer to how the knowledge was created. I based the knowledge on the existent studies by reviewing the relevant literature, but also through the participants' views on the world. All in all, from a philosophical perspective, the concepts used across the papers can be compressed into the phenomenological idea of *Dasein* and "being-in-the-world": the human being's relations to things in the world, namely through *Befindlichkeit*.

Chapter 5 PARADIGM, METHODOLOGY, AND METHODS

"In a very real sense, every method decision is an ethics decision, in that these decisions have consequences for nor just research design, but also the identity of the participants, the outcomes of our studies, and the character of knowledge which inevitably grows from our work in the field."
— Markham (2005, p. 251)

In this chapter, the paradigm chosen as a philosophical assumption is explained. Thereafter I describe the methodology. At last, I give an overview of the data collection and analysis methods used in both cases. The methods used for each of the cases are explained in detail in PART II, where I present in detail each of the cases. Ethical considerations are also included in this chapter, as well as reflections on the positionality of the researcher.

5.1 Paradigm and philosophical assumptions

Five philosophical assumptions stand at the basis of qualitative research design (Creswell 2007). These are ontological, epistemological, axiological, rhetorical, and methodological assumptions (Creswell, 2007). The ontological assumption refers to the nature of reality. In this thesis, this is done mainly through participants' views, including myself as a facilitator and researcher. The epistemological assumption refers to the relations between myself, as a researcher, and what is being researched, i.e., how the knowledge is created. The axiological assumption refers to the role of values in the research. The main value that emerges from my research is a salutogenic approach towards human beings' abilities. Further, the rhetorical assumption refers to the language used in the research. Regarding the language used, I have reflected on it in the last part of the introduction chapter (Section 1.10), but also in the last part of this chapter – the positionality of the researcher. Finally, methodological assumptions refer to the process of research. In qualitative research, this is mainly inductive and emerges during the research.

Further, the notions of *paradigm*, sometimes called the *worldview*, refer to a set of principles, premises, or beliefs that guide the researcher's action (Creswell 2007). Different researchers distinguish amongst various such paradigms. According to Creswell (2007), there are four such paradigms: post-positivism, constructivism, advocacy/participatory, and pragmatism. Further, Duarte and Baranauskas (2016) divide the paradigms and philosophical anchors into positivism-post-positivism, critical-ideological, and constructivism-interpretivism. A third division of the paradigm is from Myers (1997), Myers and Avison (2002), and Myers and Klein (2011), who distinguish instead between the following: positivism, interpretivism, and critical research. They build on Orlikowski and Baroudi's (1991) (following Chua's, 1986) work. A fourth division is made by Guba and Lincoln (2005), who divide the paradigms into positivism, post-positivism, critical theory, constructivism, and participatory. However, one can use multiple paradigms in their research (Creswell 2007).

The paradigm that was used in the two cases presented in this thesis is mainly the interpretive one, through the data collection and analysis. However, the findings of my research subscribe rather to the constructivist paradigm, where new knowledge emerges from the two cases, i.e., the concept of situated abilities emerges through the findings from the two cases included in this thesis. A few elements from positivism can also be recognized in my research. This is, however, limited to the writing style: the use of tables, reporting on gender or using, perhaps at times, jargon specific to positivist research.

5.1.1 Why interpretive research?

Interpretive research "starts with the assumption that access to reality (given or socially constructed) is only through social constructions such as language, consciousness, and shared meanings" (Myers 1997, p. 2). Interpretative research is represented through a post-modern perspective. This is carried out through an inductive approach in deconstructing meanings, for instance, through transcribed interviews; by bringing problematic points to design discourses (see Case 1 and Case 2 for details); or by arguing for designing for all *users*, or marginalized groups – such as the elderly; or such as arguing for understanding that design that will be used by a diversity of users. Last but not least, an interpretive way of understanding design and human beings' situated abilities in their everyday interaction and use of ICTs is present in both cases. Moreover, some elements of feminist theories are present in the form of my positionality as a researcher with insider knowledge, recognizing my background, and by considering ethics issues of care (Creswell 2007). (See the positionality of the researcher described at the end of this chapter.)

Moreover, interpretive research is based on a hermeneutic approach. Hermeneutics originated from the textual interpretation of the Bible (Hartman 2004). In the 1900s, hermeneutics evolved into the interpretation of literature, arts, history, but also individuals' or groups of individuals' actions. Hartman (2004) argues that hermeneutics concentrates around lifeworld – how the world is perceived, not how it is (Hartman 2004). An individuals' or group of individuals' lifeworld is understood by the researcher as a result of a process of interpretation (Hartman 2004). Further, Gadamer (1900-2002), a student of Martin Heidegger, argued that language is a way of understanding *being* (Malpas 2016). Gadamer's hermeneutics is philosophical, with a practical orientation inspired by Aristotle's *phronesis* (Malpas 2016). Furthermore, hermeneutics is holistic, containing relational theories. He says that a human being's understanding of another's lifeworld(s) depends on her background. In this thesis, the lifeworld of participants is understood mainly according to the experienced situations in their everyday interaction with and use of technologies. These are represented through the textual data in the form of transcribed interviews, photos taken, documents, but also headnotes and my own experiences while collecting data. This is done mainly through the use of language and the terminology used by the participants, but also through a presentation of my background and my positionality as a researcher.

Moreover, studies talk about the *hermeneutic circle* as an understanding of the parts and the understanding of the whole (Malpas 2016). To be able to understand the whole, I argue that it is needed to first understand the parts, i.e., to have a pre-understanding of the parts (Malpas 2016). This hermeneutic circle in this thesis can be observed in the analysis methods used for each of the cases for interpreting the data. Another level of the hermeneutic circle can also be observed through the understanding of each of the cases, Case 1 and Case 2, before we can understand the whole, by answering the first research question. A third level of the hermeneutic circle can also be observed in understanding the finding that emerged from the two cases included in this thesis, i.e., situated abilities. This is also an answer to the second research question. An additional level of hermeneutics can be found in reflecting upon my own researcher's role and positionality.

5.1.2 Why constructivist research?

The ontology of constructivist research is local, specific, and constructed knowledge (Guba and Lincoln 2005). The epistemology of constructivism is transactional/subjectivist/created findings. In constructivist research, the methodology has a hermeneutical approach (Guba and Lincoln 2005). The inquiry aim is understanding and reconstruction. The knowledge accumulation is done through "more informed and sophisticated reconstructions" and through experiences (Guba and Lincoln 2005). *Knowing* in this thesis does not limit itself to interviews, but also other data sources, such as observations, photos, document analysis, etc. These are described in the sub-section on data collection methods. Moreover, *knowing* in this thesis is instrumental, and it is used as a means to social emancipation, in terms of arguing for a diversity of users that experience their own situated abilities in their everyday interaction and use of ICTs, without focusing on individuals' disabilities, but rather on the individuals as human beings and their abilities. The resulting research is also constructive because of the nature of the second research question. RQ2 is formulated as a descriptive research question, but it is inherently critical and constructive, as specified in the first chapter. Moreover, this type of research question leads to exploring human beings' relations and abilities in terms of everyday interaction with and use of ICTs, based on how the human being finds himself or herself in a situation, depending on his or her experienced abilities in relation to the world. Finally, the research is also constructive because it investigates alternatives on how one can talk about UD without focusing on disabilities and abilities, but with a salutogenic approach in mind. This, in its turn, leads to the main concept and contribution of this thesis, namely situated abilities.

5.2 **Methodology**

5.2.1 Case study

Myers (1997) discusses four main methodologies: action research, case study, ethnography, and grounded theory. According to Myers and Avison (2002, p. 7), the case study is (the most) common methodology within qualitative research. Stake (2005) defines a case study as "both a process of inquiry about the case and the product of that inquiry" (p. 444). Case studies can be classified as intrinsic, instrumental, and collective (Baxter and Jack 2008; Stake 2005). An intrinsic case study should be, citing Stake (2005), a "functioning body," a "bounded system," a "case of itself" (p. 444). An instrumental case-study should provide insights about something else (p. 445), whereas collective case studies can be used to investigate a certain phenomenon more deeply.

This thesis is framed as an instrumental collective case study. It is framed as a case study because of the nature of the two different cases that I include: Case 1 and Case 2. Further, Baxter and Jack (2008) talk about Yin's (2003) and Stake's (1995) work, claiming that it is important to set boundaries on a case, through for instance: "(a) time and place (Creswell, 2003); (b) time and activity (Stake 1995); and (c) by definition and context (Miles & Huberman, 1994)" (pp. 546-547). Concerning this thesis, I carried out two case studies that were bounded as follows:

(a) Time and place: Case 1 was bounded in terms of place, by the limitations imposed by the MECS project: conducting research at the facilities of OK+, whereas in terms of time, it was bounded by the MECS timeframe (2016-2019, prolonged to February 2021), with the data collection taking place at OK++ during 2017. Case 2 was bounded in terms of time and place by limiting the data collection from Higher Education institutions in (Southern) Norway, with the data collection time-frame limited to 2018.

(b) Time and activity: according to Stake (2005), "we may simultaneously carry on more than one case-study, but each case study is a concentrated inquiry into a single case" (p. 444). In the same way, my research was divided between Case 1 and Case 2, each of the cases having several clearly defined activities. I have started with the data collection for Case 1 first, and then I continued with data collection for Case 2. During the analysis of the data, I alternated between the cases, trying to make progress in both of them. This required planning and coordination across the two intertwined project streams.

(c) Definition and context: the planned activities for each of the cases were specific and suitable for the context where these took place.

Since the collective case study in this thesis is also instrumental, questions such as: "What is going on? What can be learned from each of the cases?" were asked. Moreover, I have looked at the physical setting, especially for Case 1, but also at the social, political, and legal context for each of the cases, in order to frame the case, especially in Case 2. An example of the social, political, and legal context is given in Ch. 3 On Universal Design. More details are given later in this chapter, within the data collection methods.

5.2.2 Selection of the case studies

> "A final strategy for the selection of cases is choice of the paradigmatic case. Kuhn (1987) has shown that the basic skills or background practices, of natural scientists are organized in terms of 'exemplars,' the role of which can be studied by historians of science." (Flyvbjerg, 2012, p. 231).

Stake (2005) and Flyvbjerg (2006) talk about how we should learn from *atypical cases* that give us the opportunity to learn. Moreover, the choice of the cases should be strategic, that allows for access and long stays.

Case 1, for instance, had an atypical nature, since the choice of the robot to be "deployed" in the participants' homes was a vacuum cleaner robot. However, the MECS project had as its purpose to study a safety alarm robot for the elderly. Since no such robot was available at the time, and since the participants were familiar with robot vacuum cleaners and wished to test out such robots, choosing this device to be "deployed" in the homes of the participants was a strategic choice – a "win-win" situation, where both the participants got something out of the data collection, and we as researchers collected our data. In this way, we, the researchers, could *stay longer* with our participants, thus giving us access to otherwise perhaps more difficult accessible data.

Case 2 is also atypical in a way: I have investigated the complex nature of everyday interaction and use of Digital Learning Environments (DLEs) (plural!) rather than looking at the use of one specific Learning Management System (LMS) as many previous studies have done.

All in all, I framed my research as an *instrumental collective case-study*, as my research intended to investigate in an explorative way the research questions, the main source of data being the *people* involved in the study, and their understanding and lived experiences of situations from their everyday interaction with and use of digital technologies.

5.3 Data collection methods – Overview

I chose as my main source of data semi-structured interviews. It is, however, recommended that several data collection sources are employed. There is always a difference between what people say they do and what they do (Button and Sharrock 2009; Iachello and Hong 2007, p. 36; Randall et al. 2007).

Thus, I employed the following data collection methods in Case 1: group interviews and semi-structured interviews, domestic probes like participant's diary notes, observations, photos, researcher's diary, log reports, document analysis, and headnotes (Ottenberg 1990).

In Case 2, I employed the following data collection methods: photos, semi-structured interviews, story dialogue methods, researcher's diary notes, document analysis, and headnotes (Ottenberg 1990).

The overview is also given in Table 5-1 below. In this section, I only present each of these methods. In Ch. 6 on Case 1 and in Ch. 7 on Case 2, I explain details on how I have used each of these methods.

Table 5-1 Data collection methods overview for Case 1 and Case 2

Data collection method	Case 1	Case 2
Semi-structured individual interviews	X	X
Semi-structured group interviews	X	N/A
Story-Dialogue Method	N/A	X
Photos	X	X
Domestic probes as participant's diary notes	X	N/A
Researcher's diary notes	X	X
Observations	X	N/A
Log reports	X	N/A
Document analysis	X	X
Headnotes	X	X

5.3.1 Interviews

Interviews can be highly structured (such as surveys or questionnaires), semi-structured or unstructured (more informal discussions, where the researcher did not preset the outline of the interview) (Crang and Cook, 2007, p. 60). I focused on conducting semi-structured individual and group interviews with the participants in both of the cases (Case 1 and Case 2).

According to Crang and Cook (2007), arrangements for the interviews should be prepared in advance, with a follow-up afterward. It would also be good to have a checklist for the interview, for instance for booking a room where the interview takes place, sending invitations and informing people about it, knowing who from the research team is assigned to take notes during the interview, or who is going to notice the body language, etc. For each of the interviews (semi-structured and group interviews), I developed an interview protocol, usually containing three parts. The first part of the interviews contained an introduction part where I gave information about my research, the aim of the interview, and where the informed consent was signed by both the participants and myself. The second part of the interviews contained the main part where the central questions for the interviews were asked. Finally, in the last part of the interviews, I usually asked the interviewees if they had any other comments or questions and thanked them for their participation.

Central to rich-data interviewing was also the way I talked to and asked questions of the participants. The participants were, in general, more or less open to answering the questions, depending on their relations towards me as a researcher. Crang and Cook (2007) suggested that interviewers should ask "non-threatening," "grand-tour" questions of the type: 'what?', 'who?', 'where?', and 'how?'. The questions should not be "directive," i.e., value-laden, but instead neutral (pp. 68-73). Thus, I tried to encourage the participants to elaborate on their answers. In this way, the participants presented their *own* personal views on the topic, without myself interfering in their line of thought.

During the group interviews, my role was of a facilitator, or "moderator" of the group, but the participants mainly formed the main interactions. Crang and Cook (2007) suggested that the researcher should be the "expert on the procedure," whereas "the participants" should be experts "on the topic" to be discussed. This was partially valid for my research: the elderly participants, the interviewees, were not the experts on the robots as a general theme; however, they were experts on their experiences with the robots in the home. The interviewees in Case 2 were experts on their experienced situations with DLE; however, not all were experts on UD.

Other aspects that I took into account during the group interviews were power relations in the group, participants who were silent in favor of those who enjoyed talking more, the risk of "group-think" during the group interviews (see Crang & Cook, pp. 94-96), and the time allocated for each topic.

5.3.2 Story-Dialogue Method

The story dialogue method (SDM) is a method based on structured dialogue, where the participants reflect on their own experiences around a specific theme (Labonte and Feather 1996). It was initially derived from constructivism, feminism, critical pedagogy (Labonte, Feather, and Hills 1999), and critical social sciences (Labonté 2011b). This method builds upon participants' stories, which are used as a catalyst for reflection and analysis (Labonte and Feather 1996). The stories here are also referred to as case stories (Labonte and Feather, 1996). Specifically, a case story could be defined as a self-interview, where the participants present and share with other personal experiences in a particular situation (Labonte and Feather 1996). These case stories are based on a process build upon the description, covering *what* happened; explanation, covering *why* it has happened; synthesis, including *so what* questions, where the participants get a deeper understanding of what has happened; and finally, action, where the participants, ask questions in the form of *now what,* getting concrete steps on what actions could be taken towards their stories (Labonte and Feather 1996). SDM method is based on the following values: trust amongst the participants, being critical, careful, and personal (Labonte and Feather 1996). An illustration of the process is given in Figure 5-1 on the next page.

The advantages of this method are: the stories generate useful knowledge that contributes to theory, the stories are presented as a first-person experience, and in a structured way, and they are documented through notes (Laverack and Labonte 2000). The weakness of the method is that: the quality of the stories, the abstraction of the stories, and the articulation of the insights acquired during the method are highly dependent on the participants' degree of participation and commitment to preparing the stories, their capacity, and skills of abstracting their experiences, and articulating the insights they get during the method (Laverack and Labonte 2000). The stories build on narratives, with the aim of creating new meanings, theory notes, and hence knowledge from those (Labonté 2011b). These stories play an important role in advocacy (Labonte and Feather, 1996). In this thesis, the stories served as a basis for knowledge development in Case 2.

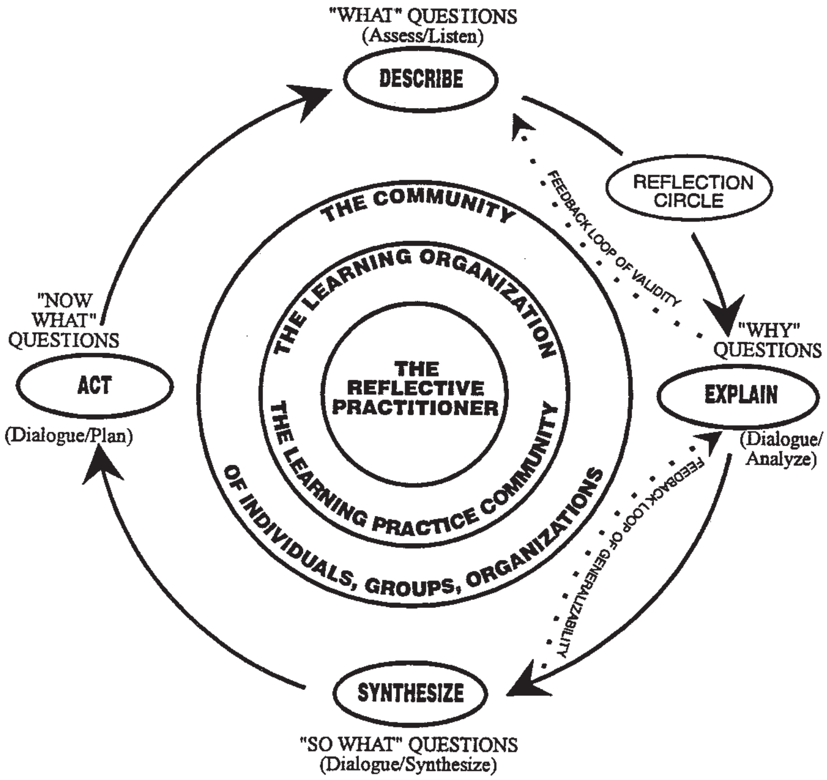


Figure 5-1 Story Dialogue Method - from Labonte & Feather (1996, p. 10)

5.3.3 Photos

Photos were taken during some of the (group and individual) interviews to document the research activities.

During Case 1, photos were also taken during the visits to the elderly people's homes or at OK+ facilities. Moreover, photos were taken during presentations at OK+, a seminar arranged by the OK+ on welfare technologies or conferences, and public forum discussions relevant to the research.

During Case 2, photos were taken during the SDM method, or when some of the interviewees wished to show something, such as an artifact, or a webpage, while they were describing their experiences during the individual interviews. Similarly to Case 1, photos were taken during presentations, meetings, public lectures, conferences, or public forum discussions relevant to the research.

Some photos from both cases are available in the dedicated chapters to each of the cases: Ch. 6 and Ch. 7, respectively.

5.3.4 Domestic probes as participant's diary notes[13]

"Probes are a method for developing a richly textured but fragmented understanding of a setting or situation" (Boehner, Graver, and Boucher 2012, p. 185). According to Gaver, Dunne, and Pacenti (1999, p. 22), probes were introduced in their study to increase elderly people's involvement in local communities. Among the (cultural) probes named by the author that could be used are: a camera, a recorder, a map, paper, glasses to draw on, postcards, etc.

In my research, I used what Boehner, Graver, and Boucher (2012) call a *domestic probe*, a probe that participants can use in their home to document their experiences with technology when the researcher is not around them. Crang and Cook (2007, pp. 111–112) explained how this form of participant's diary notes could be used for an *autoethnography*, while (see the work of Monahan, 2008) also explaining how postcards, drawings, or even sketches can be used for this purpose.

In the case of my research, for Case 1, I invited participants to use *diaries* for documenting their experiences with the use of robots in their homes. The elderly participants were provided with a physical block-note and a pen for documenting their experiences each time they used the robot vacuum cleaner. Non-elderly participants from Case 1 were not provided with any block-note or pen, but they were advised to use a free form for documenting their experiences. Some of them opted for documenting their experiences in a digital format, whereas others opted for documenting their experiences in a physical format (e.g., notes in a physical block-note).

Moreover, despite documenting the participants' relations with technology through various probes, they also proved to be a good mediator between the researchers (including myself) and participants, for starting a conversation.

Another aspect that is emphasized through this form of probes, or diary notes, is the *generation gap* that is also present in my research: "elders represent a lifetime of experiences and knowledge, often deeply embedded in their local communities" (Gaver, Dunne, and Pacenti 1999, p. 25). Hence, using these kinds of participants' diary notes facilitated the *access to knowledge* that only the participants have (see also Crang and Cook 2007, pp. 38–40; Randall et al. 2007). In this way, as a researcher, I could immerse myself in some of the participants' lives and experienced situations with robots, without being too intrusive.

[13] No participant diaries were used in Case 2.

5.3.5 Researcher's diary notes

In addition to the above-mentioned methods, I used a diary, where I wrote down notes during or right after my fieldwork. The notes were documented with a pen and paper in physical block-notes. Some of these notes were documented in digital documents when, for instance, I could not take notes during the data collection activity. However, my main focus was not on this method, but I used it as a form of a supportive tool for my *own* understanding of the process, challenges that I was dealing with, ideas, and insights – like in a light auto-ethnography (see Crang and Cook 2007). This, however, was not the main subject of my own analysis.

Moreover, within the framework for Case 1, I also tried out a robot vacuum cleaner and documented my own experiences. The reason for doing this was to get a deeper and more concrete understanding of the potential challenges that elderly users may encounter.

In addition, I documented my participation in various formal and informal meetings, seminars, presentations, public lectures, or open forum discussions in these researcher's diary notes. This is valid for both Case 1 and Case 2.

5.3.6 Observations

Among the common methods for case studies are also observations (Baxter and Jack 2008, p. 554). One could make passive or participant observations. In passive observations, the researcher would be detached and allow the lives of the participants to take place as if s/he were not there (Crang and Cook 2007, p. 38). In my data collection, I used informal participant observations during the semi-structured individual and group interviews. These were documented in the form of a researcher's diary notes.

Moreover, I made observations regarding the surroundings of the environment, especially for Case 1, where I observed the home setting and layout of the elderly people's spaces and the common areas at OK+ where some of the research activities took place. In Case 2, I did not particularly aim to make any observations. However, this indirectly took place in the form of headnotes. (See the section on Headnotes, in Section 5.3.9.)

5.3.7 Log-reports

Log-reports were used for documenting formal or informal meetings or research activities. These were usually documented in a digital format, right-after the research activities. This method was preponderantly used in Case 1.

5.3.8 Document analysis

Document analysis was used, for instance, in the form of annual reports on welfare, ICT use, and Universal Design, in Europe, Scandinavian countries, and Norway. This method was also used for studying, for instance, official documents or reports from Statistics Norway, The Norwegian government webpage, The Norwegian Ministry of Local Government and Regional Development, and Norwegian Digitalization Agency, on digitalization of the public sector, ICT politics, new laws and regulations regarding discussions and settlement of laws on universal design in Higher Education.

As Universal Design is also the background of my research, I argue that it essential to get an understanding of the national and international political context regarding Universal Design when it comes to technology. In this way, document analysis was appropriate for becoming familiar with this. More exactly, I looked into both the Norwegian, US and European laws and regulations regarding Universal Design. For this, I used official websites such as lovdata.no and the European Commission's websites. A part of this research is also documented in Ch. 3 On Universal Design.

Document analysis was also used, for instance, for investigating previous studies, such as master's theses, other relevant Ph.D. theses, or relevant student reports that were available online.

All of these sources of information and knowledge were used to better understand the context of my research, strategies available at a national and international level, relations between different public agencies in terms of the existent or future relevant laws, but also the understanding of some of the existent users. This method was used in both Case 1 and Case 2.

5.3.9 Headnotes

Headnotes are described as "experiences, impressions, encounters, and evaluations that are continuously present in [the] memory" (Ottenberg 1990, p. 32). I was inspired to use this method by Verne (2015), who has also used this method in her research. This method was used in both Case 1 and Case 2.

I have myself experience with home care services, working with elderly people, with people with communication disabilities, autism, and Down syndrome. During these experiences, I have acquired organizational knowledge on home care and what kind of challenges caretakers may encounter in their independent living in their own homes. These experiences are highly relevant to Case 1.

I have also had the experience of working within Higher Education, as a lecturer, since before starting my Ph.D., but also during my Ph.D. During my Ph.D., I developed my Higher Education experience through my engagement in teaching, through my experience as the executive secretary of UiODoc – an organization for temporary academic employees at UiO (2017-2018), and as a member of the Advisory Board of UiODoc (2018-2020). Moreover, as a committee member of the National Association for PhDs and PostDocs in Norway (SiN), during 2017-2018, through being part of the central electoral committee at UiO during 2018-2019, and through being the first deputy for the representative of temporary employees on the University Board during 2019-2020, I have added some of these experiences to my "headnotes." These experiences are part of who I am as an individual or a professional, and I cannot deny them. During these experiences, I have acquired organizational knowledge, knowledge of laws, and an understanding of how students experience their interaction with various digital learning environments.

5.4 Data analysis methods – Overview

Myers (1997) addresses three types of analysis: hermeneutics, semiotics, and narratives and metaphors. According to Myers and Avison (2002) and Radnitzky (1970) in Myers (1997), hermeneutics is an interpretive method concentrated around an understanding of the meaning of textual data, either as a whole, or as parts, and "the relationship between people, organization, and the information technology" (p. 4). Semiotics refers mainly to the "meaning of signs and symbols in language," whereas narratives and metaphors refer to stories. Further, Latour (1999) talks about how, for instance, a scenario becomes text, and a text would eventually become a table in science (p. 54). In the same way, my main data collected was in the form of text, based on the data collected from the interviews, SDM, log-reports, diary notes, or document analysis. Photos and headnotes complemented this data.

The main unit of analysis in this thesis, beyond textual data, is represented by situations experienced by users in their everyday interaction with and use of digital technologies. The users are represented by human beings of different ages, experiences with digital technologies, or exposure to digital technologies. The data, however, have eventually turned into text, and eventually into tables, through the verbatim transcription of the interviews, the raw text written in log-reports and diaries. In this way, I was interested in analyzing my data hermeneutically, focusing on the meaning of the text that was related to the areas of my research. This can slightly be in contradiction with what interpretive research says – that one should not go with pre-established ideas about what participants have to say – which I did not. However, it was somehow challenging for me not to read the textual data through the thematic filters of my research; however, I was always open to new themes emerging from the data. Crang and Cook (2007) support this idea that one cannot be fully detached and objective, both when collecting the data and when analyzing it, especially when the researcher, in the first place, has formulated the questions for the interviews or focus groups. But analyzing data hermeneutically here means to seek meaning in what participants have to say related to the topic chosen.

Crang and Cook (2007) also suggested that one could employ different means for doing the analysis, such as pen and paper, or other software tools. I had some attempts at using NVIVO; however, I personally found more Excel matrices and tables to visualize data and analyze it to be more useful. Several examples of how I analyzed the data are available in in Ch. 6 and 7. In the end, I also took into account eventual misfits and contradictions. After finding links and understanding these misfits, I could validate the findings, through, for instance, using member-check (Crang and Cook 2007, p. 148). In my case, member-check was not available; however, I could confirm my findings through other sources: either through further data collection with other participants or through document analysis.

Table 5-2 gives an overview of the data analysis method for each of the cases. Further details on the exact data analysis methods used for each of the papers from Case 1 and Case 2 are described in the corresponding chapters, Ch. 6 and Ch. 7.

Table 5-2 Data analysis methods – Overview

Data analysis method	Case 1	Case 2
Inductive analysis: latent and manifest analysis (Granheim, U.H., and Lundman, B., 2004)	X	N/A
Inductive analysis: systematic text condensation (Malterud 2012)	N/A	X
Thematic analysis	X	N/A
SDM[14]	N/A	X

5.4.1 Inductive analysis

Latent and manifest content analysis[15]

Latent and manifest content analysis (Granheim and Lundman, 2004) is a qualitative inductive analysis method. The method follows several steps, such as: first, the researchers need to read through their textual data that shall be transcribed verbatim, a few times, to get a sense of what the text is talking about. The data needs then to be de-contextualized then, by labeling and identifying meaning units. The following step usually consists of the condensation and coding of meaning units. The codes were grouped systematically into sub-categories. Thereafter, the sub-categories of codes were grouped into categories of codes. Reflective discussions amongst the researchers that analyze the data have to be performed, grounded in the study aim. The analyzing process that formed the categories resulted in manifest content analysis. Finally, the latent analysis started with the reading of the transcripts once again and trying to make sense of what the text was talking about. The result of the final step should result in an overall theme representing the data analyzed.

[14] Please, see the description of the SDM process in the earlier section on Data collection methods, since SDM is both a data collection and analysis method

[15] This method was used in Case 1

Systematic text condensation[16]

Qualitative textual data can be analyzed through Systematic Text Condensation (STC) (Malterud 2012). The analysis is usually done in several steps. Before starting the analysis, the textual data should be organized in "chunks" of up to 50 pages of transcribed text. Step 1 consists of getting an overview of the data by reading the transcribed text and findings several themes (between six and eight), out of which up to four themes should be prioritized. During step 2, the text should be read again and organized based on the earlier identified and prioritized themes. During this step, the text should also be categorized into categorizing meaning units, small "chunks" of text, such as one or several paragraphs of text, rather than individual words. These meaning units should be "defragmented" from the original text, i.e., taken out of the original text and re-organized based on the themes they belong to. During step 3, the meaning units should be condensed into codes, which in turn, the codes and the codes into meanings. The meaning units should then be organized in subgroups and categories. Finally, during the last step, the condensates should be turned into concepts.

5.4.2 Thematic analysis[17]

Thematic analysis (Braun and Clarke 2006) is a qualitative research analysis method. The method is usually used "for identifying, analyzing, and reporting patterns (themes) within data" (Braun and Clarke 2006, p. 79). The themes resulting from using this method are usually something that captures the relations of data to the initial research question (Braun and Clarke 2006). Thematic analysis is usually done in six steps: first, one should familiarize oneself with the transcribed data by reading the text a couple of times. At this stage, one should put aside the initial research question, to be open to novelty, for what may come up, and one did not think of, trying to focus on what the participants found interesting. Thereafter, in the second step, one should systematically generate initial codes throughout the whole data set. The codes should then be collated. The next step is to search for themes based on the collated codes, organizing them into sub-categories for each of the data sources. Further, during the fourth step, the themes should be reviewed. A map of the analysis can be generated here. During the fifth step, the names of the themes should be defined and established. Finally, the sixth step is to produce the report of the data analysis, including relevant data extract examples from the raw data.

[16] This method was mainly used in Case 2.
[17] This method was used in Case 1.

5.5 **Ethical considerations**

Papers I-IV cover research conducted within the framework of the MECS project. Papers V-VII cover research undertaken in the framework of the UDFeed project. Both MECS and UDFeed projects are conducted with respect to the ethical guidelines from the Norwegian Center for Research Data (NSD). The reference number for NSD in MECS is 50689. The proposed thesis' own NSD application reference is 55087, also hereby called LEARN. LEARN inherits the rights and responsibilities of MECS NSD 50689. The data collected on behalf of the two NSD applications, i.e., MECS and LEARN, were stored on the Services for Sensitive Data (TSD) facilities, owned by the UiO, and operated and developed by the TSD service group, the IT-Department (USIT). The reference for MECS is project number p260, whereas for LEARN is project number p400. I used a Yubikey to encrypt, and respectively decrypt, the data in both projects.

According to Christians (2005, pp. 144-146), concerning the code of ethics, one should follow the guidelines set by Institutional Review Boards (IRB) when working with human participants, and regard: informed consent, deception of the participants, privacy and confidentiality, and accuracy of the data. In this way, I regulated the research towards participants through written informed consent, including details about the project, data collected about them, and how the data was stored and used. With respect to privacy and confidentiality, data was anonymized, such that I did not use participants' real names, but rather pseudonyms – so no personal data can be linked to them. Concerning the data accuracy, quotations were used, and in some cases, to protect the participants from being identified post interviews, paraphrasing was used instead. The mosaic effect was avoided. Moreover, data was anonymized, and at the end of the study, the data will be deleted.

5.6 **Positionality of the researcher, ethical dilemmas and confessions**

According to Schrader-Frechette (1994, p. 4), one can focus either on the research process or on the research product. This section is concerned with ethical dilemmas regarding the research process.

Chalmers (2013, ch. 8) talks about Kuhn's theories as structures, postulating that Kuhn claims that subscribing to a single paradigm would not progress science. Drawing a parallel to this affirmation, I argue that subscribing to single ethical theories would limit oneself when dealing with moral decisions. Zevenbergen et al. (2015, p. 13) frame this type of multi-faceted approach as *ethical pluralism*. Here, one should not solely look to philosophical theories of ethics and "moral and political deliberations" (ibid, pp. 13-14). Further, Markham and Buchanan (2012) and Zevenbergen et al. (2015) explain two types of approaches: top-down or bottom-up. Zevenbergen et al. (2015) develops this and describe that theoretical philosophers have a *top-down deductive approach*, whereas, as they call them, "*the anti-theorists*" have a *bottom-up inductive approach* (ibid). If I look now at my role as a researcher, I see myself not only as an *ethical pluralist,* but also as a researcher adopting a *bottom-up inductive approach.* I argue that the theory we rely on is grounded in our philosophical assumptions, which I see them as superior to moral and political deliberations, as they determine the starting-point of our ethical decisions. Concerning the moral and political deliberations, I see them as somehow more *formal ethical guidelines* that should *guide* our research, in order to protect those taking part in it. In the following section, I discuss my role as a researcher in MECS, from several ethical reflexive perspectives – from an inner level (*self*) towards an outer relational level (*participants and society*), by incorporating philosophical ethical theories.

Further, I argue that the more we know ourselves, the more we can relate to other people. As a researcher, developing some sort of self-awareness is not only necessary, but it is essential (see also Crang and Cook, 2007, p. 26). Despite the methods that I chose to employ in my research, I often asked myself: *Who am I? What is my role in my research? What is my role in the project?* I often found myself asking reflective questions, such as: *What is the role of my research for me as a person? What is the role of my research for the organization, community, and society? How can, and how will my research influence society? What kind of contribution do I want to have through my research, and in which way I want to contribute "to the world"?* Before continuing, I wish to introduce some of the ethical theories and frameworks briefly.

5.6.1 Brief on ethical theories and frameworks

Zevenbergen et al. (2015) give an overview of different ethical theories or frameworks. One of the ethical theories is practical ethics, i.e., *what is right to do by applying moral reasoning*. Another ethical theory is consequentialism, concerned with the *quality of an action*. Deontology is concerned with treating people as *ends* in themselves, not as *means* (also discusses power relations in terms of *agency* - when *power* is given *to* people, and when people are treated as *patients - power over* people (see more on power relations in Bratteteig and Wagner, 2014). Further, virtue ethics is concerned with the *character of the actor,* in this case of the researcher. Principlism focuses mainly on *medical ethics*. Further, pluralism and casuistry support *multiple ethical perspectives*, that sometimes might be conflicting. Finally, computer ethics is concerned with *ethical uses of computing* – this is also called occasionally digital ethics (see Bergsjø and Bergsjø 2019).

Earlier, in the previous section, I claimed that I see myself as an ethical pluralist, that sees the value in both moral and political deliberations and philosophical ethical theories. So far, I have only developed how my research can be regulated through the former one. However, I hope that my research presented in this thesis can also contribute to moral, and eventually, political deliberations. These will be discussed later in the last section of Ch. 9 Discussion. Further, I reflect again on my role as a researcher by applying the latter one.

5.6.2 On my background

I was born to a Romanian mother and Romanian-Hungarian father. I lived in Romania for 19 years, where I followed the Romanian education up to high school. During my school years, from primary school to the final years, I developed an interest in grammar, and languages in general (French, English), while I learned Spanish by watching TV-series. This eased somehow my path for when I later moved to Sweden as a 19-year old. I was so passionate about the language (and languages in general) that I learned it up quite fast.

Later, working at the university as a lecturer made it even easier for me to learn academic words and further develop my vocabulary. When I got the Ph.D. offer, I thought of moving to Oslo, Norway would be similar to moving to Stockholm. Somehow, very naïve, I thought it should not be that much of a difference. I did not know about details such as that I will have to use new digital systems within work and outside work: new Human Resources portal, modern LMSs, or new DLEs, new ways of finding information and resources internally, new banking systems, new apps for the public transport, new online systems for taxes, new healthcare system, and I could go on. This, of course, besides the Ph.D. work itself, I had to deal with all these small everyday challenges: learning to deal with new systems, sometimes under the time pressure, learning about new rules, and picking things up on the go. This is not a critique of the systems themselves, or the people creating them. I simply wish to present my standing point, and my situation as this fueled my motivation and intellectual curiosity for exploring the topics included in my Ph.D., without focusing on people with physical or cognitive disabilities. This is also a very good illustration of situated abilities – the concept explored in this thesis.

When I started my Ph.D. studies, I joined MECS as a research project. However, I previously worked with both elderly and young people with cognitive and physical disabilities, as I also explained in the headnotes section. However, this time, I wished to shift the focus from disabilities and focus on participants as *users* of design, without labeling physical or cognitive disabilities. As Suchman (1987) says, a designer communicates through its *artifact*; he or she transmits a message to the user on how to use the artifact; therefore, one should design artifacts that talk by themselves; otherwise, the designer failed to design it (Suchman 1987, pp. 14-15): "The designer of any artifact that is a tool must communicate the artifact's intended use and, in some cases, the rationale for its behavior, to the user. There is a strong sense, therefore, in which the problem with such a premise, however (as archaeologists well know), is that while the attribution of some design intent is a requirement for an artifact's intelligibility, the artifact's design per se does not unequivocally convey either its actual or its intended use. While this problem in the interpretation of artifacts can be alleviated, it can never fully be resolved, and it defines the essential problem that the novice user of the artifact confronts. Insofar as the goal of design is that the artifact should be self-evident; therefore, the problem of deciphering an artifact defines the problem of the designer as well." (Suchman 1987, pp. 14-15).

5.6.3 Self-reflexivity: I towards myself

According to Ess and Fossheim (2013, p. 41), one has “core conceptions of selfhood and identity.” The authors discuss *the self* in terms of *individual-* and *relational selfhood.* In this subsection, I discuss my *individual selfhood* as part of two research projects and cases.

My *individual selfhood* relates to how I identify myself as an individual, beyond being a researcher in the project. At the same time, Crang and Cook (2007, p. 26) talk about developing *self-reflexivity* and *self-awareness* towards one’s positionality within the research. The authors claim that one cannot be entirely detached from its own research (*when doing qualitative research*), and one’s positionality affects the research outcome. Ziman (1996, pp. 751-754) also addresses this aspect in terms of *objectivity of research,* while the researchers pursue “the truth.” Looking at how *the (scientific) truth* is formed, I want to address how *my positionality*, as an individual with linguistic and cultural background, affected this research.

I as an individual with cultural and linguistic background

Crang & Cook (2007, p. 26) talked about developing a linguistic self-reflexivity. I have developed a linguistic self-reflexivity, especially at the start of my research. At the beginning of my data collection, I have used both Swedish and Norwegian languages with the participants. This posed some challenges in transcribing the data. However, later, when it was possible, and especially during Case 2, I have opted for conducting my research activities in English, if the participants felt comfortable with the language. This helped to a better flow of the research activity but also helped me in easier transcribing the data.

But this type of linguistic self-reflexivity is not limited to the language we as researchers use and the words we choose to use (Crang and Cook 2007, p. 26). Sometimes I questioned how *I was perceived* if I talked in Swedish in a Norwegian context. Was I perceived as a Swede, as an immigrant, or who was I? I developed an awareness of whether or not I was perceived as being a Swede or being Romanian. I often reacted to this kind of statement from the participants, especially when they seemed to be very interested in my background because I did not want to be categorized or labeled based on the language I spoke or where I came from. I often answered the participants: “I like to consider myself a citizen of the world.” Crang and Cook (2007) say that we are not *detached researchers*, but we enter the research with our embedded background and culture. In my case, I feel that I had a rich mix of multicultural backgrounds. However, this struggle of how I was perceived took place at the beginning of the research, or when meeting new participants.

One concrete example illustrates the use of language in the fieldwork. This “*language game”* affected, to some degree, my interaction with the participants, while “[*about the language game*] becoming *a condition* for the *possibility of data*” (Knorr, 1979, p. 351, emphasis added). Moreover, I identified myself as what Chalmers (2013, p. 232) calls an *anti-realist*, an *instrumentalist,* that uses theories as instruments when analyzing the data, adopting the top-down approach. Hence, my *hermeneutical understanding* and *analysis* of the research material was affected already while being out in the field and collecting data.

Who was I when I was out in the field?

I often reflected on how I was perceived as an individual with a different cultural background when I was in the field. Ess and Fossheim (2013, p. 13) say that gender and equality issues belong to *individual selfhood*. From this point of view, as a woman, I often reflected on how participants from both Case 1 and Case 2 saw myself as being (*sometimes the only*) woman at research activities and meetings. In which way did my gender affect my research when I collected data? Was I seen as an *equal* to my male co-researchers? Crang and Cook (2007, p. 43) discuss such an example of a woman being first seen as a *woman researcher* and eventually as a *mother* later when she gots a child during the research timeframe. Ess (2015, p. 66) addresses this in terms of *selves* as dynamic "fluids." One could say that they had what Sjøberg (2002) says to be the "stereotypical image on scientists and engineers," which usually is portrayed as a male image (p. 6). In fact, I was just confirming that there are fewer females in science and technology, as also shown by Sjøberg and Schreiner (2010, pp. 4, 26). What kind of relations did I develop with the participants, based on my gender? Did *my selfhood* change over time in the eyes of the participants? In that case, how?

I am not going to argue for- or against this type of polemics, but I wish to point out that I was aware that my gender affected in some way how I was perceived as a researcher. These types of roles shift with time, from being someone or something to being someone or something else. I also argue that we, as researchers, should be aware of these shifts and that our roles do not stay intact, but change and (r)evolve with time.

Moreover, during the research activities, I often reflected on the words and gestures that I used, besides how I was perceived as a woman. I also developed attention towards participants, my body posture, if I was standing or sitting while talking to participants (e.g., if they sat, and I stood, the communication between us is, to some degree, was shaped by these levels).

During my time in the field, I also developed awareness on what to pay attention to and what to- or not to document: what to write down, and what not, body language, posture, words used, etc. I was also aware that all of these details might have subtracted from my energy of being there, present, and listening to what participants had to say. Crang and Cook (2007, p. 55) talked about this as seeing things in-breadth and focusing "on what's most important." However, in my role as a researcher, I tried to be aware of holding a balance when I was out there in the field.

A duality battle between myself and I

Asking myself *who was I, what was I,* and *what was I not* helped me to get to know myself better. However, these different roles that one may have may sometimes create conflicts between who one is and who one is not, and *when* one is*, and when* one is not.

I was discussing once interpretive research with some of my colleagues, arguing that my research fits under the interpretive paradigm. However, as also proved in this thesis, I am relying very much on tables, structure, and order – it's my way of "sorting things out." At the time of the discussion with some of my colleagues, I was writing an essay that was pointing towards the same issues. I was asked: *What gives you this? Does it give you anything? Does it contribute to your research?* For me, this type of structure gave and gave me some kind of *control,* informing me about *what* I am doing and *why*. At the same time, I understood that having this type of structure may limit ourselves from seeing what it is important to take further our research, or what to discard (see also Maanen, 1995, p. 133 on topics that are "going nowhere" and need to be discarded). It helped me, however, to structure my research, but it perhaps also restricted me from seeing what it is "*out there.*"

Further, I also realized, at some point, that when I wrote about my research, or when I analyze it, I had some positivistic elements in my writing.

On the one hand, having a background in natural sciences dating back since my high-school (mathematics and intensive informatics), and throughout my higher education studies (computer science) is somehow naturally for me to seek that sense of structure, to seek "boxing" and structuring things in smaller and bigger research components, and to try to find the logic between them. But this is, however, only my professional side as an individual.

On the other hand, my side in my research is reflected through continuous (self-) reflection. It is not surprising that I am very interested in personal development, self-development, psychology, social sciences, and generally speaking, I am interested in people: how we are as individuals, why we choose to make the choices we do, how we think, and why, etc. I can see this as the interpretive part of myself, the one who is not striving after results, but that rather reflects, interprets experiences (personal, or through discussions with other people), and tries to learn from those.

Thus, these two sides denote the duality: I as a positivist and I as an interpretivist. I see these as "two forces" that, at times, compete with each other. But, I also see them as assets – my role was during my research to learn how to use them properly, instead of competing and creating confusion, they should contribute to each other. Whether or not I succeeded, I do not know. But I know I have tried my best. However, this is not always trivial, since there are many external factors: people, events, situations - that I interacted with.

In the next section, I explore my positionality, moving from my inner world towards my external one – I towards participants.

5.6.4 Relational selfhood

M. Natanson (1970, p. 47) in Ess (2015, p. 60) converted Descartes' "I think, therefore I am" to "We are. Therefore I am." In the same way, my relational self was defined through my relations with *others.* Ess (2015, p. 60) places this type of self within *feminist ethics* and *ethics of virtues*. How did *I* then relate to participants and to society when doing research? In the following sub-sections, I discuss my *relational self.*

Relational selfhood: I towards participants.

On proximity. Doing research with human participants in uncontrolled settings comes along with both rewards and challenges. As a researcher, sometimes you have to deal with keeping a balance between your role as a researcher and you as an individual with a personal life. Not long after starting my research, I already had to deal with different types of ethical dilemmas, which I describe in the next paragraphs.

When it comes to my positionality towards participants, I often relate to my proximity to them. *Who was I towards them, and what was my role?* I often preferred to position myself as one of them, i.e., by trying to empathize with them and understand their struggles. However, when doing interpretive research, one should not take sides. And I tried to do not to take sides. But what I try to say is that I adopted a somewhat neutral position, where I tried "to put myself in the participants' shoes" to understand their world better. I often took a facilitator role, letting the participants being the experts on the topic (during the individual interviews or group interviews, etc. - see Crang and Cook, 2007, on the researcher being "an expert on the procedure").

However, what it is even more important to understand, is that this proximity creates a space of interaction with the participants, where the relations between myself as a research and the participants (r)evolved. *Was this relation professional or personal? Did this relation mean that being or becoming personal in your own research is unprofessional? What were the limits?* From my own experience, people usually tend to share more if you are willing to share as well. In this way, by relating to your stories, they will relate to themselves, and thus share their own stories. But sometimes you do this involuntarily – because this is who you are. And they will share their stories as well.

Here it is an example from my fieldwork: At a research activity, after a discussion with one of the participants, I got asked to "hang-out" *sometimes* for coffee. As a researcher, I had to both balance of being polite and to refuse in a kind way the offer, after analyzing the eventual consequences of my answer (i.e., applying in a way consequentialist ethics, on how my choice of whether accepting or refusing the offer can affect my research), in order to protect the participants from *deception* at the end of the study, when this type of "hanging out" will not be possible (see Iachello and Hong, 2007, p. 40; Schrader-Frechette, 1994, p. 7 on the deception of participants).

One has to draw lines between what is research and what becomes personal relations. Button and King (1992) in Randall et al. (2007) point out that '*Hanging around is not the point*,' and that the researcher shall develop *expertise*, not *personal relations* with the participants (p. 180-181). In this sense, I had to think of utilitarian ethics, of doing "the greatest good for the greatest number of people" (Ess 2015, p. 51) while negotiating *personal space* (see Stine Lomborg 2012, ibid, p. 63).
I do not think that this type of situation is unique, but how could I, as a researcher, hold a balance between becoming too personal (read getting to close) and being too professional (read keep a distance)? When people can relate to you, they can connect to you for whom you are. They will challenge this personal/professional blurred line. What should you, as a researcher, do in this kind of situation? I reflected immediately on my role and how this proximity can evolve. I concluded that I was there to "execute" a task, that in the end, will result in a Ph.D. and hopefully contribute to as many as possible. But in this case, I also could see that not only the participants were in a vulnerable position, but also the researchers. If you say yes, and the relation will evolve, you are afraid that when you come at the end of your research, maybe you won't be able to "hang out" with the participants. Thus, you would be afraid of disappointing them and making them feel "used." Along the same lines, Markham (2005, p. 815) talks about always having the participants in mind, which would "both [shift] the ethical considerations and [allow] for socially responsible research." Conducting responsible research is also thinking about the proximity and relations we develop with them, so they do not end up in the disappointment of the participants, our informants – the ones who provide us with data.

'What do I get?'. One of the questions that often raised during our research activities in Case 1 was of the type: "I am very interested in the research you do, but what do I get? How can I have use of it?" The participants often claimed that they were too old, and they will not have use of what we do – however, they were still interested in the work we, the researchers in MECS, do and want to contribute. Both my colleagues and I often struggle with this type of question, and usually, our reply was of the type: "We generate knowledge, not a final product, and we are here to learn from each other, and hopefully to contribute in some way." My colleagues and I tried to involve the participants by giving something back to them, such as providing them with a robot vacuum cleaner – a robot type that they were willing to try out. This type of challenge, however, was not encountered in Case 2.

Relational selfhood: I towards society

I was a researcher also felt responsible towards society: on the one hand, towards the taxpayers that fund my research, and on the other hand, towards the organizations and people, I have worked with. This type of positionality is, in a way, a sense of self within a bigger context, where one takes responsibility for what and how the findings are presented, considering the consequences that it can have in society.

Along these lines, Latour (1999, p. 54) talks about how the data collected through different methods becomes science eventually through text, tables, figures. At the same time, the way we choose to represent *others* in science (participants, colleagues, project partners, etc.) will not only affect our relational self towards them (Walsham, 2006, pp. 328-329), but we also shape science. As a researcher, I had the responsibility to choose proper research methods, such that the research I conducted to contribute in the best way to society (i.e., utilitarianism ethics), not only because my research is publicly funded, but because we, as researchers, do, in a way, *politics by other means* (see the example discussed by Nygaard, 1992 on how our choices can escalate). Hence, the way we write about *others* and how we present our scientific research *outcomes* can eventually influence education and policies (consequentialism ethics).

Emerson et al. (1995, p. 136) talked indirectly about how, when the researcher presents findings or facts, "when theory becomes anonymous, it loses style." This is again a discussion on presenting findings as an attached or detached researcher (see Crang & Cook, 2007). The style adopted in this thesis and the papers I wrote gives a sense of how I represented "others."

Part II Presentation of cases

Detailed presentation of each of the cases, e.g.,

Case 1 and Case 2, covering their specific aspects, such as their corresponding:

- *Background*
- *Study design*
- *Methods*
- *Summary of papers*
- *Findings*

Chapter 6 CASE 1: UNDERSTANDING EVERYDAY USE OF ROBOTS IN THE HOME

"I feel like I am in another world, you know.. I do not know so much about these things we discuss now… and this has to do with the [world] we grew up within… a different one, yes. What I mean is that we start getting so old, that there is so much surpassing us. We are not able to keep up the pace. However, the authorities do not take this into account."

— Participant, Interview (Paper I, p. 203)

This chapter presents Case 1 in this thesis, *Understanding everyday use of robots in the home.* The case is part of the MECS project, as mentioned in the earlier chapters. The chapter starts with giving the background to the case and addresses the first research question, RQ1. Specifically, the chapter answers the first research sub-question, SRQ1. The chapter also includes an overview of the background to Case 1, the study design for Case 1, methods used in Case 1, and a summary of the papers included in Case 1. Finally, the chapter ends with a presentation of the findings from Case 1.

6.1 **Background**[18] [19]

This sub-section gives a background on the context of Case 1. After that, it explains the motivation behind Case 1.

6.1.1 Context: adoption of robots

Studies show that the elderly population worldwide tends to increase, compared to the younger population (Beer et al. 2012; Unbehaun et al. 2019). This creates some challenges for the workforce related to the elderly home care services: there are not enough nurses to cover the increasing needs for elderly care. According to Bossen and colleagues (2013), '[b]y 2050, the number of older persons in the world will exceed the number of young persons, for the first time in the history.' (Bossen et al., 2013, pp. 189-190). An earlier study from Japan shows that this trend is visible there (Yamazaki et al. 2007). By 2050, Japan's aged population is predicted to surpass 42.6% (Doelling et al., 2014).

[18] Text adapted based on (Saplacan, Herstad, and Schulz, *forthcoming*)
[19] Text adapted based on (Saplacan and Herstad 2019)

In Europe, the same trends seem to be taking place. In Europe, the number of working-age individuals *per* 65 years old or older inactive individuals will decrease from 3.3 working-age individuals *per* inactive person over 65 years old to 2 individuals *per* inactive person over 65 years old, by 2070 (European Union 2018). Moreover, a report from the U.K. shows that between 1.6 and 1.7 million people use telecare services, while over 300 000 use pendant alarms (Clark and Goodwin, 2010).

At the same time, the elderly population in Norway (over 65 years old) is predicted to know an increase of around 10.5% between 2016 and 2070. Specifically, the elderly population in Norway will increase from 16.5% in 2016 to 17.5 in 2020, 20.2 in 2030, and 27% in 2070 (European Union, 2018, p. 360). At the same time, the life expectancy in Norway is also expected to increase by ca two years by 2070 (European Union 2018). Moreover, the number of expected care recipients in Norway will increase by ca 448 000 between 2016 and 2070. Specifically, it will increase from 367 000 in 2016, to 387 000 in 2020, to 485 000 in 2030, reaching a number of 815 000 in 2070 (European Union, 2018, p. 362). The numbers include those in receipt of institutional care, home care, and cash benefits (European Union, 2018). However, what is interesting is to look at the number of home care recipients, which seem to be predicted an increase from 200 000 in 2016, to 212 000 in 2020, to 263 000, and reaching a top of 420 000 by 2070 (European Union 2018). At the same time, it seems that the institutional care will see an increase from 45 000 in 2016 to 131 000 in 2070, and those in receipt of cash benefits will see an increase from 121 000 in 2016 to 264 000 in 2070 (European Union 2018). Hence, these numbers, including the home care recipients, are the highest amongst the reference scenario composed of cash benefits, institutional – and home care (European Union 2018).

Moreover, the literature shows that many of the elderly are willing to accept robots in their homes *if* they see a practical benefit of those (Beer et al. 2012; Saplacan, Herstad, and Pajalic 2020). An elegant overview of the robots used in studies for supporting independent living is given in Bedaf, Gelderblom, and De Witte (2015). Amongst the projects investigating the use of robots in the home is Acceptable robotiCs COMPanions for AgeiNG Years (ACCOMPANY) (Bedaf et al. 2016; Amirabdollahian et al. 2013). ACCOMPANY developed the Care-O-Bot robot (Birgit Graf, Hans, and Schraft 2004; Hans and Baum 2001). Others such robots are Movaid, Handy 1, and Nursebot built for the elderly or the disabled; Smart-Cane PAMM, Hitomi, PAM-AID, GuideCane, PAMM, and Smart-Walker PAMM. These robotic prototypes were built to be walking aid for the blind, elderly, or the disabled (B. Graf 2001). Amongst the European Union projects are ETHICBOTS, MARIO, EP6, EURON RoboEthics Roadman, BREATHE, and ICT & Ageing Project (Felzmann et al. 2015), Robot-Era Project (Riek 2017), and Multi-Role Shadow Robotic System for Independent Living (SRS) (Pigini et al. 2012). The latter investigated Activities of Daily Living (ADL). It showed that frail elderlies use walking chairs, sticks, or wheelchairs (Pigini et al. 2012). The study also showed that teleoperated robots could be accepted by users in some situations.

However, direct physical interaction with a service robot can be perceivied by the users as posing serious difficulties, in some situations (Pigini et al. 2012). However, housing-related needs seem central for learning and adopting these kinds of technology *if* these technologies function well (Pigini et al. 2012, p. 303). A similar study to ours talks about introducing personal service robots, a Roomba Discovery vacuum cleaner, in homes (Forlizzi and DiSalvo 2006). The home is viewed as an ecology of products, people, activities, a social and cultural context of use, and a place – a bounded environment (Forlizzi and DiSalvo 2006). It seems that the expectations one has of technology are highly related to shaping the initial expectations of technology. The use of the robot also influenced the practice of housekeeping: in some households, the male participants set-up the robot; in others, only the women use it (Forlizzi and DiSalvo 2006).

Companion robots are also used in studies with the elderly. An example of a companion robot is PARO, the seal robot (McGlynn et al. 2017; Wada, Takasawa, and Shibata 2014; Giusti and Marti 2006). The seal robot PARO was used in facilities for the elderly in the Nursing-care Robot Promotion Project, in Japan (Wada, Takasawa, and Shibata 2014). An initial study showed that the elderly participants suffering from various mental or behavioral issues, but who interacted with PARO over time improved their communication, reduced their aggression and wandering, as well as improved the sociability of the participants over time (Wada, Takasawa, and Shibata 2014). PARO also seems to be widely accepted across cultures (Wada and Shibata, 2007). Other examples of companion robots are Pepper and NAO used in exploratory studies, as shown in (Hoefinghoff et al. 2015). AIBO, Furby, and NeCoRo are a few other robots representing animals that were used in therapy with children or in nursing homes with the elderly.

Other studies show that socially assistive robots, such as Pepper, are beneficial, supporting the elderlies' daily social interactions (Unbehaun et al. 2019), whereas an early study from (Caine, Šabanovic, and Carter 2012) investigated the perceived privacy in the home when using monitoring robots. Some studies investigated how robots that are remotely controlled can be integrated into the homes of the elderly (Yamazaki et al. 2007), whereas others investigated trust in human-robot collaboration (see Newaz and Saplacan, 2018; Rossi et al., 2017; Schwaninger et al., 2019). Others have designed frameworks for the use of robots in domestic settings, e.g., Domestic Robot Ecology, the Need Finding framework, or the Robot Facilitation Framework (Pantofaru et al. 2012; Soma et al. 2018; J. Sung, Grinter, and Christensen 2010), or explored the human-robot relations (see Coeckelbergh, 2011; Soma and Herstad, 2018).

Amongst other robots used in the home are ARMAR III, ASIMO, Care-o-Bot, Cody, PR2, RIBA, Robotic Nursing Assistant, ROSE (Doelling, Shin, and Popa 2014), Giraff plus telecare robot (González-Jiménez, Galindo, and Ruiz-Sarmiento 2012), and Videre robot (Caine, Šabanovic, and Carter 2012).

Thus, the aged population seems to be the 'key driver' in the development and adoption of robots (Doelling, Shin, and Popa 2014). New forms of ICTs, such as robots, are introduced in the elderly's homes to prolong their independent living (Bedaf and de Witte 2017; 2017; Bedaf et al. 2016).

6.1.2 Case 1: Motivation

The integration of the robots in the homes of the elderly are justified, on the one hand, by the statistics regarding the aged population (Section 6.1.1), but also by the longer life span accompanied by the corresponding disabilities coming with age, and by the difficulties in Activities of Daily Living (ADL) experienced by the elderly. Nevertheless, the adoption of robots in home care services is also justified by the increased costs and the lack of (human) resources for supporting home care services for the elderly (Petrie and Darzentas 2017).

In addition, policies and political agendas are introduced concerning the integration of robots in home care services. One such example is the Vulnerability in the Robot Society (VIROS)[20] project at the University of Oslo, Norway, a joint research project between the Department of Informatics and Faculty of Law. Other similar projects at the EU level are the EU Active Assistive Living (AAL) and EU Horizon 2020 Robotics Roadmap (Petrie and Darzentas 2017). Another project from the EU project under Ambient Assisted Living (AAL) is Enabling Social Interaction Through Ambient (EXCITE) (González-Jiménez, Galindo, and Ruiz-Sarmiento 2012). The project introduced the Giraff robot in several homes with the purpose of studying "social interaction through robotic telepresence" (p. 827), an idea that stemmed from the RoboCare project (Cesta et al. 2016).

Moreover, some of the preferred robot activities that the elderly found relevant seems to be those that do cleaning activities and housekeeping (Beer et al. 2012; Doelling, Shin, and Popa 2014). Studies investigating the use of robots in homes, such as Roomba vacuum cleaner robots, have been popular for a while (see Forlizzi and DiSalvo 2006; Saplacan and Herstad 2019; Sung, Christensen, and Grinter 2009). It seems that robot vacuum cleaner technology is amongst the largest group of personal service robots in the world, with prototypes dating back to 1991, and the first commercial use in 2001 (Doelling, Shin, and Popa 2014). Roomba robots are also declared as supporting the elderly with their physical activities in maintaining their household (Petrie and Darzentas 2017), which many of the elderly experience as very demanding (Beer et al. 2012).

However, although aging well has long been discussed (see an elegant overview of aging in place in Vasunilashorn et al. 2012), designing for situated elderliness means investigating elderly people's everyday practices and designing for those (Brandt et al. 2010; Subasi et al. 2013). One of the solutions to these challenges is to support aging in place for the elderly population, i.e., supporting the elderly with their Activities of Daily Living (ADL) (Beer et al. 2012).

[20] Vulnerability in the Robot Society (VIROS) research project, https://www.jus.uio.no/ifp/english/research/projects/nrccl/viros/index.html, last accessed 04.10.2020

6.2 Study design

Case 1 includes four papers that can be divided into three phases of the case. The first phase includes the first paper (Paper I), which explores the elderly's views and expectations on robots and other modern ICTs. The second phase includes the main data collection analyzed from different angles (Paper II and Paper III), focusing on introducing a robot in the homes of the participants. The last phase defines the idea of situated abilities, which is also explored in-depth in this thesis, by applying the learnings from the first two phases of the case 1. The idea takes form as a proof of concept illustrated through the last paper in Case 1 (Paper IV). Figure 6-1 shows an illustration of the study design for Case 1.

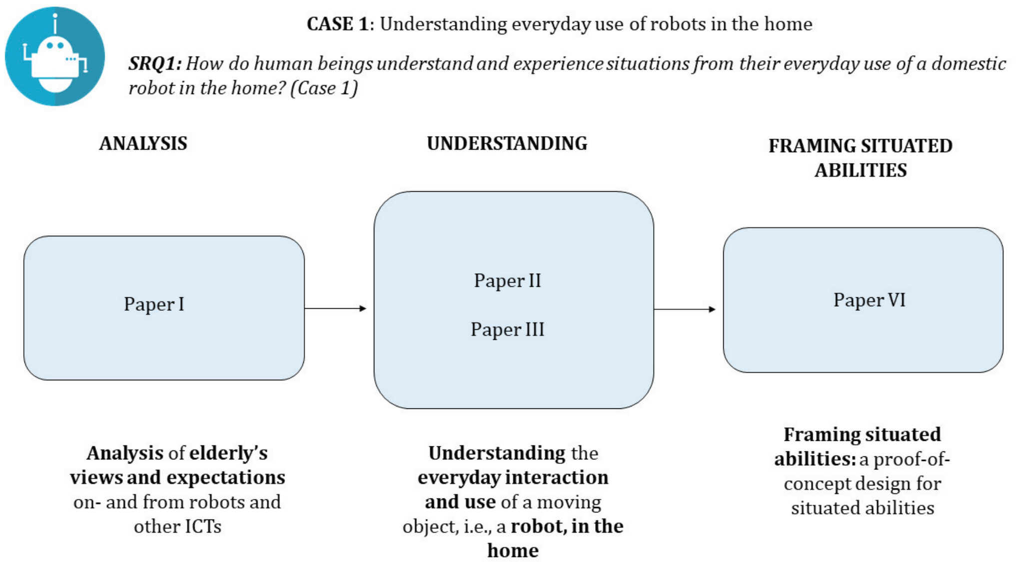


Figure 6-1 Study design - Case 1

6.3 Methods

6.3.1 Participants

The participants in this study were elderly (≥ 65 years old) living at OK+ and non-elderly participants using digital technology. All the participants were recruited based on free will.

The elderly people were recruited through the partner organization OK+, after meetings with the organization's leadership board, informal visits to the organization, and open presentations of the MECS research project, dedicated to the elderly living at OK+. For each data collection session, the researchers in MECS (including myself) made contact with the organization itself, or directly with the participants. Many informal visits at the OK+ were paid for during 2017, usually every Wednesday, around 5 PM, or sometimes during lunchtime, when the elderly were in the coffee area of the facility. During this time, I, together with other researchers in MECS, have informally met several of the elderly people and the OK+ staff. Arrangements for individual interviews were carried out through personal contact, often established during these informal visits. The non-elderly participants were recruited through personal contacts. An overview of the participants in the papers included in Case 1 is given in Table 6-1 below.

Table 6-1 Overview of the participants in Case 1

Paper	Number of participants (gender)	Participants
Paper I	16 (9 females, and 7 males)	Elderly over (≥ 65 years old)
Paper II	13 participants (7 females and 6 males)	6 elderly and 7 non-elders
Paper III	13 participants[21]	6 elderly and 7 non-elders
Paper IV	2 homes	Young and old

6.3.2 Data collection and analysis methods

The data collection and analysis methods were earlier explained in Ch. 5 Methods. However, an overview of the data collection and analysis methods used specifically in Case 1, for each of the papers included, is given in Table 6-2. Figures 6-2 and 6-3 show some photos from the data collection and analysis process.

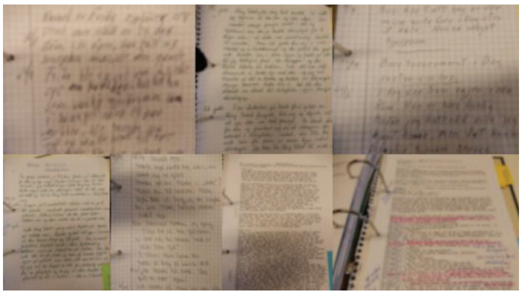
Table 6-2 Overview of the data collection and analysis methods in Case 1

Paper	Type of study	Data collection methods (qualitative methods)	Data analysis methods	Field of contribution	Contribution
I	Empirical	Group interviews, Individual interview, photos, log reports	Latent and manifest content analysis (Granheim, U.H. and Lundman, B., 2004)	HCI, HRI	Investigation on how the elderly understand the concept of a robot
II	Empirical	Participants' diary notes, Researcher's diary notes, Photos, Interviews	Thematic analysis (Braun & Clark, 2010)	HCI, HRI	Feedback as motion, transition feedback
III	Theoretical and Empirical	Literature review	N/A (see study III)	HRI, CSCW	Division of work between humans and robots. A framework on work tasks is presented.
IV	Designerly and Theoretical	Initial tests in two homes	N/A	UD, HRI, HCI	Situated abilities and UD. Dimensions of situated abilities.

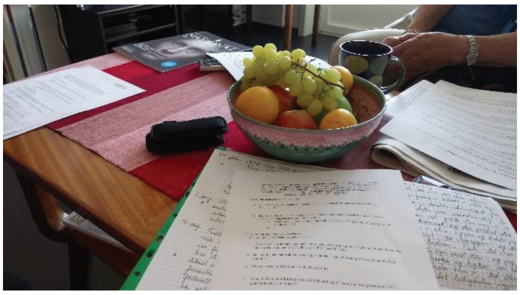
[21] Paper III uses the same data as in Paper II. However, the papers differ from the theoretical approach adopted and the disciplines they address. Paper II subscribes to HCI/HRI, whereas Paper III subscribes to HRI/HCI and CSCW.

a) Photo example from a group interview (Saplacan et al., 2020, p. 202)

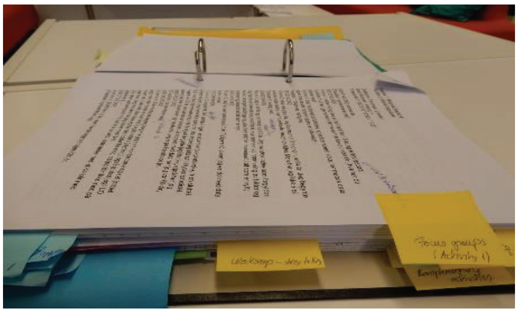
b) Photo example from an individual interview with a participant using the robot



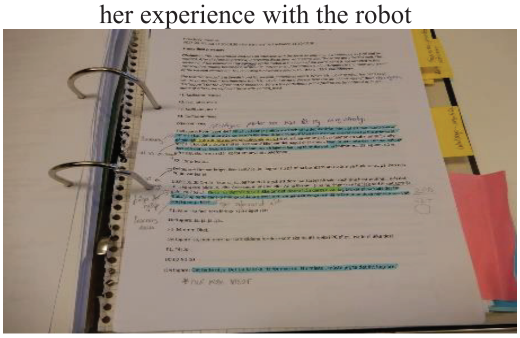
c) Participants' diary notes and transcripts of the interviews



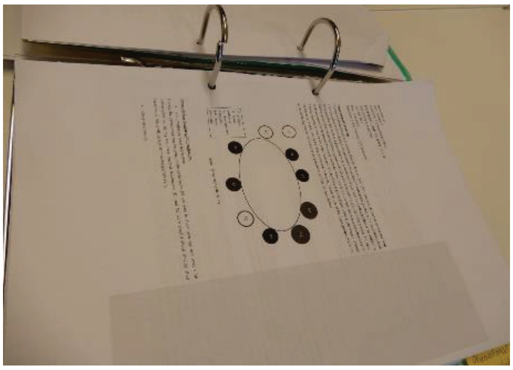
d) Interview with a participant – discussing her diary notes describing her experience with the robot



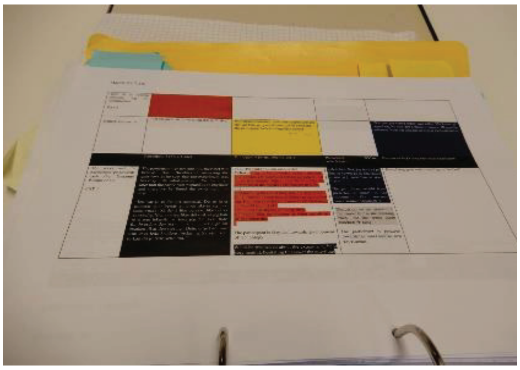
e) Organized documentation of the research activities in Case 1



f) Example of a transcript from interviews

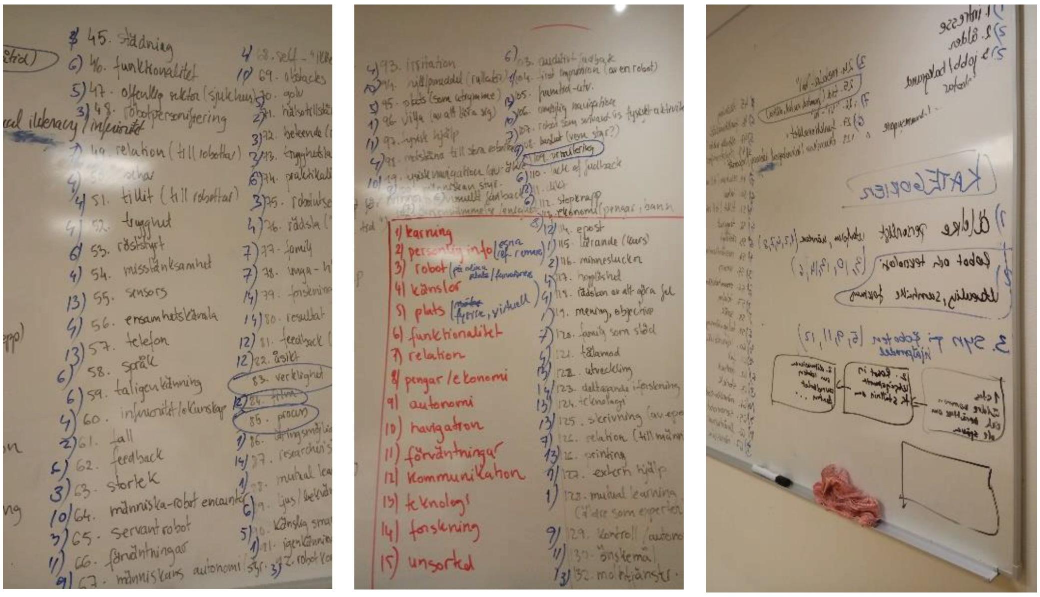


g) Example of a log report illustrating how the participants sat around the table



h) Example of analyzing and organizing the data in tables and color-codes

Figure 6-2 Photo examples from the data collection - Case 1



a) Example of the analysis process of data using latent and manifest content analysis carried out together with another researcher.

b) Example of the analysis process, using latent and manifest content analysis illustrating different sub-categories

c) Example of the analysis process, using latent and manifest content analysis illustrating different themes

Figure 6-3 Photo examples from the data analysis using latent and manifest content analysis

6.4 Summary of papers

Several papers, including short and long papers, were published or submitted for publication, on behalf of MECS' WP3 and WP4, during this Ph.D. All the papers were interconnected, representing both work in progress and the final findings of the research. However, this part of the thesis includes the four main studies (Papers I-IV). Their disciplines are addressed, and main contributions are indicated in Table 6-2 above. The summaries of each of these papers are included below.

Paper I Saplacan, D., Herstad, J., Pajalic, Z. (2020). *An analysis of independent living elderly's (≥65 years) views on robots and welfare technology – A descriptive study from the Norwegian context*, in Proceedings of the Thirteenth International Conference on Advances in Computer-Human Interactions (ACHI), ISSN 2308-4138, p. 199-208.

Abstract. This study illustrates the independent living elderly's (≥65 years) views on robots. The data was documented through audio recordings of interviews, photos, and written logs. The analysis was done through qualitative manifest and latent content analysis. The results of the analysis were sorted into three categories: aging during the technological renaissance, domestic robots, and the elderly's expectations of robots. The overall resulted theme was: integrating robots in the elderly's everyday life. The results were discussed through the lenses of the Sense-of-Coherence (SOC) theoretical construct and its belonging elements: comprehensibility, manageability, and meaningfulness. The relevance of this paper contributes to giving an understanding of the domestic robots' requirements specifications and the elderly's expectation of human-robot interaction.

Keywords: *robot; comprehensibility; manageability; meaningfulness; healthy aging; independent living elderly; Norway; Sense-of-Coherence (SOC) theory; salutogenesis; elderly; human-robot interaction, domestic robots.*

Paper II Saplacan, D. & Herstad, J. (2019). *An Explorative Study on Motion as Feedback: Using Semi-Autonomous Robots in Domestic Settings*. International Journal on Advances in Software. ISSN 1942-2628. 12(1&2), p. 68- 90.

Abstract. This paper presents motion as *feedback*. The study is based on empirical data from an explorative study of semi-autonomous robots used in domestic settings. We explore feedback received from stationary technology, e.g., a smartphone, and technology that is self-propelled, e.g., a semi-autonomous robot. The paper has its theoretical foundation in the *familiarity* concept used as a contextual and analytical tool for unpacking *feedback*. The data analysis is done through thematic analysis. The findings are structured in *feedback* received from a smartphone app technology, *feedback* received from the robot-mediated via an app, and *motion as feedback* received from the robot. *Motion as feedback* is discussed in terms of (a) what type of emotions feedback triggers in the users, and (b) making sense of the motion as *positive, negative, homeostatic, archival,* and *transition feedback*. We argue that having *familiarity* in mind when designing new technologies can make it easier for the user to *know-how* to *engage with* the technology. Our conclusion is that: a semi-autonomous robot technology can become more familiar to the user if it triggers positive feelings, if its motion is coherent, if its navigation is appropriate to the situation, and if its motion is not disturbing or interrupting the user; and lastly, *familiarity* needs to be considered when designing for a robot for the elderly.

Keywords: *feedback; motion as feedback; semi-autonomous robot; familiarity; emotions.*

Paper III Saplacan, D., Herstad, J., Tørresen, and Pajalic, Z. (2020). *A Framework on Division of Work Task between Humans and Robots in the Home,* Multimodal Technologies Interactions, vol. 4, nr. 44, ISSN: 2414-4088, p. 22

Abstract. This paper analyzes work activity in the home, e.g., cleaning, performed by two actors, a human and a robot. Nowadays, there are attempts to automate this activity through the use of robots. However, the activity of cleaning, in and of itself, is not important; it is used instrumentally to understand if and how robots can be integrated within current and future homes. The theoretical framework of the paper is based on empirical work collected as part of the Multimodal Elderly Care Systems (MECS) project. The study proposes a framework for the division of work tasks between humans and robots. The framework is anchored within existing research and our empirical findings. Swim-lane diagrams are used to visualize the tasks performed (WHAT), by each of the two actors, to ascertain the tasks' temporality (WHEN), and their distribution and transitioning from one actor to the other (WHERE). The study presents the framework of various dimensions of work tasks, such as the types of work tasks, but also the temporality and spatiality of tasks, illustrating linear, parallel, sequential, and distributed tasks in a shared or non-shared space. The study's contribution lies in its foundation for analyzing work tasks that robots integrated into or used in the home may generate for humans, along with their multimodal interactions. Finally, the framework can be used to visualize, plan, and design work tasks for the human and for the robot, respectively, and their work division

Keywords: *framework; human; robot; division of work; work task; human work; robot work; joint activity; human-robot interaction (HRI); human-robot cooperation; computer-supported cooperative work (CSCW).*

Paper IV Saplacan, D., Herstad, J., Schulz, T. (Submitted), *Situated Abilities within Universal Design – A Theoretical Exploration*, submitted to International Journal On Advances in Intelligent Systems, v 13 n 3&4 2020, p. 14.

Abstract. This paper investigates Universal Design (UD) through the idea of designing for situated abilities, rather than focusing on designing for disabled users. This shift in perspective from disabilities to abilities is explored through the design of a domestic robot that integrates into our homes in a familiar way. We explore the concept of designing for situated abilities through a proof-of-concept robotic wooden table, the T-ABLE, as an alternative design for domestic robots. Finally, the paper identifies four dimensions of situated abilities.

Keywords: *robotic wooden table: design; Universal Design; situated ability; elderly.*

6.5 Findings from Case 1: Understanding everyday use of robots in the home

This section explains the main findings from Case 1, based on the findings from Paper I-IV.

6.5.1 The elderly's views and expectations on- and from robots and other ICTs (Paper I)

Paper I shows that the use of personal devices, such as wearables safety alarms or mobile phones, by the elderly participants, was minimal. Regarding robots, the majority of the elderly participants had limited knowledge about the use of robots in the home. Some of the elderly participants mentioned that they were familiar with industrial robots, while others mentioned that they had seen robots mostly on TV, and wondered if a semi-autonomous vacuum cleaner robot or a lawnmower robot could be considered as robots (Saplacan, Herstad, and Pajalic 2020). Moreover, it seemed also that domestic robots were more familiar to them than other robots.

In addition, regarding robots, the elderly participants focused on the appearance and functionality of the robots. Although we, the researchers in the MECS project, were mainly interested in the specification requirements and design of a safety alarm robot, the elderly participants were willing to have domestic robots which could be categorized as servant robots: robots that could help them out with the household activities, to bring them things, or to clean their homes. Only one participant pointed out that this type of robot may potentially reduce their physical activities (Saplacan, Herstad, and Pajalic 2020). Moreover, they were reluctant to have robots that were big in size due to the limited space in their apartments. In general, the appearance of the robot was less important than functionality; however, it was more important for female participants than male participants. Navigation of the robots was one of the participant's main concerns, as they saw the furniture being potentially problematic for the navigation of a robot.

Further, when asked about how they viewed robots, the elderly people stated that they saw the robots as inferiors, being subordinate to people, saying: "he is *just* a robot" (Saplacan, Herstad, and Pajalic 2020, p. 204). Moreover, they often sought a practical benefit of having such a robot in the home. As one of the participants said, "When I should learn something new, I am asking – what's the point?" (Saplacan, Herstad, and Pajalic 2020, p. 204).

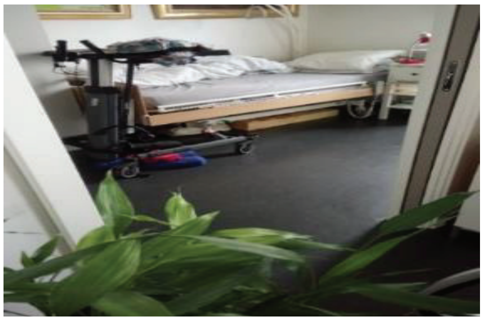
The idea of a companion robot was, however, accepted by the elderly, as many of them often felt lonely. They said that the robots could supply daily dialogical interaction since they felt alone at times and needed to talk to someone. However, in general, they felt anxious about such modern technologies, often fearing "doing something wrong" while interacting with these modern digital technologies (Saplacan and Herstad 2018).

Finally, the participants pointed out two other main issues: 1) they found the robots too expensive and did not recognize themselves as the right target group for using robots; and 2) they felt that laws and regulations were not adapted for introducing such robots into their homes, according to them.

6.5.2 Understanding the interaction with- and use of a robot in the home (Paper II and Paper III)

Together with other researchers in MECS, I first investigated the elderly's expectations of robots and other ICTs (Paper I), as explained in the previous section. During the next phase of the study carried out in Case 1, I tried out semi-autonomous robots in the homes of the participants: both non-elderly people (≤65 years old) and old people (≥65 years old). I have used the definition from gerontology to define what is considered old (Baltes and Smith 2003; Field and Minkler 1988). Some of the old participants were the same participants that took part in the first phase of the study (Paper I). Figure 6-4 exemplifies some of the homes of the senior-participants.

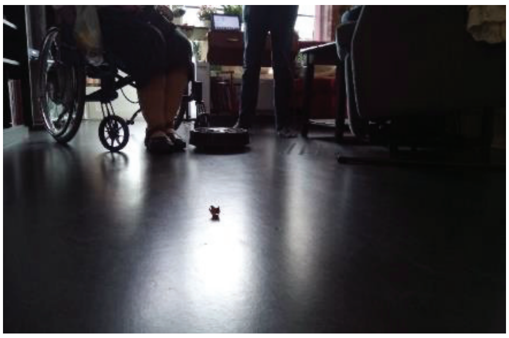
a) The home of a participant, using a walking chair.



b) Example of a bedroom

c) A living room with a participant in a walking chair

d) The bathroom area, including a walking-chair



e) A living room with a participant in a walking chair

f) Example of the robot navigating around.

Figure 6-4 Photos from the data collection illustrating the home of the participants

The semi-autonomous robots introduced in the homes of the participants were domestic, sometimes referred to as *domotics.* Researchers in MECS, including myself, acquired three such robots, namely, vacuum cleaning robots: the iRobot Roomba 980, Neato BotVac, and Samsung PowerBot VR20H to introduce them into the homes of the participants (Saplacan and Herstad 2019). After introducing the robots in the homes of the young participants, my colleagues and I soon noticed that only the iRobot Roomba 980 and the Neato BotVac were suitable for the elderly participants. The reason is that the participants wished to use robots that were small in size: their apartments were quite small, and they were complaining that they did not have space for large robots. Figure 6-5 shows each of these robots.

Figure 6-5 Robots acquired for introducing them in the homes of the participants (Newaz and Saplacan 2018, p. 683)

Moreover, the literature shows that "housing-related needs" seem to be central for learning and adopting technology, *if* these technologies function well (Pigini et al. 2012, p. 303). At the same time, men seem to have more serious difficulties than women in managing housekeeping tasks, according to Pigini et al. (2012). In addition, it also seems that around 190 million people are struggling with Activities of Daily Living (ADL) (Riek 2017), including home chores. Along the same lines, the senior participants in this study were reluctant to use unfinished robot prototypes in their homes, while they also had a hard time imagining and discussing the robots of the future to be used in their homes.

Thus, introducing this kind of robot, namely vacuum cleaning robots, was a strategic choice from our side. On the one hand, the old participants in the study were familiar with industrial robots from their earlier working lives, and with the vacuum cleaner and lawnmower robots that they had seen on TV, as mentioned in the first phase of the study described in the previous section (Saplacan, Herstad, and Pajalic 2020). Moreover, the majority of the senior participants had a paid cleaning service every other week. In this sense, we, the researchers in the MECS project, found it valuable to introduce autonomous vacuum cleaning robots to their homes semi-, creating a "win-win" situation: the elderly benefited from using the robots, supporting their housekeeping activities, while we could learn and understand more about their everyday interaction and use of a moving object, a robot, in their homes.

Based on Papers II and III, we have identified three main areas of interest: (1) issues related to the robot deployment in the participants' homes, (2) issues related to human aspects, and (3) issues related to the home space. (1) The issues related to the robot deployment illustrated concerns with regard to robot navigation, the use of the smartphone app to control the robot, and properties of the robot itself (blue). Further, (2) the issues on the human aspects were concerned with the feelings experienced by the participants when using the robot, and the participants' perceived autonomy (green). Finally, (3) the issues concerned with the home space related to types of work that had to be performed by the human, the presence of other things in the home – such as furniture, and the presence of other people in the home (red). These themes that emerged are illustrated in Figure 6-6. Our findings covered a large area of these three aspects. Papers II and III describe and illustrate in-depth the findings on understanding everyday interaction and the use of semi-autonomous robots in the home. Paper II illustrates mainly issues (1) and (2), whereas Paper III illustrates mainly issues relating to (1) and (3).

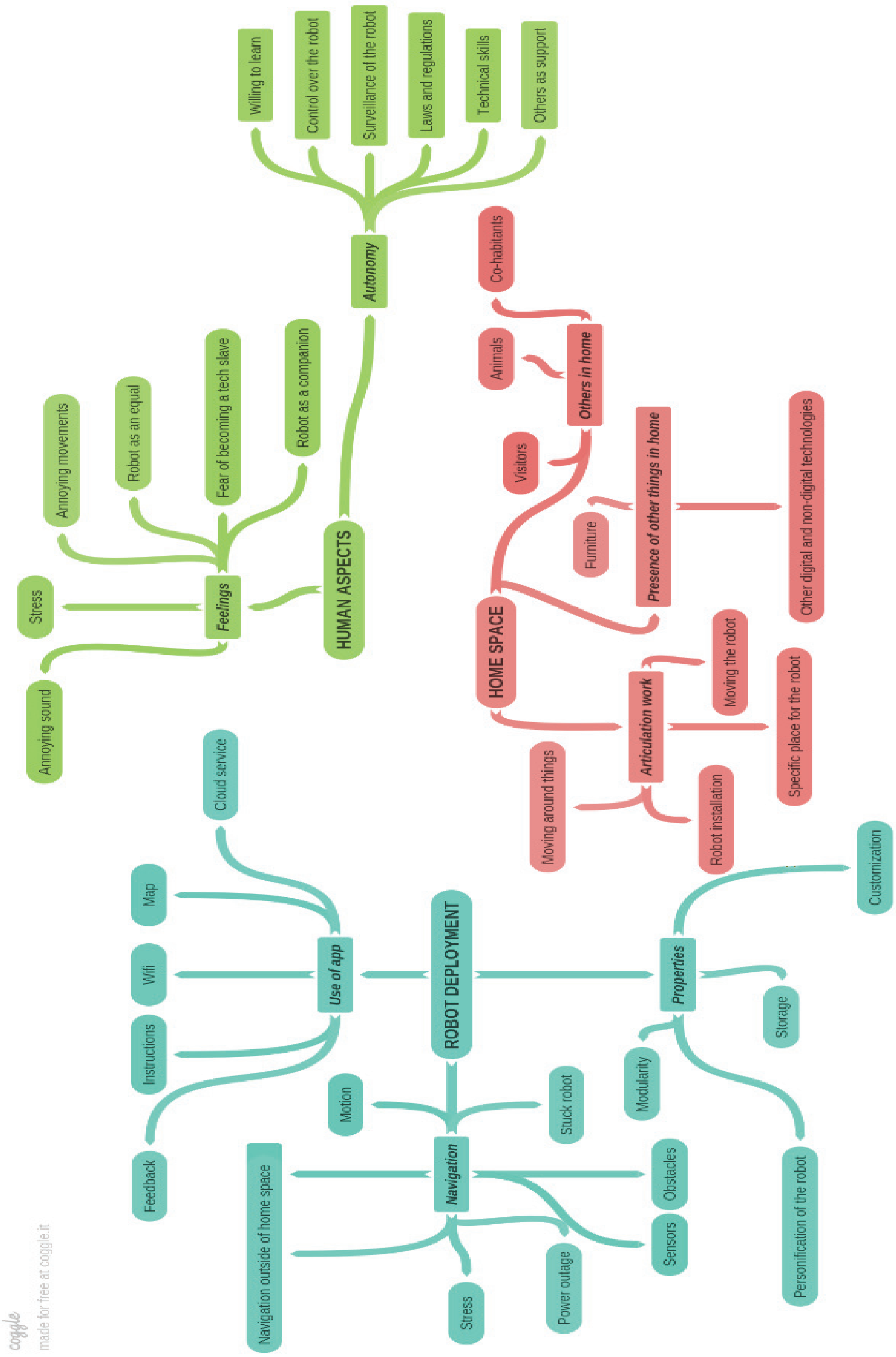


Figure 6-6 Understanding everyday interaction and use of semi-autonomous robots in the home: Final themes emerged from the data analysis (Saplacan et al. 2020a, p. 10)

6.5.3 Direct, mediated, or remote interaction in a shared- or non-shared spaced with- a robot (Paper II and Paper III)

Papers II and III identify several situations where the human interacts with and uses the provided robot in the home. Specifically, the papers' findings can be summarized into three situations experienced by the participants: mediated human-robot interaction via a smartphone app, in a shared or non-shared space, and human-robot direct interaction. Situations 1 refers to mediated human-robot proximate interaction via a smartphone app, where the human and the robot share a physical space, such as the home. This means that both the human and the robot are co-located in that space; however, their interaction takes place via the smartphone app. Situation 2 refers to human-robot remote, but mediated interaction via a smartphone app. Finally, Situation 3 refers to a human-robot direct interaction, where the human and the robot are co-located in the same space and interact directly, without the smartphone app. Table 6-3 illustrates these situations. Note also that Situations 1 and 3 can also be experienced at the same time by the user.

Table 6-3 Possible situations - interacting with a semi-autonomous robot in the home

#	Situation	Space	Human (H)	Robot (R)	App (A)
1	H-A-R proximate mediated interaction	Shared	H	R	A
2	H-A-R mediated remote interaction	Non-shared	H	R	A
3	H-R direct interaction	Shared	H	R	-

Situation 1. H-A-R proximate mediated interaction. In general, the findings showed that the majority of the elderly were not able to control the robot through the use of a mobile app as a remote controller for the robot (Saplacan and Herstad 2019). Specifically, only one of the senior participants was able to use the smartphone app to interact with the robot. The participant was a female participant who was very interested in technology. She was the owner of an iPhone, an Apple tablet, and was used to working and writing in Word using computers or printing things. However, she had no experience with semi-autonomous vacuum cleaner robots. Although she was familiar with technology, she encountered several challenges in her everyday experience with the robot. For instance, once she experienced a power outage that made the Wi-Fi connection between the smartphone and the robot break (Saplacan and Herstad 2019). Consequently, due to the power outage, she could not use the smartphone app to control the robot anymore. For instance, she received an error feedback message on the smartphone app, saying, "it cannot connect to the *cloud services*" (Saplacan and Herstad 2018, p. 176; Saplacan and Herstad 2019, p. 82). She pointed out that she did not understand the technical language expressing "cloud services," wondering what the term meant.

Likewise, other participants pointed out other similar language barriers. One participant expressed that he once received a feedback error message displayed on the robot: "*Please clear my path (2000) and a red cross"*, as he wrote in his diary notes (Saplacan and Herstad 2019, p. 78).

In addition, others complained about the language barrier in the design of the robot and the use of the English language: *"Because even if I understand pretty well English, these technical things are a lot worse, because you do not understand them so well: technical language is more difficult!"*, said one participant in an interview (Saplacan and Herstad 2019, p. 78).

Along the same lines, another participant mentioned that she missed an instruction manual in Norwegian: *"Yes. So, it was another time when it got stuck in the charger, and it blinked. It was something about the light, but I did not understand what it was. I have missed a Norwegian instruction manual. It would have been very nice to have one"* (Saplacan and Herstad, 2019, p. 78). We, the researchers in the MECS project, had to print out a Norwegian version of the instruction manual for the robot to decrease the gap in the language barrier and provide the senior participants with instructions written in Norwegian instead of English. Figure 6-7 (bottom right corner image) exemplifies a photo of this, where we, the researchers in MECS, provided the participants with a printed version of instructions in Norwegian.

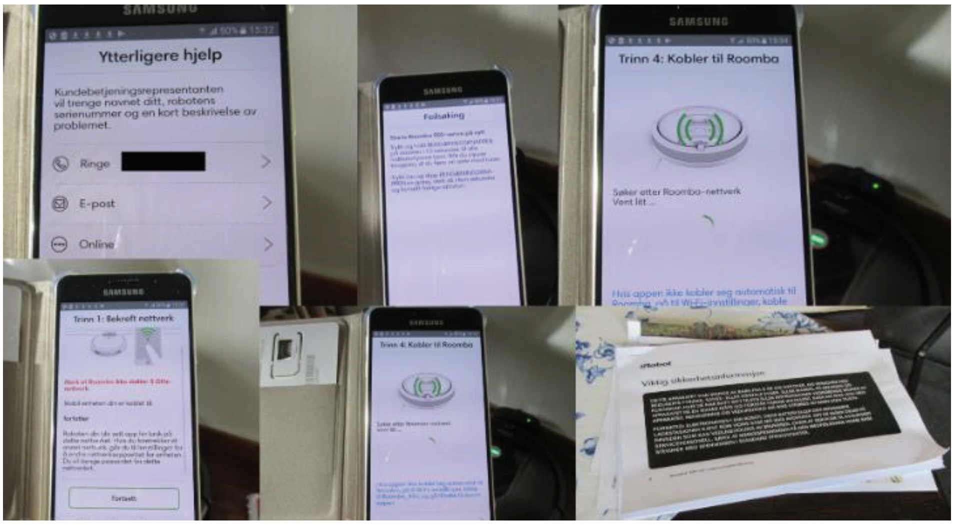


Figure 6-7 Technical language or foreign languages a common issue amongst the users - often underestimated in the design

Another concern mentioned by the elderly was related to privacy: they were concerned about the robot "seeing" in their bathroom, through the robot's sensors and camera. They were not aware that the robot had an Infra-Red (IR) camera that was used for the navigation of the robot.

Along the lines of the privacy, we, the researchers in MECS, paid a high number of visits in the elderly people's homes to support the senior participants with the installation of the robot, of the smartphone app, and to follow up on the senior participants' everyday interaction and use of the robot, including unforeseen situations such as the one illustrated with the power outage. In order to install the smartphone app, there were several steps that the user had to do: the user had to install the app, have an email address, choose the type of the robot, give a name to the robot. Due to privacy reasons, but also due to the senior participants' low ability to install the robot and the smartphone, we supported this installation through the use of our own emails.

Using the app was found useful by one old lady who participated in our study, as well as the non-elderly participants. However, it was nevertheless controversial with regard to the privacy and the data collected from the users' homes. For instance, the app drew a navigation map of the indoor area navigated by the robot, how many square-meters were covered, when the robot was run, and how long the cleaning time took. Figure 6-8 exemplifies the installation.

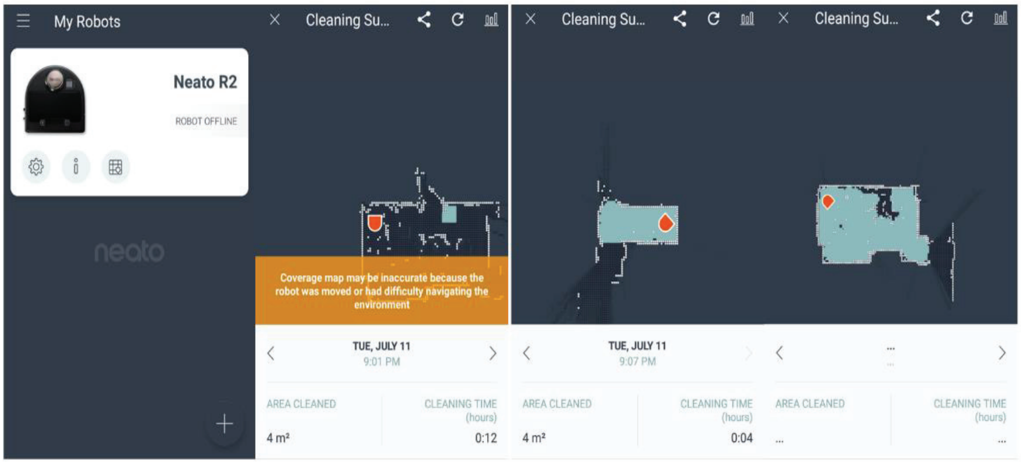


Figure 6-8 Indoor robot navigation map and other stats

Situation 2. H-A-R mediated remote interaction. None of the elderly participants chose to use the H-A-R mediated remote interaction to interact with the robot. There were two main reasons for not interacting with the robot via a smartphone app: first, the majority of the elderly people did not own a smartphone, and second, they wanted to "supervise" the robot while it was running. For instance, one of the participants expressed explicitly her conviction that she could not leave the robot running while she was away from home because she was afraid that something could go wrong after she had experienced several situations when the robot either got stuck under the bed or in the cables.

However, the non-elderly participants opted for mediated remote interaction. Two of them explained how it got stuck while they were away and how they were not able to do any facilitation work for the robot: "Went out to meet some friends; when I got home, I found the robot running. Apparently, I had turned on a schedule when I had last used the app. I'm not sure *how* I did this, but I did it. The wife was home, so she picked up the rug in the entryway." Another similar situation is illustrated in one of the participant's diary notes: "A bit annoyed, I looked at its schedule. It seems it will be going at 9:30 tomorrow evening. We'll be ready for it this time. I enjoy that it has created a staggering vacuuming schedule, but a bit annoyed that it just launches itself out there." (Saplacan and Herstad 2019, p. 81) Another participant explained a similar situation: "I pressed the 'HOME' button; it started. After a while, it got stuck. I remembered the previous installation at home when the app gave notifications about this – when I was out-of-the-house. This information was disturbing at that time since I did not want to do anything with it. It interrupted a nice train journey I remember now and started off a train of thoughts of where it was stuck, and why (since I had done my best to make a "clean floor" there as well." (Saplacan and Herstad, 2019, p. 80).

In this kind of situation, the robot often needed facilitation work from the human side in order to make the robot run again. This required the co-location of the human in the same location as the robot was, i.e., at home.

Situation 3. H-R direct interaction. In general, the majority of the participants preferred to interact with the robot directly without using its smartphone app. The direct interaction with the robot can be described as triggering different feelings in the participants, both positive and negative laden. For instance, the robot's incoherent motion triggered feelings of anger, stress, and annoyance (Saplacan and Herstad 2019). Moreover, in general, the participants were disturbed by the noise it was making. At the same time, the robot also triggered the development of participants' affection towards the robot: they saw it as a companion, they talked to the robot and gave it a name, such as Klara, King Robot, Frida, or Snilla (Saplacan and Herstad 2019).

However, one of the points that this interaction situation illustrated well was that the human needed to carry out a lot of articulation work in different situations. I dedicate the next sub-section to illustrating several examples of this.

6.5.4 The need for articulation work to make the robot's "work" work (Paper II and Paper III)

The human was often required to carry out articulation work to make the robot's "work" work. For instance, the human often had to move around the furniture in the home in order to facilitate the robot's navigation (Figure 6-9). At the same time, the robot often got stuck in cables, under the bed, or when it was supposed to cross the door threshold. This was especially difficult for the senior participants since they had difficulty bending their bodies. It was especially difficult for one lady who was sitting in a wheelchair – she had to wait several days until her brother came to visit her and helped her with retrieving the stuck robot from under her bed.

Figure 6-9 Photo examples of articulation work to make the robot's "work" work

Another illustrative situation when the human had to carry out articulation work to make the robot’s “work” work was when the robot did not return to its charging station, or it stopped before reaching it. In those situations, the human had to manually move the robot close to its charging stations in order to charge it.

In addition, the participants described his experience with the robot when it “escaped” the apartment’s boundaries, and it did not know how to turn back. The participant sat in a wheelchair, and he had to go out and bring the robot back inside the apartment. Figure 6-10 illustrates several such examples.

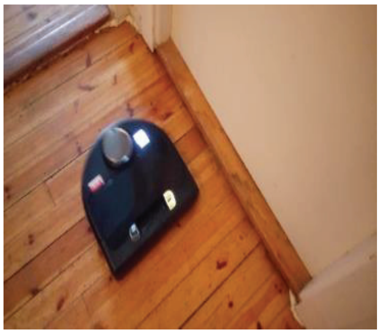
a) The robot gets stuck under the bed

b) The robot gets stuck under the bed, in the bed's cables

c) The robot gets stuck in curtains

d) The robot gets stuck in the cable of a lamp and breaking it

e) The robot got stuck in a cloth hang-dryer



f) The robot gets stuck in the threshold of a door. It couldn't cross it.

g) The human doing articulation work before running the robot by putting the curtains up to make the robots' navigation easier.

h) The robot is not reaching the charger.

i) The robot after the human moved the robot into its charging station.

Figure 6-10 Examples of situations where the robot gets stuck and the human needed to carry out articulation work to make the robot's "work" work

6.5.5 When does the need for articulation work occur?

Paper II identifies two situations when the need for articulation works occurs in the human-robot interaction, being proximate mediated interaction via a smartphone app (Situation 1), mediated, and remote interaction via a smartphone app (Situation 2), or direct interaction (Situation 3). Besides, Paper III identifies the division of work tasks between the human and the robot as a third reason for the articulation work occurring. Each of these is explained below.

Situation 1: Lack of feedback from the robot or the smartphone app (Paper II).

In general, the participants did not know how to interact with the robot when there was a lack of feedback on the robot's side. For instance, one requirement from the senior participants' side was that the robot should be able to "talk," i.e., to interact through speech, and specifically, using the Norwegian language, for them to be able to interact with it.

Situation 2: Improper feedback from the robot or the smartphone app (Paper II).

In general, the interaction with a robot is based on a lack of feedback or improper feedback. There were several types of feedback: negative, positive, homeostatic, and archival, similar to other static ICTs, such as the feedback between a smartphone app and a user. In general, the improper feedback was represented either through the technical language used, such as error messages, or the English language. However, in addition to these types of feedback, as a form of communication between the human user and the robot, Paper II identifies also the robot motion as feedback, namely the transition feedback: a form of the robot transiting from one state to another (Saplacan and Herstad 2019). Sometimes the robot would navigate the environment in a very random way that did not make sense for the user.

Situation 3: Division of work tasks between humans and robots: planning and designing work tasks for humans' abilities (Paper III).

After introducing a robot in the homes of the non-elderly and senior participants, we, the researchers in MECS, noticed that the robot, as a moving object in the home, an uncontrolled environment, created a lot of additional work tasks for the human (Saplacan et al. 2020). This was not only because of the lack of or improper feedback in the interaction with the robot but also due to bad planning and design of work tasks by the robot.

Thus, to analyze the division of work tasks between the humans and the robot, Paper III uses the theoretical framework from Verne (2015) and Verne and Bratteteig (2016), who present different types of work tasks that come along with automation. To do this, Paper III has analyzed the work activity of the human in two situations: a) when using an ordinary device vs. b) when using a semi-autonomous device. The work activity analyzed was one of cleaning. However, the work activity of cleaning in itself was less important, and it was used only instrumentally, to understand the potential challenges a human needs to deal with when having a moving object, a robot, in the home. However, in addition to the types of tasks identified in the work of Verne (2015) and Verne and Bratteteig (2016) on automation of desktop systems, Paper III identifies some new dimensions of work tasks, namely the temporal and spatial distribution that comes along with automation of tasks that are carried out by a physical robot. These dimensions are summarized in Table 6-4.

Table 6-4 Exemplified Framework on Division of Work Tasks between Humans and Robots: Including the Spatial and Temporal Dimensions (Saplacan et al. 2020a)

Tasks dimensions	Type of task	(When the human actor is using a non-moving actor (N/A* = Not Available)	When a robot is introduced in a physical environment
Tasks that come with automation (based on Verne, 2015, and Verne & Bratteteig, 2016)	Residual tasks	Yes. Humans need to do some manual work tasks	Yes. The human needs to clean some of the areas that the robot did not reach.
	Redundant tasks	N/A	Yes. The human needs to start the robot through direct (e.g., by pushing the button) or remote (e.g., through the app) interaction.
	Tasks within the automation	N/A	Yes. The robot gives audio or visual feedback to the human.
	Tasks outside the automation and new tasks	Yes.	Yes. The human chooses to move the robot or to remove obstacles without the robot indicating it.
	Tasks generated with the automation and new tasks	N/A	Yes. The human needs to charge the robot, to lift the robot from one place to another, when it gets stuck, to bring it back when it "escapes."
Temporality of tasks	Sequential	Yes.	Yes, partially. Some sequential tasks, for each of the actors, are available. When the tasks for one actor is interrupted or paused, usually the other actor takes on the tasks.
	Parallel	No. The device itself cannot perform tasks on its own. However, the human can perform several tasks at the same time.	Yes. The human and the robot can perform tasks in parallel.
	Linear	Yes. The device is controlled by humans.	Yes. Both the human and the robot can perform linear tasks. However, linear tasks are often interrupted.
Spatiality of tasks	Spatial tasks in shared spatiality	Yes. The human and the device share the space.	Yes. Both of the actors can share space and perform different tasks at the same time.
	Spatial tasks in distributed spatiality	No. The human and the device cannot be in two different places and work on a joint task	Yes. The robot can perform tasks remotely, while the human can control or give autonomy to the robot through an app that can be used remotely.

Finally, the proposed framework on the division of work tasks between humans and robots, based on the empirical case of using a domestic robot in the home, is illustrated in Figure 6-11. This framework can be useful when designing a robot and planning its work tasks, depending on their type and temporal and spatial distribution. The framework indicates, in other words, how the division of work tasks can be shared between the human and the robot and how they can be planned. However, in the long term, with the automation of work, the main idea is that as few work tasks as possible should be on the human side. The work should be moved to the robot side, however, without a cost to the humans' privacy.

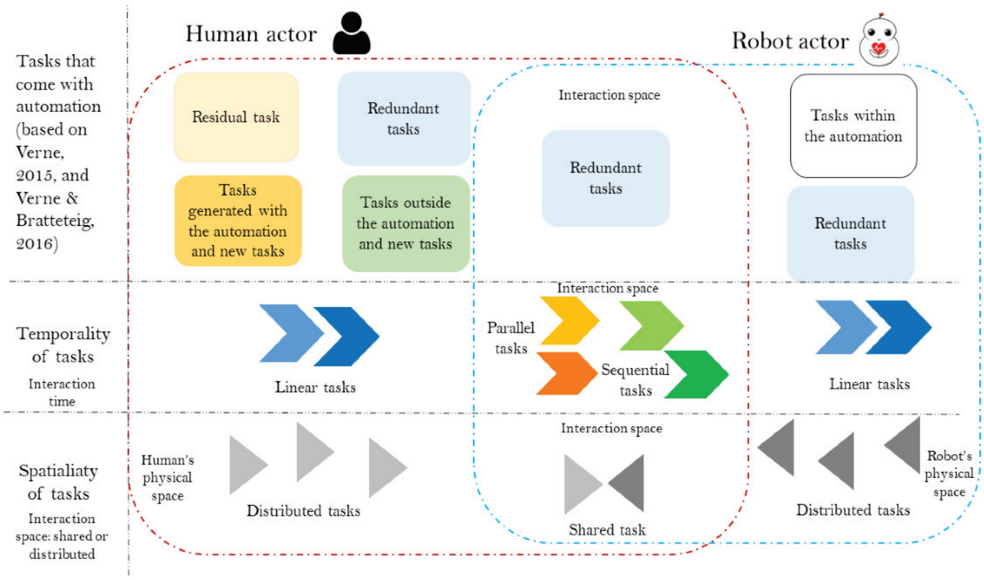
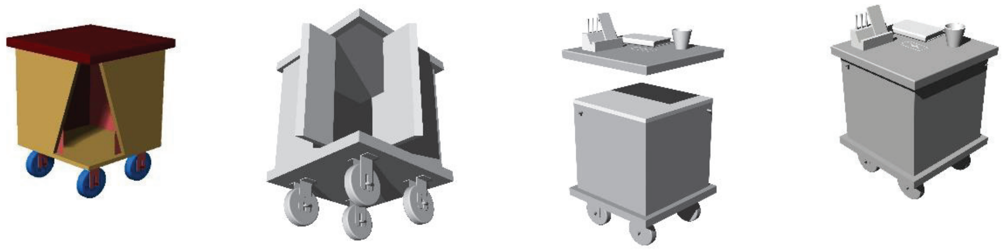


Figure 6-11 Division of work tasks between humans and robots (Saplacan et al. 2020)

6.5.6 Exploring situated abilities within Universal Design (Paper IV)

Paper II and Paper III focused on the interaction with and use of an existent consumer robot, namely a vacuum cleaner robot. In the last phase of the study carried out in Case 1, together with other researchers in MECS, I have explored the idea of situated abilities instead through a practical design representing a proof-of-concept robotic design for situated abilities. Specifically, the paper presents a domestic robot that fits and integrates into our homes. The robot is a robotic wooden table, named T-ABLE, an acronym originating from the terms *table* and *able*, or *ability*. In other words, the paper presents T-ABLE as an alternative design for domestic robots.

The paper relies on designing this domestic robot with a wooden look that fits the environment or the situated context of the user, e.g., the home. Besides, the paper proposes a shift in perspective, from focusing on universal design and the disabilities of the user to focusing on designing for situated abilities. The paper argues that the abilities of individuals are strongly connected with the context and situations they find themselves in. Designing a robot with the look of a table, avoiding designing robots with, for instance, a zoomorphic or anthropomorphic, or mechanic look, Paper IV illustrates a proof-of-concept design. The design of the T-ABLE is anchored in a scenario and persona, Eve, designed together with a senior participant. Its design also starts from Universal Design principles and moves beyond these, arguing that starting from the design of familiar things to the user as a point of departure for designing for abilities can illustrate well the idea of designing for (high) situated abilities. Some illustrations of the T-ABLE design are shown in Figures 6-12 and 6-13 below.



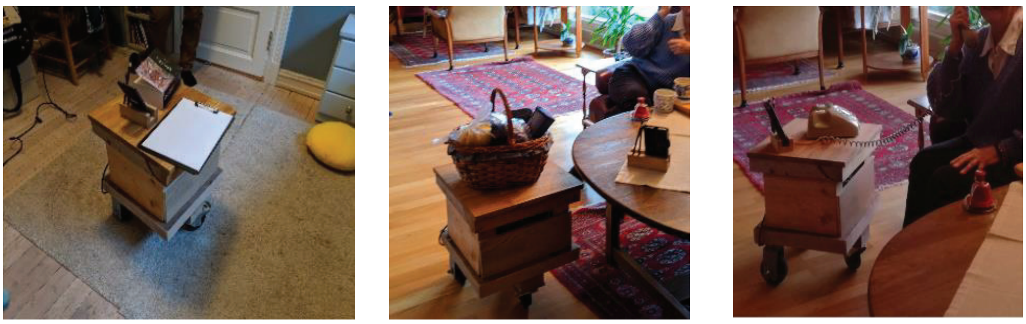
a) Iteration 1 – T-ABLE drawing by Nicholas Ibicheta

b) T-ABLE with telephone and charger

c) T-ABLE with an extra tabletop extending the horizontal surface;

d) version of the T-ABLE with a place for depositing items

Figure 6-12 T-ABLE as a proof-of-concept design for designing for situated abilities; figure from Saplacan, Herstad, and Schulz (forthcoming)



a) A prototype of T-ABLE transporting things in the home

b) A prototype of T-ABLE transporting things in the home

c) A prototype of T-ABLE where an elderly participant uses it to bring the home fixed phone and the mobile phone closer to her

Figure 6-13 Prototype of the proof-of-concept design of T-ABLE used in one of the senior participant's homes – a figure from Saplacan, Herstad, and Schulz (forthcoming)

In addition, Paper IV moves beyond the seven Universal Design principles and illustrates several dimensions of designing for situated abilities, such as a) A social dimension – the user can place the technology within his understanding of the environment surrounding him; b) A relational dimension – the user can relate to the design of the technology through its embedded familiar elements; c) A socio-relational dimension – the user sees the technology as a habituated object, and d) An empowering dimension – the user feels in control of his or her abilities to interact with the technology. These dimensions are illustrated and discussed further in Ch. 8. Finally, the concept of situated abilities is also the overall theme of this thesis. This is further explored in Case 2. A dedicated chapter (Ch. 8) is available in this thesis introducing, framing, and defining situated ability.

Chapter 7 CASE 2: UNDERSTANDING EVERYDAY USE OF DIGITAL LEARNING ENVIRONMENTS IN HIGHER EDUCATION

"It's not necessarily difficult, but complex."

— Participant, Interview (Paper VII, p. 264)

This chapter presents *Case 2* in this study, *Understanding everyday use of Digital Learning Environments in Higher Education.* The case is part of the UDFeed project, as mentioned in Ch.1. This chapter starts with giving a background on the case and the addressed research question RQ1. Specifically, the chapter answers the second research sub-question, SRQ2. The chapter also includes an overview of the study design for Case 2, methods of data collection and analysis in Case 2, and a summary of papers. Finally, the chapter ends with a presentation of the findings from Case 2.

7.1 Background

There are several action plans, agendas, and white papers, at a global, European, and national level focusing on the digitalization of Higher Education.

For instance, OECD (2009) reports on the globalization of Higher Education to 2030 to address the importance of collaboration through Information Communication Technology (ICT) solutions in education and research. Along the same lines, the World Economic Forum explains that the students' 21st-century skills shall embed ICT literacy and communication (World Economic Forum 2016). Moreover, the Sustainable Development Goal (SDG) 4 addresses the goal of ensuring "inclusive and equitable quality education" that "promotes lifelong learning and opportunities for all" (United Nations 2018). In addition, according to the latest updates from the UN, the COVID-19 pandemic has intensified the inequalities in education, as remote learning is still out of reach for as many as at least 500 million students. Further, the Higher Education Sustainability Initiative (HESI) argues that HE and further education need to be re-designed to support both a green recovery and regenerative pathways for education.

Following these global education directions and initiatives regarding the use of ICTs in education, at the European level, several action plans concerning the digitalization of education have been adopted. One European action plan includes Digital Inclusion for a Better EU Society, covering accessible ICTs, assistive technologies, skills and digital skills, and social inclusion (European Commission 2016a). Other plans talk about Opening Up Education, with the help of ICTs that now may offer increased effectiveness in education and increased equity where the knowledge is accessible to all at lower costs, and nevertheless upskilling the workforce with skills and competencies that are not only limited to digital literacy (European Commission 2016b). Another plan at the EU level is Digital Learning & ICT in Education (European Commission 2018b). The plan works towards modernizing policies addressing the education and training sector, promoting 1) the use of digital technologies in teaching and learning; 2) developing digital competencies and skills, and 3) improving education through better data analysis and foresight (European Commission 2018a).

At the same time, Norway is one of the most advanced e-government countries, being amongst the most digitalized countries in the world (#8 in 2012, and #13 in 2014, and #2 in Scandinavia in 2014) (Begnum 2019). Moreover, the digitalization of the Norwegian public sector, including education, was put on the digitalization agenda 2019-2025 of The Norwegian Ministry of Local Government and Modernization. The agenda aimed to improve the efficiency of the public sector, supporting its digital transformation (Ministry of Local Government and Modernisation 2019). In one White Paper from the Norwegian Ministry of Research and Education (Meld- St. 16, 2016-2017) (Ministry of Education and Research 2017), the government stated its main objectives concerning the improvement of the quality of Higher Education (HE). The White Paper describes that the world is undergoing continuous change and the HE needs to address professionally relevant digital competence and advanced ICT literacy, but also "digital judgment, which is relevant across disciplines" (Norwegian: "digital dømmekraft, som er relevant på tvers av fagområder," p. 9) (Ministry of Education and Research 2017, p. 9). Amongst its objectives, there are included aspects such as a good study start, including a focus on diversity and accessibility, and a learning environment for quality. Further, the White Paper also states the importance of Universal Design. The paper states that all new ICT solutions should be universally designed, starting from 1st January 2021. This fact is also confirmed by Norwegian law, in The Discrimination and Disability Act (Lovdata 2017), and in a regulation referring specifically to the Universal Design of ICT solutions to be used in education and training, including Higher Education (Kommunal- og moderniseringsdepartementet 2017). Specifically, it refers to information that should be published or made available through the use of ICTs, internet-based solutions that should use a Uniform Resource Identifier (URI) and which use the Hypertext Transfer Protocol (HTTP protocol) or likewise, and digital learning interfaces that should be used in pedagogical work, to support learning activities. The change made to this regulation during 2017 came into force as of January 1st, 2018

(Lovdata 2017). The change says that the education and training sector is obliged to ensure that new ICT solutions within this sector should be universally designed at the latest one year after the regulation came into force, whereas existent ICT solutions should be universally designed as of January 1st, 2021 (Knarlag 2017; Kommunal- og moderniseringsdepartementet 2017, based on own translation into English from Norwegian).

Moreover, a recent report from PROBA (2018) (PROBA samfunnsanalyse 2018) shows that not only do people with disabilities encounter challenges in HE, but also students who are not necessarily medically diagnosed as physically disabled. Specifically, the report showed that the number of respondents with cognitive disabilities is higher than those with physical disabilities (PROBA samfunnsanalyse 2018). Moreover, it seems that four out of five respondents face pedagogical barriers, and 27% out of the total number of respondents (#723) face digital barriers.

7.1.1 Case 2: Motivation

Thus, based on the facts described above, I argue that Norway, although a highly digitalized country in terms of its ICT solutions in the public sector, encounters challenges, such as the digital exclusion of its citizens, at least in education. If these sectors do not reach out to all their users with their digitalized ICT solutions, this could have huge consequences on society. To counter-encounter these challenges, I argue that the upskilling of the future workforce and the universal design of ICTs are essential and absolute necessities for a regenerative and sustainable future higher education.

Moreover, another concrete argument that motivates Case 2 is that there is a lack of studies investigating the user experience when using multiple digital learning environments, not only single platforms. Many studies regarding the use of Learning Management Systems (LMS) in Higher Education were carried out (see, for instance, Lonn and Teasley 2009; Coates, James, and Baldwin 2005; Machado and Tao 2007; Graf 2007). Some studies relating to the Universal Design of learning also exist (see Moore 2007; Rose and Meyer 2006; Lanterman 2011; Rose and Meyer 2002; Rose et al. 2006). However, specifically, the challenge is when students and course instructors, or other teaching staff, in Higher Education and training are asked to use various LMSs but do not simply one LMS platform. They use other platforms as well, such as social media platforms, dashboards, virtual worlds, and other webpages, such that the information and the course materials become distributed over several channels, which I call here Digital Learning Environments (DLEs).

7.2 Study design

Case 2 includes three papers that can be divided into three phases for the case. The first phase includes the first paper belonging to the UDFeed project (Paper V), which is an analysis of the everyday interaction and use of Digital Learning Environments in Higher Education. The second phase includes another paper (Paper VI) focusing on understanding the everyday interaction and use of Digital Learning Environments in Higher Education. The third phase includes one paper (Paper

VII) and frames the idea of situated abilities, which is also explored in-depth in this thesis. Figure 7-1 gives an illustration of the study design for Case 2.

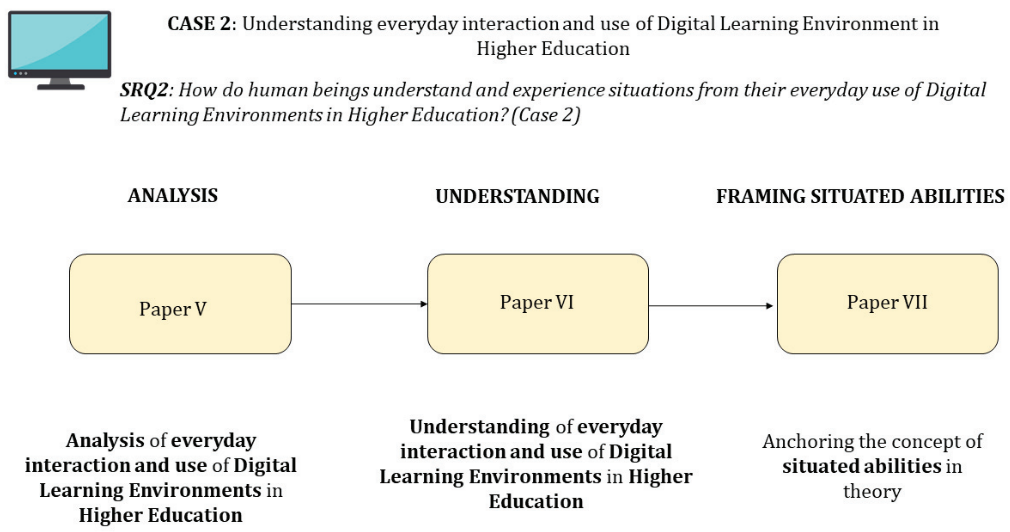


Figure 7-1 Study design - Case 2

7.3 Methods

7.3.1 Participants

The participants in Case 2 were students, teaching staff with expertise either in Universal Design, informatics, or pedagogics, or a combination of both. All the participants were recruited through personal contacts. Their participation was based on free will. Table 7-1 below gives an overview of the participants in Case 2 based on the paper included in this thesis. In addition, 12 other participants took part in an SDM workshop during NordiCHI 2018 (Saplacan, Herstad, Mørch, et al. 2018), and three other experts and leaders in Universal Design were interviewed, besides the participants for the Papers included in this thesis as part of Case 2.

Table 7-1 Overview of the participants in Case 2

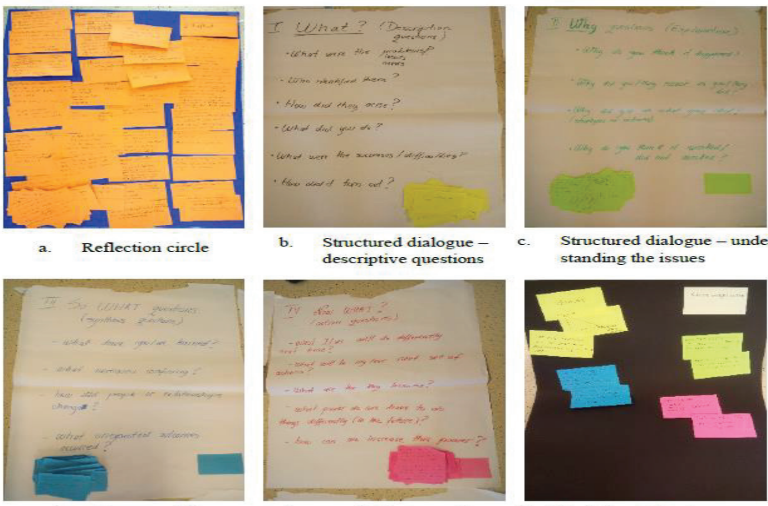
Paper	Number of participants (gender)	Participants
Paper V	3 (2 females and 1 male)	Teaching staff, experts in pedagogics
Paper VI	11 (4 females, 7 males)	5 students facilitated by 1 junior researcher and 1 senior researcher using the SDM method, and 4 teaching staff – experts in informatics
Paper VII	6 (5 females and 1 male)	3 pedagogical experts (the same as in Paper V), and 3 academics with expertise in UD and/or HCI

7.3.2 Data collection and analysis methods

The data collection and analysis methods were earlier explained in Ch. 5. However, an overview of the data collection and analysis methods used specifically in Case 2, for each of the papers included in this thesis, is given in Table 7-2. Photo examples of the data collection and analysis are illustrated in Figures 7-2 and 7-3.

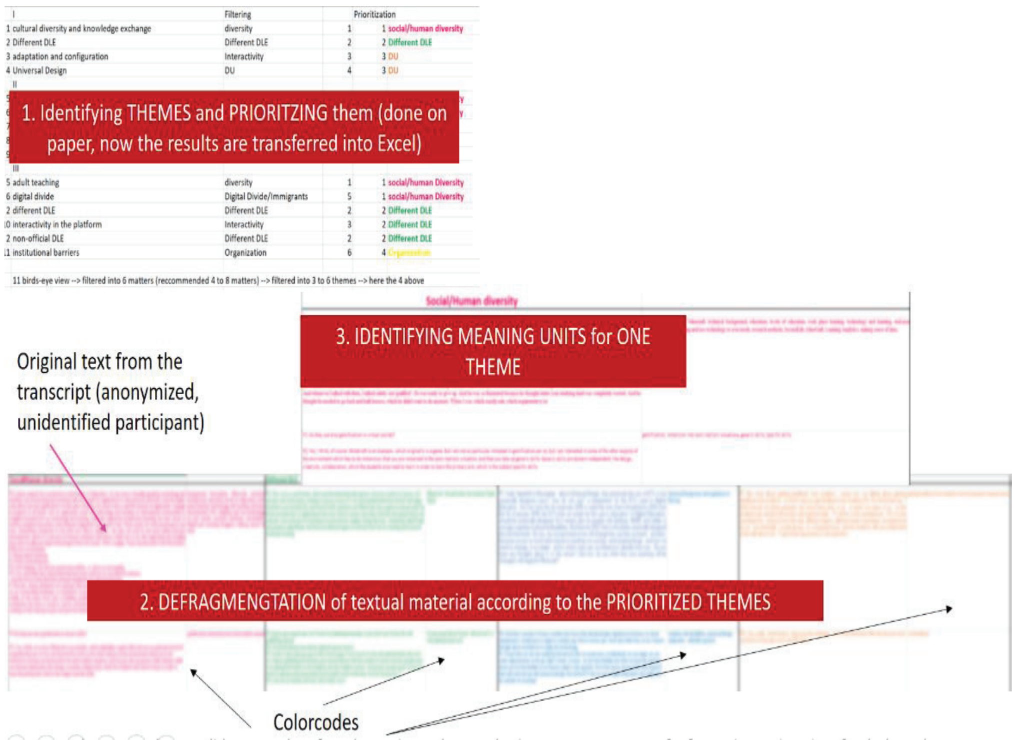
Table 7-2 Overview of the data collection and analysis methods in Case 2

Paper	Type of study	Data collection methods (qualitative methods)	Data analysis methods	Field of contribution	Contribution
V	Empirical, Theoretical	Semi-structured interviews	Systematic Text Condensation (STC) (Malterud 2012)	CSCW	Digital Learning Environments viewed as Common Information Spaces
VI	Empirical, Theoretical	SDM, Semi-structured interviews	SDM (Labonte, Feather and Hills 1999) STC (Malterud 2012)	HCI, CSCW	The use of multiples Digital Learning Environments contribute to fragmented information awareness
VII	Empirical, Theoretical	Semi-structured interviews	STC (Malterud 2012)	HCI, UD	Introducing the idea of situated ability – a salutogenic view on designing for abilities, not disabilities

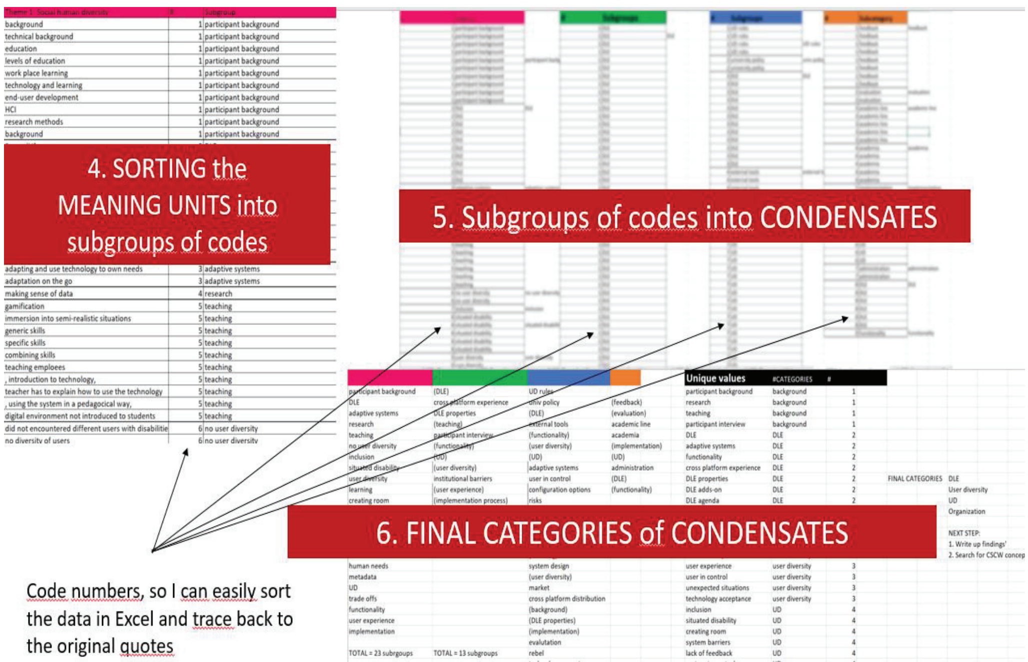


a. Reflection circle
b. Structured dialogue – descriptive questions
c. Structured dialogue – understanding the issues
b. Structured dialogue - lessons
e. Structured dialogue - what could have been done differently
f. Insight cards – theory notes

7-2Example of data collection with Story-Dialogue Method (SDM) (Saplacan, Herstad, Elsrud, et al. 2018)



a) Example of Systematic Text Condensation (STC) analyzing process, using Excel



b) Example of Systematic Text Condensation (STC)analyzing process, using Excel

Figure 7-3 Photo examples of data collection and analyzing methods - Case 2

7.4 Summary of papers

Six articles, including short, long, and workshop papers, were published or submitted for publication, on behalf of the UDFeed project, during this Ph.D. All the papers were interconnected, representing both work in progress and the final findings of the research. However, this part of the thesis includes the three main studies (Paper V-VII) (Saplacan 2020a; Saplacan, Herstad and Pajalic 2020; Saplacan 2020b). The findings from the papers excluded are presented in Saplacan, Herstad, Mørch, et al. (2018), Saplacan, Herstad, Elsrud et al. (2018), Saplacan, Herstad, and Pajalic (2018). The reason for excluding those is that they cover adjacent areas to this thesis. The disciplines of the papers included in this thesis (Paper V-VII) and their main contributions are indicated in Table 7-2 above. The summaries of each of the papers are included below.

Paper V Saplacan, D. (2020). *Cross-Use of Digital Learning Environments in Higher Education: A Conceptual Analysis Grounded in Common Information Spaces*. In Proceedings of the Thirteenth International Conference on Advances in Computer-Human Interactions (ACHI), ISSN 2308-4138, p. 272-281.

Abstract. This paper addresses the cross-use of different Digital Learning Environments (DLE) in Higher Education (HE). The paper aims to analyze DLEs and their use in a HE organizational entity through the lens of Common Information Spaces (CIS), a concept grounded in Computer Supported Cooperative Work (CSCW). In general, CSCW literature focuses on individual systems regarded as CIS. Moreover, the research shows that DLEs are often analyzed from an educational perspective, and less from a cooperative work perspective. However, a teaching/learning context can be viewed as a co-dependent cooperative work arrangement, where the exchange of information and knowledge is performed *through-* and *with* the help of DLEs. In this way, DLEs should be rather viewed as being part of a complex cooperative ensemble rather than analyzed as individual CIS. This paper sheds light on such complex information spaces, where the information spaces are formed through clusters of DLEs, rather than individual DLE units. Finally, the contribution of the paper consists of addressing the cross-use of DLEs from a CIS perspective, moving beyond looking at DLEs just through an educational perspective.

Keywords: *Digital Learning Environments (DLE); Higher Education (HE); Computer-Supported Cooperative Work (CSCW); Common Information Spaces (CIS); information spaces.*

Paper VI Saplacan, D., Herstad, J, Pajalic, Z. (2020). *Use of Multiple Digital Learning Environments: A Study about Fragmented Information Awareness.* Interaction Design and Architecture(s) Journal (IxD&A), nr. 43, 2019-2020, ISSN 1826-9745. p. 86-109.

Abstract. The study focuses on Digital Learning Environments (DLEs), rather than on Learning Management Systems (LMSs). This study goes beyond adopting an educational perspective as the classical studies on LMSs do. DLEs are defined as a plethora of digital systems that may be used within a teaching/learning context, including LMSs, but also social media shared dashboards, communication tools, etc. used in such context. The paper addresses the issues encountered by different actors (students, teaching staff) when using DLEs. The study is theoretically anchored within the HCI/CSCW concept of awareness, repurposing the concept in an educational setting. The paper introduces a new form of awareness, namely, fragmented information awareness. This perspective is new to the extensive existent body of literature that focuses much on designing systems supporting Situation Awareness (SA), distributed, and shared awareness. The contribution of this paper lies in defining, describing, and addressing fragmented information awareness, grounded in empirical qualitative data. Moreover, the study addresses the Universal Design (UD) issues by proposing a set of recommendations for non-fragmented information awareness from within and from without. Overall, the study subscribes to the third and fourth HCI waves.

Keywords: *Digital Learning Environments (DLE), Learning Management Systems (LMS), Higher Education (HE), Human-Computer Interaction (HCI), Computer-Supported Cooperative Work (CSCW), fragmented information awareness, information awareness, Universal Design (UD).*

Paper VII Saplacan, D. (2020*). Situated ability: A Case from Higher Education on Digital Learning Environments*, 22nd International Conference on Human-Computer Interaction (HCII 2020), Copenhagen Denmark, 19-24 July 2020, published in Antona M., Stephanidis C. (eds) Universal Access in Human-Computer Interaction. Applications and Practice, Lecture Notes in Computer Science, Part I, vol. 12189, Chapter 19. Springer, Cham. e-ISSN 1611-3349, ISBN 978-3-030-49107-9, pp.19.

Abstract. Universal Design (UD) is often associated with disability studies. However, UD is not about disabilities, but about designing for as many people as possible. Traditionally, disability studies are discussed through the lens of medical, relational, social, or socio-relational models. This paper proposes a new salutogenic approach instead, namely the concept of *situated ability*. Based on the work of Aaron Antonovsky and the salutogenic approach of ease/dis-ease model and his Sense-of-Coherence (SOC) theoretical construct, the paper proposes and discusses *situated ability* and the *ability continuum*. Situated ability is suggested as a form of catalyzing discussions around social equity in a digital society. The proposed concept is supported with examples from an empirical qualitative study on Digital Learning Environments (DLE) used in Higher Education (HE). The empirical data was collected through interviews and analyzed using Systematic Text Condensation

(STC). The findings are discussed through the lens of the proposed concepts. Finally, the paper argues that such perspective is needed for maintaining the dignity of *others,* i.e., the users who experience lower situated abilities when interacting with digital systems; for fostering *salutogenic* discussions about practice and design that enables users, without focusing on dedicated solutions for the lower abled, such as assistive technologies; and for social equity in a digital society.

Keywords: *Universal Design (UD), situated ability, diversity, Digital learning Environments (DLE), Higher Education (HE).*

7.5 Findings from Case 2: Understanding the everyday interaction with- and use of Digital Learning Environments in Higher Education

The second case focuses on the everyday interaction with and use of Digital Learning Environments in Higher Education. Digital Learning Environments (DLEs) are defined as "digital platforms, websites or specific webpages used by course instructors and students in a course for exchanging information or knowledge, relevant for their learning, respectively teaching, within the frame of the course" (Saplacan 2020, p. 272). A lot of studies have, until now, focused on studying one Learning Management System at a time, from a student, course instructor, or administrative point of view (Saplacan, Herstad, and Pajalic 2020). However, fewer studies focus on the experience of the user, the individuals, or group of individuals, in terms of how they experience the everyday interaction with and use of Digital Learning Environments (Saplacan, Herstad, and Pajalic 2020), as earlier defined, as a holistic experience. To do this, I had to investigate the types of DLEs used (Paper V). Thereafter, I had to analyze the experience of the users in their interactions with these DLEs (Paper VI and Paper VII). Finally, the concept of *situated abilities* emerged (Paper VII and this thesis), showing that the majority of the participants encounter challenges in their everyday interactions and use of DLEs, in different situations, not only people medically diagnosed as disabled. In the next sub-sections, I describe the findings from Case 2.

7.5.1 "It's not necessarily difficult, but complex!": The interaction with- and use of official and non-official Digital Learning Environments in Higher Education (Paper V, Paper VI)

Paper V focuses on understanding the cross-use of DLE analyzed through the lens of Common Information Spaces (CIS) (Schmidt and Bannon 1992) and the seven parameters of CIS (Bossen 2002). After some initial interviews, I have soon found out that three participants (course instructors) used in total a number of 23 DLEs, with a minimum of five DLEs and a maximum of 15 DLEs (Saplacan 2020). All the participants, in this case, were part of the same Higher Education organizational entity. All the DLEs were sorted and categorized, such that they belonged to a specific category: official systems, third-party applications, social media, quiz input systems, virtual games environments, and other specialized software. Figure 7-4 illustrates an example of this, where I have regionalized the DLEs into categories and clusters of information spaces.

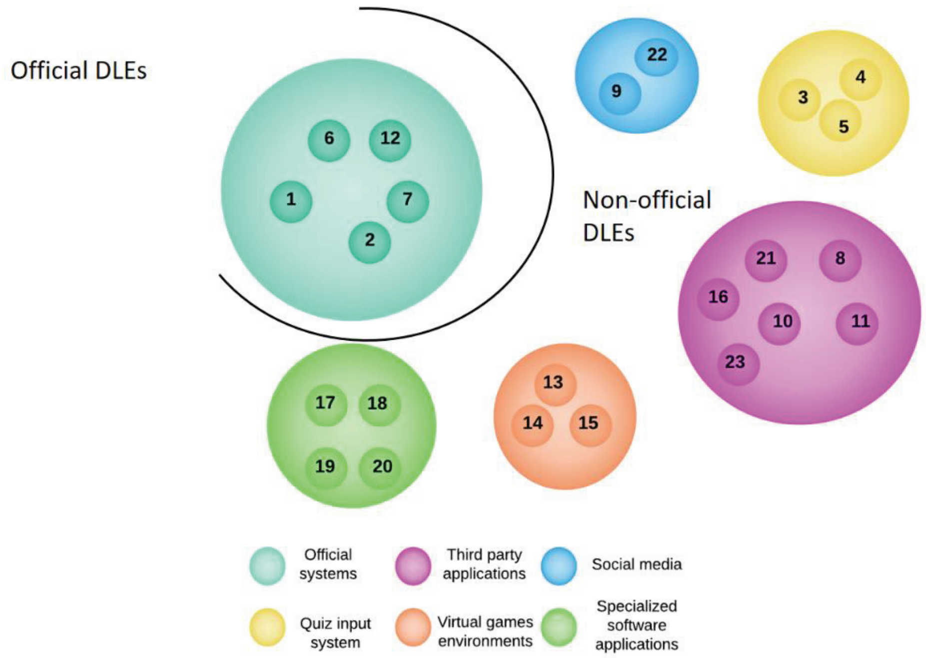


Figure 7-4 Heat-map over the types of DLEs used (Saplacan 2020a, p. 278)

Similar findings were also shown later in Paper VI (Saplacan, Herstad, and Pajalic 2020), where 18 DLEs were used at another Higher Education entity, with a minimum of six DLEs and a maximum of ten DLEs per course instructor. The study also shows that only five of these DLEs were official systems adopted by the Higher Education institution, whereas the rest of them (18) was non-official DLEs.

Based on the findings from Paper V and Paper VI, this thesis shows the number of DLEs used at two Higher Education organizational entities was 28 DLEs since some of these DLEs were used in both organizational entities. However, all the participants belonged to the same HE institution. Table 7-3 shows an overview of all the DLEs mentioned as being used by the participants.

This points to several issues and dilemmas experienced by both students and course instructors. These are described in the next sub-sections.

Table 7-3 Overview of the Digital Learning Environments used at two Higher Education organizational entities – An example from seven participants based on Saplacan (2020a) and Saplacan, Herstad, and Pajalic (2020)

PAPERS		Paper V			Paper VI			
#	Participant (CI) / Systems used in a HE Organizational Entity	#1	#2	#3	#4	#5	#6	#7
1	Publishing system		X	X	X		X	X
2	Internal submission system				X	X	X	X
3	Internally and externally used submission and assessment system	X		X	X		X	
4	External communication system							X
5	External quiz and input system 1			X	X		X	X
6	External quiz and input system 2			X	X			X
7	External quiz and input system 3			X				
8	Email	X	X	X	X	X	X	X
9	New DLE system	X	X	X		X		
10	Third-party application			X		X		
11	External quiz application					X		
12	Social media platform 1			X		X		
13	Social media platform 2					X		
14	Web service for forum discussions and wikis		X			X	X	
15	MOOC or MOOC like platform		X					X
16	Examination platform	X		X				X
17	Virtual game environment 1	X						
18	Virtual game environment 2	X						
19	Virtual game environment 3	X						
20	Learning Analytics	X		X				
21	Specialized analysis software 1	X						
22	Specialized analysis software 2	X						
23	Specialized video analysis software 1			X				
24	Specialized video analysis software 2			X				
25	Cloud-based storage			X				
26	Different variants of messenger applications			X				
27	The third-party plugin used in the official DLE system			X				
28	Screen and speech recorder software							X

7.5.2 "I am personified with my problem!" – Students' perspectives on the interaction with- and use of Digital Learning Environments (Paper VI)

There are several situations when the students encounter challenges interacting with and using DLEs, as described by the students taking part in the study. I describe those next.

According to the data from Paper VI, many of the students struggled with understanding how to use and manage the use of multiple DLEs during their courses. Some of them struggled with understanding what was communicated through DLEs, or where to find information belonging to one course. Some of the students were complaining that they did not get trained in using the DLEs provided once they started their studies. Other students had multiple roles, such as teaching assistants and students, at the same time. This gave them both opportunities to learn how to use these DLEs, but also struggles. Although the work of teaching assistants was supposed to be aimed at giving feedback through DLEs, some of them often encountered technical and language barriers in giving feedback to the other students by using DLEs. The student participants in our study argued that DLE design was limiting the richness of information that had to be transmitted by using the DLEs examination (Saplacan, Herstad, and Pajalic 2020). One of the student participants in the study explained how he, in his role as teaching assistant, had to physically meet students outside the DLEs to give the feedback because the DLEs were not sufficiently well designed to provide support for communicating information well. One of the participants, being a course instructor, supported this claim from the students' side and argued that DLEs used in the examination does not support the need to draw schemes and diagrams during a digital examination very well (Saplacan, Herstad, and Pajalic 2020).

In other words, the situations encountered by students when their abilities are lowered by the interaction with and use of DLEs are situations or, often, a combination of them, where the students as users encountered challenges in:

Situation 1: Finding course resources and how these are distributed across DLEs

Situation 2: Lack of training in using DLEs

Situation 3: Mediated human-human communication through DLEs

Situation 4: Technical and language barriers, such as the platforms not being fully translated into English, or is available only in Norwegian Bokmål or Nynorsk

Situation 5: The DLEs' lack of richness of information that can be transmitted through the digital platforms or tools in use, i.e., the human-human information transmitted is mostly textual, the systems lack functions for providing feedback in a multimodal way. This is especially challenging for students with dyslexia who have difficulties in reading and understanding text.

Situation 6: The experienced lack of or fragmented control over the digital systems, platforms, or tools. As one of the students taking part in the study said, "I am personified with my problem" (Participant, SDM) (Saplacan, Herstad, and Pajalic 2020, p. 95).

7.5.3 "If you try to build a mammoth, then everybody would want a different thing": Disagreements, practices, and dilemmas amongst course instructors or at different organizational layers (Paper V, Paper VI, and Paper VII)

In general, the findings in Papers V-VII show that there were some disagreements, different practices, and dilemmas amongst course instructors. While some of the course instructor participants argued for using a system that is "everything in one system," others were against this idea of having "one system doing it all." One participant said when asked about her opinion on having only one system: *"Absolutely, I do have a strong opinion on this in the sense that, that I don't really like the idea of building a mammoth, doing it all, because it is not really possible for a software to do it all, like discussion, and courses, and projects, and everything. If you try to build a mammoth, then everybody would want a different thing"*; by a "mammoth," she meant a one single system doing it all (Saplacan, Herstad, and Pajalic 2020, pp. 13-14).

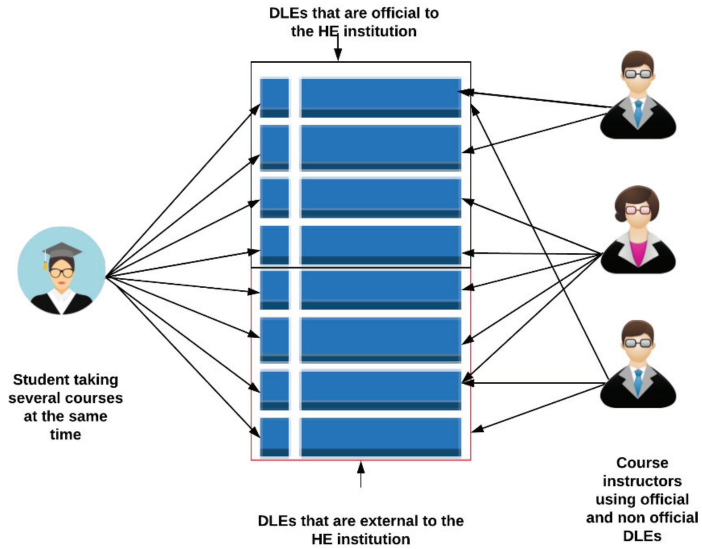


Figure 7-5 An illustrative representation of students' and course instructors' relations with Digital Learning Environments (DLE) (Saplacan, Herstad, and Pajalic 2020, p. 18)

In addition, it seemed that many of the course instructors did not have a common approach to what DLEs to use when. Such a common approach was not established either between different course instructors, at the organizational entity level, or at the institutional level. These decisions were often taken by individual course instructors themselves, rather than official agreements at the Higher Education institution or organizational entity level. This often created difficulties for the students.

For instance, one participant pointed out: "*So, it's very difficult for students to understand where to find the material, if all the material is there, and when it is uploaded and so on and so on. I see the problem not in using 20 tools, but in using 20 different tools to do the same job. So, it would be nice if we were using much fewer tools when it comes to content and holding, to chats, to whatever, and to, of course, project deliveries. I think it would be much easier for the students to have these tools of choices"* (Interview, participant) (Saplacan, Herstad, and Pajalic 2020, p. 15). Figure 7-5 gives an illustration of the relations between students, DLEs, and course instructors and DLEs, showing that a student, taking a course from several course instructors, was often asked by the course instructors to use several different DLEs. This often led the students to feel cognitively overwhelmed due to this multiple cross-use of DLEs, but also to more often encounter technical challenges or language barriers.

Further, some of our participants indicated that some students struggled with using these DLEs and did not know how to use them properly. One participant, for instance, stated that some of the students see DLEs as some sort of "dump place" where all the slides, course materials, and information is dumped (Saplacan 2020a, p. 277). According to her, the students did not see DLEs as tools or instruments to engage in their learning activities. She said: *"(...) for some of the students, they were not used to it, and they were not introduced to it in the way I would like to do it, it was just like a.., sort of a repository, like a 'dump place,' where all this information about the course, slides, whatever the material teachers wanted to use, it was kind of thrown into that, in an organized way - which is good. For them, this was not a discussion platform; it was not a place where they could express their views or interact with the materials where they would say: okay, I would want it in this way, or I would post my idea or view in an idea or knowledge in a discussion. They did not perceive technology as something that offers them the possibility to express, learn, engage, and be an active participant in this case in a learning activity. And I think it is an important function of the technology to provide a platform for those that either do not have a possibility or the attitude to do this face-to-face in plenary, for various reasons, or for those that are at a distance. So, this is an opportunity. I think it is a missed opportunity if we do not present it and use it as teachers, or those who introduce it in the right way"* (Participant, Interview) (Saplacan 2020a, pp. 278-279).

Moreover, some of our course instructor participants argued that many of the foreign- or exchange students did not know how to use DLEs – and this posed difficulties in their learning, although some of them were ambitious students. For instance, one of the course instructor participants said: *"It's often that the students, like the natives, they come to the University, first-year students and they know they will be using learning platform, digital learning platforms because most of them have used it in high school, or even in lower grades, while students coming from other parts of the world, don't have this ingrained experience, or simply the experience of using the technology in this way. And I think there is always a gap there that often creates difficulties for the other group, not because they are not good performers, or good learners, or interest or motivated, because they* *simply need, a different encounter- start encounter with technology"* (Participant, Interview) (Saplacan 2020a, p. 278).

Lastly, one of the course instructor participants specifically pointed out the lack of information visualization in different DLEs or across DLEs, supporting the students' arguments that only textual feedback or textual communication is often available in such digital systems. However, another participant disagreed with this view and argued that the majority of the students prefer textual communication, while only around 5% understand communication that is multimodal (Saplacan, Herstad, and Pajalic 2020).

To summarize the findings, these can be described in the following situations:

Situation 1: Disagreements amongst course instructors regarding the interaction with and use of DLEs: while some wish to have everything in one system, others wish to have dedicated systems for specific purposes; however, not more than one system should be used for the same purpose. This disagreement amongst course instructors and the choice of DLEs to be used in their courses contributes to lowering the students' abilities to interact with and use DLEs in their learning.

Situation 2: Some students with a foreign background do not have the same ingrained experience in interacting with and using DLEs; however, they might otherwise be good performers. This situation lowers their abilities in their learning.

Situation 3: Disagreements amongst course instructors and at a different organizational level regarding how the communication through DLEs should be: only textual, or multimodal, or which technical features the DLEs should include. This disagreement amongst course instructors and the topic of uni-modality or multimodality of DLEs to be used in their courses may contribute to lowering the students' abilities to interact with and use DLEs in their learning.

7.5.4 Fragmented information awareness from within and from without (Paper VI)

Along with the above-described findings from Case 2, the main theme of findings from Paper VI was that students and course instructors experienced fragmented information awareness. Fragmented information awareness happens in two situations:

Situation 1: either when there is too little information awareness about the interaction and use of DLEs and how these are experienced by the students; in this case, it occurs due to a lack of understanding of the context.

Situation 2: or when there is too much information awareness distributed across DLEs, then cognitive or mental overload takes place.

Paper VI concludes that fragmented information awareness occurs at different organizational levels: either from within or from without. Fragmented information awareness from within occurs when there is an incongruity in the system image views amongst students, course instructors, and others using the DLEs (Saplacan, Herstad, and Pajalic 2020). This is also supported by the arguments and examples of situations described in the previous sections based on the findings from Saplacan (2020a), Saplacan, Herstad, and Pajalic (2020), and Saplacan (2020b). Fragmented information awareness from without occurs when there is a lack of knowledge on the current laws and regulations concerning the design, interaction with, and use of DLEs in HE, such as for instance, the regulation regarding the Universal Design of ICT-solutions to be used in HE (Kommunal- og moderniseringsdepartementet 2017). Lack of knowledge on procedures and rules at an institutional level, with regard to Universal Design, may also lead to fragmented information awareness from without (Saplacan, Herstad, and Pajalic 2020). I talk more about this in the next sub-section.

7.5.5 Recommendations on the design, interaction, and use of multiple Digital Learning Environments in Higher Education (Paper VI)

In general, it seemed that the majority of the participants, including students and course instructors, had fragmented information awareness from without about the laws and regulations with regard to Universal Design in HE (Saplacan, Herstad, and Pajalic 2020). While some of them were more informed, the majority associated universal design with disabilities. Based on the findings above, Paper VI indicates a set of recommendations on how to counter-encounter fragmented information awareness from within and from without.

Table 7-4 Set of recommendations (Saplacan, Herstad, and Pajalic 2020, p. 105)

	Set of recommendations for the use of multiple DLE in HE
#	**Organizational recommendations for contributing to better awareness from without**
1	Systems should comply with existing laws and regulations at the national level.
2	No more than one DLE should be used for one purpose (e.g., publishing course material, submission, assessment, peer-review, supervision).
3	The use of multiple DLEs would benefit from agreements and rules set at a local level of the organization.
4	The DLEs used should comply with UD standards.
	Design recommendations for contributing to better awareness from within
5	The user should have the option of being notified through email when changes or updates are performed in any of the DLEs used.
6	Each DLE should follow a logical structure for the user.
7	A DLE dedicated to the examination of students should include tools for performing drawing, visuals, schemes, and diagrams.
8	DLEs should support the distribution of course material in several formats and be accessible for those who cannot attend the class physically. This should not be in contradiction with personal data (e.g., voice recording) concerns of the individual who publishes it.
9	DLEs should support human-mediated feedback, that is: personal, fit the person, or user receiving it, be careful (as opposed to involving careless feedback), clear (as opposed to vague), nuanced enough, and represented through multimodalities (textual, audio, video, schematics), however, without being cluttered. Multimodal representation of it is recommended, such that language barriers that allow for unfortunate interpretation is dismissed or, at least, decreased at some level.
10	DLEs should support relevant, concrete, specific, multimodal, and adjustable system feedback. Each DLE's system feedback should be available in all the official languages. The system feedback should empower the user.
11	The user should be in control. The design of DLEs should: support the adjustments of the current system, rather than building new systems; have low barriers for accessing and using the system; be designed *for* people; give control to the user over the system; be universally designed, and invite human feedback.

7.5.6 Design for all of Digital Learning Environments is not a design for situated abilities (Paper VII)

In the last phase of the study, we found that both students and teaching staff at various HE entities experienced a variation in the abilities of the students with regard to the everyday interaction with and use of DLEs. As one of the participants said, the Digital Learning Environments "*are not necessarily difficult, but complex*" to interact with and use in everyday life (Saplacan 2020b). The students encountering difficulties in interacting with the DLE were both new students, starting their studies, but also non-Norwegian students (Saplacan 2020b). One of the issues that was indicated by the course instructor participants was the embedded language barriers in the system. For instance, students could not change the language of the system without logging into some of the systems; the button for changing the language of the system was difficult to find; however, if the user succeeded in logging in and changing the language from Norwegian to English, Norwegian words popped-up. One of the course instructor participants explained: "*And we had a lot of international students. So, they also had this language barrier. Because not everything is in English. And you have to open; you have to log into [the old system] before you can choose that you want to have it in English. And with the last version we had in [the old system], it was difficult to find the button for choosing English too. And then you did choose English; not everything was translated. So you suddenly had Norwegian words popping-up*" (Saplacan 2020b, p. 10).

Another issue that was pointed out by the participants was the cultural and social dimension. One of the participants argued that Digital Learning Environments in Higher Education often do not take into account these dimensions in their design (Saplacan 2020b). Others explained how these digital systems are designed for the majority of users, but not for the exceptions, often introducing invisible social barriers for some of the users.

Furthermore, some participants clearly indicated that not only people medically diagnosed as disabled people encountered difficulties in their everyday interactions with and use of Digital Learning Environments. Amongst those mentioned were both foreign students with lower digital literacy, but also adult students and elderly who did not grow up with digital technologies. One of them said: "*Yeah, I can tell. It's not only people with disabilities that are frustrated, have frustrations about the access to ICT, or the amount of different things they have to go into (laughs)... and be logged onto and getting information everywhere from. So, it's a bit time-consuming. And that was not only problematic for the disabled, but also for other students. And the same with the hearing environment at university X, where there were a lot of frustrations about noise, in the overall areas, in the areas where they get together with people, and in the lecture rooms. It was difficult to hear the teachers: what they were saying. So, a lot of complaints about that - not only the hearing impaired students!"* (Saplacan 2020b, p. 12).

Finally, for illustrating these or similar situations, when people who are not necessary medically diagnosed with any kind of disabilities encounter difficulties in their everyday interaction and use of Digital Learning Environments, I have framed the concept of situated abilities. The concept is also an overall finding for this thesis, and therefore I chose to include more details about it in the next chapter.

Part III Putting things together

Situated abilities

- *How the concept of situated abilities emerged*
- *Overall thesis theme: the concept of situated abilities*
- *Examples*

Discussion

- *Re-visiting the research questions*
- *Phenomenology and situated abilities*
- *Situated abilities are seen from Universal Design, Human-Computer Interaction, Human-Robot Interaction, and Computer-Supported Cooperative Work perspectives*
- *Ethical implications on situated abilities stepping outside of design fields*

Conclusion

- *Summary and contributions*
- *Concluding remarks*
- *Suggestions for further work*

Chapter 8 SITUATED ABILITIES

" You cannot teach a man anything; you can only help him discover it in himself."-

— Galileo Galilei (1564-1642)

This chapter presents the overall theme and the concept which emerged from the two cases included in this thesis, namely the idea of situated abilities. The chapter answers the second research question, RQ2.

In the introduction of this thesis, I explained its design and structure (Ch. 1, section 1.7). The original Figure 1 illustrating the design of the thesis is included again here in order to enable a discussion about the process by which the concept of situated abilities was formed. However, this time, in addition to presenting the overall structure of the thesis, more details are given to illustrate the process by which the concept of situated abilities was reached. A summary is given of how the concept started and evolved, but the key findings from each of the cases that support it are also included.

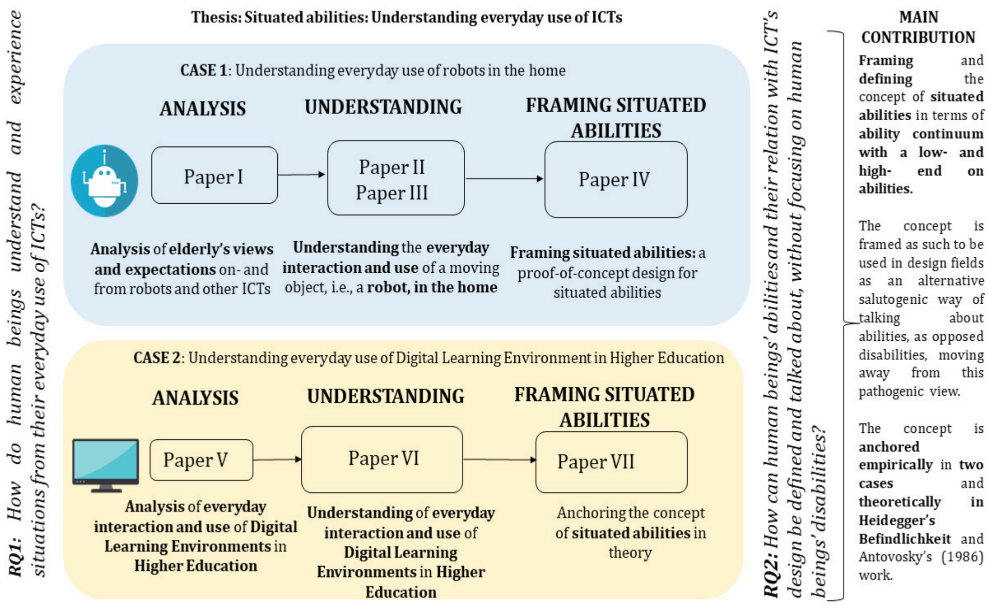


Figure 8-1 Thesis design – overview - the same figure as in Figure 1-1

8.1 How the concept of situated ability emerged: the process

Data collection and analysis for Case 1 were the starting point for the thesis. Thereafter, data collection and analysis for Case 2 were undertaken around 12-18 months later than Case 1. During this time, the literature on Universal Design, laws, and regulations was researched. However, there were certain challenges encountered in integrating directly with a Universal Design-debate concerning robots in the home, when the available literature on Universal Design discussed WCAG web accessibility guidelines and standards, while many of the previous studies focused mainly on quantitative ways of testing the accessibility of websites. These web-interfaces were often tested in the form of user tests. This literature was often related to the physical disabilities of the users, such as designing for blind or deaf users. Literature on Universal Design concerning robots was eventually identified, but it was talked about very much in terms of ergonomics (see Matsuhira et al. 2009; 2008).

Additionally, when I mentioned Universal Design as part of my research in different contexts, I was often challenged with questions such as: '*Do you work with people with disabilities?*' I was, at times, frustrated about this question. I did not wish to focus on categorizing individuals as people with disabilities and people with abilities when talking about Universal Design. I asked myself, at times, whether I necessarily needed to talk about disabilities when discussing Universal Design when the definition of Universal Design refers to designing services and products so that as many people as possible can use them.

Thus, with this definition of Universal Design in mind, I wished to talk about it in terms of people who were not medically diagnosed as disabled; I was interested in Universal Design and the experiences of abled people. Demonstrating that even people without any known medically diagnosed disabilities may encounter challenges in their everyday interaction with and use of ICTs was a key foundation of my research. This view, as I mentioned in earlier chapters, does not reject, ignore, or dis-acknowledge, in any way, all the work on Universal Design and people with disabilities that others have carried out so far, or that they will carry out in the future. Instead, it supports their contributions to design and to the social development of how we think, talk about, work with, or design for abilities. However, my perspective tries rather to propose an alternative way of talking, thinking, discussing, and designing in the area of Universal Design.

However, before being able to talk about Universal Design in relation to robots, without focusing on the ergonomics of the robots, I had to study the previous and current debates in the Universal Design literature on the desktop metaphor, specifically, the web. Thus, Case 1 aimed to explore the challenges of everyday interactions with and use of DLEs, as experienced by students and course instructors. Below is a description of how the concept emerged from Case 1, and thereafter from Case 2.

8.1.1 How the concept emerged from Case 1

[22]Initially, during Case 1, in the analysis phase, specifically in Paper I, I came across the work of Antonovsky (1996), on the recommendation of my external supervisor. I found Antonovsky's (1996) work very interesting, as he framed the term salutogenesis, as opposed to pathogenesis. His alternative way of seeing dis-ease (note that I use his way of writing the term *disease*) was different. He did not focus on what is wrong with the individual, but rather what is wrong with the context he finds himself within, and what is wrong with the situation that creates difficulties for the individual. He viewed salutogenesis as a health promoter and as a foundation for his later work on the Sense-of-Coherence (SOC) theoretical construct (Super et al. 2016). He defined an individual's SOC as: "a global orientation that expresses the extent to which one has a pervasive, enduring though dynamic feeling of confidence that (1) the stimuli, deriving from one's internal and external environments in the course of living are structured, predictable and explicable; (2) the resources are available to one to meet the demands posed by these stimuli; and (3) these demands are challenges, worthy of investment and engagement" (Antonovsky, 1987, p. 19 in Super et al. 2016). He explained that the theoretical construct includes three elements: comprehensibility, manageability, and meaningfulness. Comprehensibility refers to the motivation that lies behind the challenge and makes the individual able to cope with the situation at hand (Benz et al. 2014). Manageability refers to the individual's available resources for coping with the situation at hand (Benz et al. 2014). Meaningfulness refers to the individual's understanding of the challenge he has to cope with (Benz et al. 2014).

However, many of the studies based on Antonovsky's (1996) theoretical construct of SOC are mainly quantitative, with only a few using a qualitative methodology (Super et al. 2016). In spite of this limitation, I found similar studies that promoted the same idea. One such example is the study by Svenaeus (2013), in which the author adopts the idea of "being-in-the-world" from Heidegger in order to present modern technologies. He argues that our perspective on the world can be made visible through medical technologies (Svenaeus 2013). Robots acting as safety-alarm robots, in line with the MECS project's main aim, could be considered medical technologies.

Thus, I borrowed Antonovsky's (1996) theoretical construct and the elements of comprehensibility, manageability, and meaningfulness to study robots from the perspective of elderly people and in the context of their expectations of everyday interactions wit and use with ICTs, and specifically, with robots in the home (Saplacan, Herstad, and Pajalic 2020). The reason for borrowing and repurposing this concept when talking about everyday interaction with and use of robots in the home was that the robots to be designed for the elderly, i.e., a safety alarm robot, in line with the MECS project goal, had to be designed to comfort the senior participants, moving away from the idea of monitoring senior users. In other words, I argued that a salutogenic approach should be adopted, i.e., the elderly should be able to interact with and use the robots, rather than adopting a

[22] Text adapted from Saplacan, Herstad, and Pajalic (2020)

pathogenic approach, which may leave them feeling as if they were being monitored and surveilled. Such a salutogenic view helped me see that the elderly did not wish to have monitoring robots, but they were interested in servant robots. This initial understanding was essential for the later work carried out as part of Case 1, but also for my work in Case 2. For instance, throughout the work carried out in Case 1, several key findings emerged. These are summarized in Table 8-.1. These are compressed in terms of manageability, comprehensibility, and meaningfulness, abilities, and situatedness – the core elements of situated abilities.

Table 8-1 Key findings from Case 1

#	Key findings	Key elements
1	The senior participants wished for **servant robots** rather than monitoring robots.	Meaningfulness of the robot
2	**Functionality** was more important than appearance. However, the appearance was important for the female participants.	Manageability of the robot, abilities
3	The senior participants wanted, if they were to have a robot in their homes, to be able to interact with the robot through **speech.**	Comprehensibility, abilities to understand the interaction
4	The robot should be **small in size** due to their apartments' limited space.	Situatedness
5	When we introduced familiar robots into the participants' homes, many of the participants, both elderly and non-elderly participants, encountered two main situations in their everyday interactions with the robot: **1) The robot either lacked feedback; thus, the interaction was faulty, or** **2) The robot gave improper feedback.** The senior participants experienced the same types of situations, even in their interactions with non-moving ICTs.	Lack of Manageability, comprehensibility, and meaningfulness of the robot, low human abilities to understand how to interact with the robot as a result of its feedback
6	It was **difficult** for the **senior users to use a mobile app** to control the robot: only one of the senior participants opted for this alternative.	Lack of manageability, comprehensibility of the app, low human abilities
7	All the senior participants received support from the MECS researchers (including myself) **to install the robot** in their homes.	Lack of manageability to install the robot, and low human abilities
8	Many of the **non-elderly participants** chose to **use the mobile app to control the robot**. However, they still **encountered difficulties**, especially when using the mobile app to control it remotely.	Manageability and comprehensibility of the mobile app, human abilities

9	Both **English and the technical language** used in the design of devices to give informative feedback to the users was challenging for many of the participants in the study. The senior participants complained both about the English as the language of the device and the mobile app, but also about the technical language used, such as: "It cannot connect to the *cloud services*" or "*Please clear my path (2000) and a red cross*" (Paper II). The non-elderly participants complained about the technical language used when displaying technical errors.	Lack of comprehensibility, meaningfulness, and manageability of the robots' language, human abilities to understand the digital technology's language
10	The **robot movement triggered different feelings** in the participants, both positive and negative, such as the feeling of stress and annoyance.	Situatedness triggers feelings, human abilities
11	The **participants had to carry out different types of work tasks** when carrying out the joint work activity of cleaning together with the robot. Amongst the work tasks types that came along with the automation of the work activity were: • **Residual tasks,** such as the human needed to clean some of the areas which the robot did not reach; • **Redundant tasks,** such as starting the robot either through the smartphone app or through pushing the robot start button itself; • **Tasks within the automation,** such as the robot gave audio or visual feedback to the human, which the human, at times, did not understand how to translate; • **Tasks outside the automation,** such as moving around the robot from one place to another, or removing obstacles from the robot's navigation path; tasks generated with the automation, such as charging the robot, moving the robot when the robot "escaped the place."	Lack of manageability, comprehensibility, and meaningfulness of the work tasks, the situatedness of the work tasks, human abilities to deal with different work tasks
12	The **human and the robot had to carry out certain tasks in a shared way or distributed in time and space**. For instance, they sometimes needed to carry out tasks sequentially or in parallel, as well as distributed in time or at the same time. This also created a different situation for the human being and her interaction with the robot.	Lack of manageability, comprehensibility, and meaningfulness of the work tasks, the situatedness of the robot and the human being, human abilities to deal with different work tasks

Based on the key findings above, in the last phase of Case 1, I explored the idea of situated abilities through a proof-of-concept design of a robotic table, the T-ABLE, as described earlier in Ch. 6 (Section 6.5.6) and Paper IV (Saplacan, Herstad, and Schulz, *forthcoming*). This design, with the wooden look of the robotic table, seemed appropriate for the senior users, as they were more familiar with tables in the home rather than robots. They knew how to use a table. However, they encountered challenges in interacting with a robot, even if the robot was a vacuum cleaner robot, and they were familiar with these types of robots from watching TV.

If we look back at the SOC presented earlier by Antonovsky (1996), and the salutogenic elements of the theoretical construct relating to comprehensibility, manageability, and meaningfulness, a table fulfills the requirements for these elements. The T-ABLE is comprehensible for the senior users, i.e., they understand its function. The T-ABLE is manageable for the senior users, i.e., they understand how to use it. The T-ABLE is meaningful for the senior users because they understand its familiar design being a table, how to cope with the challenge at hand, such as placing an item on the table or moving a table around. The novelty element of the robotic wooden T-ABLE design was that the table was able to move around by itself but was controlled by the user. In this way, the senior users had to deal with learning new skills in terms of how to interact with the table, within their zone of proximal development (see Vygotsky 1978). The T-ABLE was also small in size, a requirement identified earlier by the senior participants, in order for an item to fit into their space. Further, the T-ABLE proof-of-concept for designing for situated abilities seems to be an appropriate design for senior users or other users who are not used to interacting with moving things in their homes, i.e., robots. Moreover, a robot designed with the look of a table in wood seems to better integrate into the users' homes, given that it looks like furniture, rather than looking like a robot with a zoomorphic or anthropomorphic look. As the literature shows, zoomorphic and anthropomorphic robot looks may be appropriate for certain aims. For instance, PARO, a robot with a zoomorphic look, which looks like a seal, (see Shibata et al. 2004; Wada and Shibata 2007; McGlynn et al. 2017), may be appropriate for users suffering from Alzheimer. Other robots with an anthropomorphic look, such as NAO and Pepper, may be of interest in studies with children with Autism Spectrum Disorder diagnoses, in order to help to train their social skills. Sophia, the robot, also has an anthropomorphic look, along with other humanoid robots, or geminoids, such as those created by Hiroshi Ishiguro and his robotics lab: Geminoid HI-2, a copy of himself, Geminoid F, Geminoid DK, Erica, Telenoid, Elfoid, Geminoid HI-4, Geminoid HI-5, Otonaroid, or Kodomoroid. However, these robots with a zoomorphic or anthropomorphic look often provoke uncanny valley challenges (Mori 2012).

Thus, the T-ABLE did not have any zoomorphic or anthropomorphic look, but it was rather designed to look like a piece of furniture. The situation explored through its design was one of a robot fitting in the home of the users. Hence, its design was built on the idea of users' abilities, thus enabling them to use it through its inherently table look design. Finally, this proof-of-concept design proposed a designing for situated abilities in the last paper of Case 1, namely Paper IV (Saplacan, Herstad, and Schulz, *forthcoming*).

8.1.2 How the concept emerged from Case 2

Having knowledge of the SOC theoretical construct from Case 1, challenged me to find alternative ways to think about how we can talk about Universal Design from a salutogenic perspective. *How could I emphasize the abilities of people without focusing on the dichotomy of abilities vs. disabilities?* My point of departure was that by trying to understand the individuals' everyday interaction with and use of ICTs, in different situations, their everyday experiences, without focusing specifically on people medically diagnosed as disabled, it would be easier to talk about Universal Design without focusing on disabilities. Another argument for this perspective was that if "abled" people encounter challenges in their everyday interaction with and use of ICTs, these challenges are even greater for people medically diagnosed as disabled. Thus, since the debates around Universal Design and robots were limited to ergonomics, Case 2 provided the opportunity to explore the everyday interaction with and use of web interfaces through an analysis of the experiences and situations experienced by students and course instructors when using Digital Learning Environments.

However, as discussed earlier, many studies have already explored everyday interaction with and use of individual Learning Management Systems (LMS) (see Coates, James, and Baldwin, 2005; S. Graf, 2007; Lonn and Teasley, 2009; Machado and Tao, 2007). These types of studies are especially popular in Education Studies. I could perhaps have investigated one such LMS and identified everything about how it was *not* universally designed. However, I did not do this, mainly because it was outside of my area of interest. I did not wish to test such a platform and whether or not the platform complied with the WCAG accessibility guidelines. I could see the benefits of such a study could have been limited to that specific LMS and its users. I wished, instead, to investigate and understand human experiences from the perspective of a user who is required to navigate, understand, retrieve information, and use multiple such systems. Accordingly, I defined Digital Learning Environments as "digital platforms, websites or specific webpages used by course instructors and students in a course for exchanging information or knowledge, relevant for their learning, respectively teaching, within the frame of the course. In a course, a course instructor can use one or more such DLEs: for instance, the course instructor can use both a dedicated Learning Management System (LMS), the email system, the HE website, and a social media platform or channel dedicated to the course. Each of these is considered individually as a DLE when they are used for teaching/learning" (Saplacan 2020a, p. 272). Thus, I focused on channeling my attention towards individuals' experiences of everyday interactions with and use of DLEs.

Moreover, having Antonovsky's (1996) theoretical construct of SOC in mind, I focused on whether or not the everyday experience of interacting with and using these DLEs is comprehensible, manageable, and meaningful for the individuals using those, namely students and course instructors. Acquiring this understanding was essential for being able to discuss Universal Design in terms of abilities. Thus, the key findings from Case 2 are illustrated in Table 8-2. These are compressed and expressed in terms of manageability, comprehensibility, and meaningfulness, abilities, and situatedness – the core elements of situated abilities.

Table 8-2 Key findings from Case 2

#	Key findings	Key elements
1	The **majority of the DLEs used in HE were non-official systems** for the HE institution.	Meaningfulness of using the DLE, situatedness
2	There was **no consensus amongst the course instructors of a specific HE entity regarding the choice of DLEs for teaching/learning.**	Lack of comprehensibility, situatedness, manageability
3	Many of the DLEs chosen for teaching/learning in HE were the choice of the course instructors, and sometimes of the students themselves.	Choice of DLE based on situatedness and abilities
4	DLEs used by single users, either course instructors or students, can be structured into an individual regionalization of information spaces formed by DLEs. This also means that: • The course instructors had different constellations of the DLEs used for specific courses. • The students had to adjust their use of DLEs based on the course studied. • Having different course instructors in different courses could mean that the **students were required to use, for every course, several new DLEs** to be able to follow the course.	Choice of DLEs based on situatedness, human abilities, comprehensibility, manageability to interact with- and use DLEs
5	**Articulation work** had to be **carried out by both students and course instructors** to be able to retrieve information or course material related to one or several courses, or to communicate with other course members, including other students, teaching assistants, or the course responsible.	Human manageability and comprehensibility to interact and use DLEs, abilities, situatedness
6	Students experienced **language barriers in the systems** used due **to two official languages (Norwegian Bokmål and Norwegian Nynorsk).** Some of the systems were not available in both languages.	Human ability, lack of language manageability and comprehensibility
7	Students experienced **fragmented control** in their interaction with various DLEs: • They did **not** have **the opportunity to report or correct issues** that occurred in the system when they occurred. • The students often felt **powerless** in the context of the system due to their faulty design.	Lack of humans ability to control, manageability, comprehensibility, meaningfulness, human situatedness

8	Everyday interactions with and use of DLEs often triggered **strong (negative) emotions**, or emotions of frustration when systems often broke down, as one of the participants indicated: "I am personified with my problem." (Paper VI)	Humans emotions depending on the abilities to interact with DLE
9	**Using DLEs creates fragmented information awareness.** • The students experienced a fragmented understanding of the mediated feedback through DLEs because the DLEs supported mostly textual communication. • There is a need to create DLEs that allow the users to communicate in a rich and nuanced way, including visuals and drawing, not only text.	Lack of manageability, comprehensibility, and meaningfulness of DLEs
10	**Students and course instructors have a fragmented awareness of UD** in terms of DLEs in HE.	Lack of comprehensibility of DLEs and their content, humans ability
11	The **distribution of course materials in DLEs was fragmented across multiple DLEs**. Sometimes **multiple DLEs were used for the same aim**.	Lack of manageability, comprehensibility, meaningfulness of DLEs, humans abilities
12	**Fragmented information awareness** results from a **lack of orderliness from within or from without.**	Lack of comprehensibility of fragmented information awareness
13	There is an **increased workload** on the user due to **the use of multiple DLEs**.	Lack of manageability of DLEs, situatedness, ability to cope with it
14	The **design of DLEs are for the majority of users, but not for the exceptions.**	Lack of manageability and comprehensibility on how to interact- and use DLEs, humans abilities
15	The **cultural and social dimensions** of the DLE users can **lay the foundation for a variation in the ability to interact with and use DLEs.**	Humans abilities and situatedness
16	The everyday interaction with and use of DLEs **also depend on the users' situation at hand.**	The abilities of human beings depend on their situatedness

Based on these key findings, from Case 2, I have explored the idea of situated abilities. The idea of situated abilities was formed in the last paper of Case 2 (Paper VII). This concept is also foregrounded in this thesis.

8.2 Overall thesis theme: the concept of situated abilities

Based on the key findings from Case 1 and Case 2, several common findings were inductively elevated:

1) Both cases involve empirical data based on the lived experiences of the participants.

2) The majority of the participants, although they were not medically diagnosed with any kind of cognitive disabilities, encountered challenges in interacting with ICTs, both with the robots and in DLEs.

3) The participants encountered challenging situations in their everyday interactions with and use of ICTs.

4) The participants' abilities in their everyday interactions with and use of ICTs depended on the design of the ICTs and the situations at hand.

5) Although the participants were abled in general in their everyday lives, they found themselves less abled in certain given situations when interacting with and using ICTs.

6) Many of the participants were often not able to comprehend how to interact with and use the ICTs due to the design of those and their situated abilities.

7) Many of the participants were often not able to manage their interactions with and use of the ICTs, due to their design and their own situated abilities.

8) Finally, many of the participants found that the everyday interactions and use were not meaningful, at times even frustrating, when the design of the interaction with ICTs was neither suitable nor enabling for them in certain situations, but instead, rather faulty.

Given these overall common findings from Case 1 and Case 2, the theme and concept that emerged from these findings can be summed up as *situated abilities.* Figure 8-2 shows a Venn diagram of the two cases and their overall common findings.

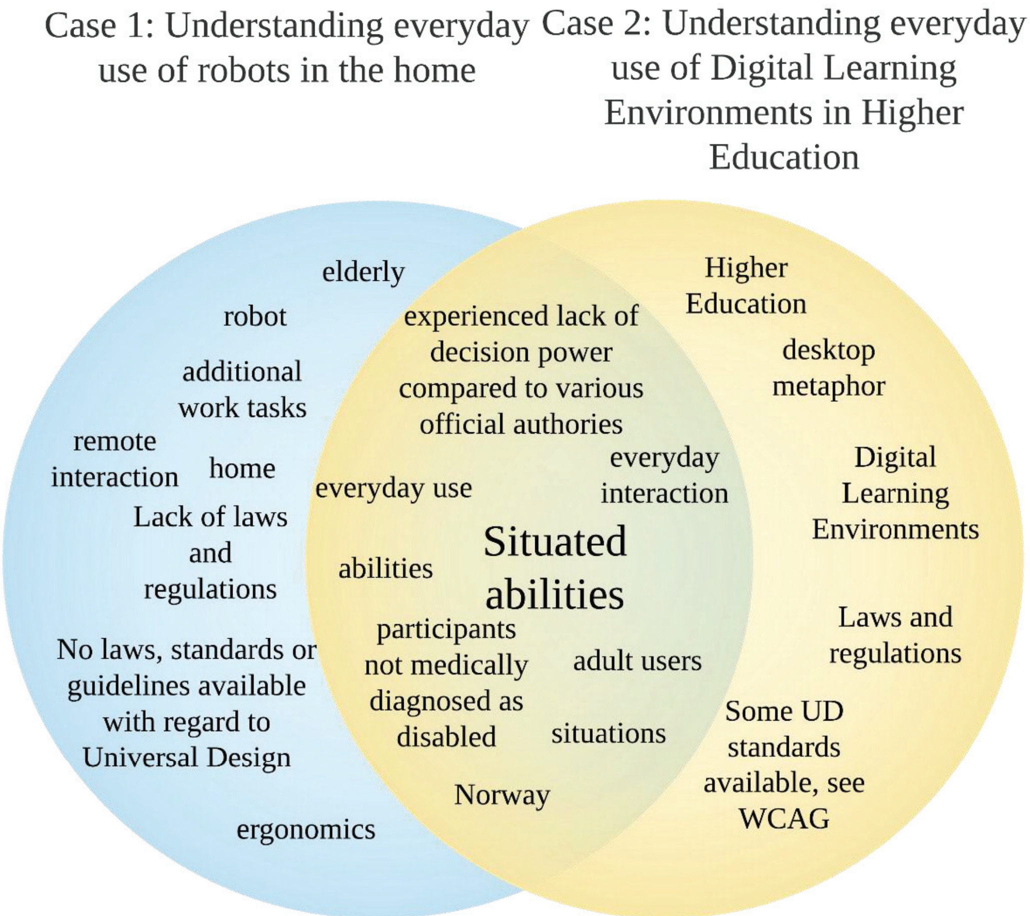


Figure 8-2 Venn diagram on the overall common findings from Case 1 and Case 2

In the next subsection, I define and explain the anatomy of the concept and its continuum.

8.3 Situated ability: its definition and anatomy

The definition of situated abilities evolved from my initial reading of Antonovsky (1996) in line with elements of his Sense-Of-Coherence theoretical construct, referring to the ability of an individual to relate to his or her comprehension, manageability, and meaningfulness of a situation, and from the cases included in this thesis. The following definition is based on my earlier work (Saplacan 2020b, p. 9):

> **Situated ability refers to the ability to comprehend, manage, and find the meaning in the everyday interaction with and use of digital technology or system.**

Thus, the anatomy of situated abilities is composed of three elements: how comprehensible is the design of an ICT in a given situation for the individual, how manageable is the design of an ICT in a given situation for the individual, and how meaningful is the design of an ICT in a given situation for the individual.

To this anatomy of situated abilities, we can also add a situated ability continuum. Situated abilities, as opposed to the dichotomic ability-disability perspective, can be understood in the form of a continuum, namely the situated ability continuum. The situated ability continuum is based on the human being's ability to move along the continuum to a lower ability or a higher ability. A situated ability experienced by the human being when they are "more abled" can be placed on the high-end of the ability continuum. This means that the individual has high comprehensibility, manageability, and meaningfulness of the lived situation in his or her everyday interaction with and use of ICTs. A situated ability experienced by the human being when they are "less abled" can be placed on the low-end of the ability continuum. This means that the individual has low comprehensibility, manageability, and meaningfulness of the lived situation in his or her everyday interactions with and use of ICTs. Figure 8-3 visualizes this ability continuum for the concept of situated abilities.

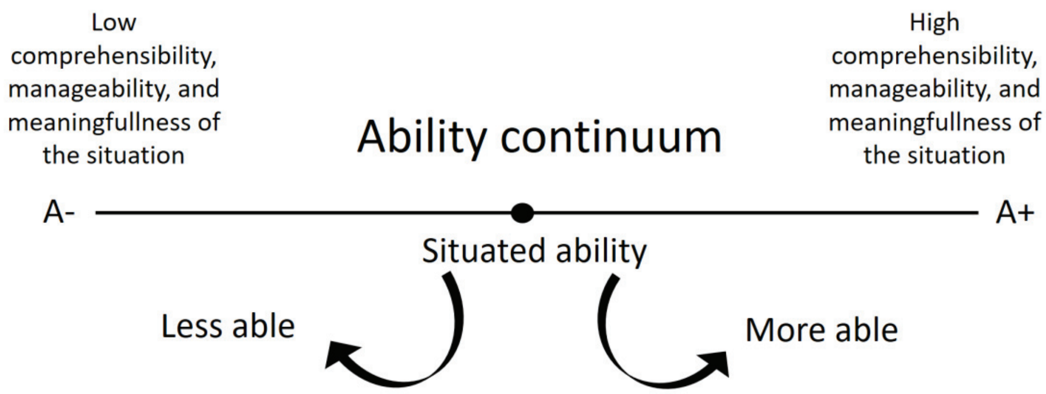


Figure 8-3 The ability continuum (Saplacan 2020b, p. 13)

8.3.1 Some dimensions for designing for situated abilities

This section presents some identified dimensions of situated abilities. These were earlier described in Paper IV (Saplacan, Herstad, and Schulz, forthcoming) and exemplified through the T-ABLE wooden robotic table presented in the paper.

1) A social dimension of designing for a human's situated abilities can be described as a situation when the user can place the technology within his understanding of the environment surrounding him. In other words, the social dimension refers to the fact that the environment must be corrected because it disables and oppresses the individual (Lid 2013; 2014).

2) A relational dimension is inherited from the Scandinavian or GAP models (Lid 2013), models that resist the categorization of humans between abled and disabled individuals, acknowledging human diversity and individual experiences (Lid 2013). This relational dimension for designing for a human's situated abilities refers to when the user can relate to the design of the technology through its embedded familiar elements. It focuses on the relationship between the human and the environment.

3) A socio-relational dimension of designing for humans' situated abilities refers to when the user sees the technology as a habituated object. This dimension assumes that the abilities are theorized, subscribing to the socio-relational model. This dimension indicates both a social and a relational dimension, namely that the abilities are experienced by the individual as an embodied experience in the environment the individual is part of.

4) An empowering dimension of designing for humans' situated abilities refers to when the user feels in control of his or her abilities to interact with the technology: the empowering dimension focuses on the abilities of the individual by empowering the individual through the design of technology. This dimension subscribes to the UD empowering model that trusts each individual's autonomy, decision-making power, and control, and the professionals are regarded only as advisors rather than experts (Begnum 2016b). The model regards the individual as the expert on his own body (Begnum 2016b).

8.4 Examples of situations when situated abilities occur

Paper VII illustrated a couple of examples of situated abilities, which are included here to clarify the concept, its anatomy, its continuum, and dimensions. These examples are based on those earlier illustrated in Saplacan (2020b, p. 13-15).

Example 1: A senior adult is asked to find a physical book and read from it. The old adult knows how to find a physical book, to open it and to read it. This is a situation where the senior adult shows comprehension of the situation, manages the situation, and the steps he/she follows make sense for him/her, i.e., it is meaningful for the individual. This situation illustrates situated ability on the high end of the ability continuum. A contrasting example of a situation where a senior adult is on the low end of the ability continuum is when the individual is asked to find an e-book in an online library system, borrow it online and read from it. The old adult will perhaps comprehend the task in a semantic or linguistic sense. However, the old adult, especially if he does not have any previous experience with such a task, will more like not comprehend what steps to take, or manage it without assistance. Therefore, the task will not be meaningful for the old individual. This is an example of an individual having a situated ability on the low end of the ability continuum.

Example 2: A blind person is asked to find and read a physical book. The blind person will perhaps manage to find the physical book and to open it at a random page. However, the blind person will not be able to read the book. The person will comprehend the task and will partially manage the task, i.e., by finding a book. However, the task is not meaningful for the person considering his/her situated ability. If we look at this situation, from a situated ability continuum perspective, we can say that the individual has a situated ability on the very low end of the ability continuum. A contrasting situation to this is when a blind person is asked to find an e-book on an online e-book reader on his/her smartphone and listen to it at a very low volume. The individual will be able to navigate through his/her smartphone, find the right e-book reader application using some form of voice command inputs, and listening carefully to the very fast-speaking smartphone audio output. The individual will be able to comprehend the task, to manage the task, and also find it meaningful. The individual will more likely even manage to perform the task in quite a short amount of time, compared to someone who is not blind and has never performed such a task. This shows that the blind person, in the given situation, has his/her situated ability on a very high end of the ability continuum.

Example 3: One example on the low end on situated abilities is when an international student newly arrived in a new country is asked to use an online digital system that has the country's official language as the default language and the language cannot be changed unless the user is logged in. Moreover, the official language is not English. The student can speak English, but he/she has not yet learned the language of his/her new country. The individual will find him/herself on a lower ability continuum, given the circumstances, compared to a native-speaking student. He/she will comprehend the task to navigate the online digital system, will manage the task, and it will become meaningful, however it will be characterized by small challenges on the way, because of the language barrier. This is an example of a low situated ability on the ability continuum. After a while, the student will perhaps learn the language, and the online system, and then he/she will not have the same challenges with navigating the system. In this case, the individual will comprehend the language better, will be able to manage the tasks better, and it will be more meaningful for him/her to navigate the online system. Consequently, his/her situated ability has moved from a lower end on the ability continuum to a higher end on the ability continuum.

8.5 Why situated abilities?

There are several reasons why I argue that choosing the perspective of situated abilities, rather than simply abilities, is both interesting, relevant, and timely.

First, framing the overall theme within the concept of situated abilities allows us to think and discuss the abilities of people that may be lower or higher, depending on the situation at hand. This helps us also in terms of shifting our perspective from disabilities to abilities. If we choose to talk only about abilities, but not about situated abilities, we may risk entering the ability-disability debate. This runs the risk of shifting the focus from the importance of the situations and how fully-abled people may experience lower abilities in certain situations in their everyday interactions with and use of ICTs, to disabilities.

Moreover, the experienced abilities represent the first-person experience, and these are indeed situational: human beings that are fully able may experience themselves as less abled in certain situations, an assertion which is backed up by, for example, Lid (2014). We cannot separate the experience of a human being from a situation. The human being will always find himself or herself in a situation, in line with Heidegger's description of *Dasein* and "being-in-the-world" and *Befindlichkeit*, as *Dasein*'s situatedness, or attunement to a situation.

In addition, we are all only "temporarily abled" throughout our lives (Kittay 2011, p. 19). For instance, Kittay (2011) argues that human beings form dependencies relationships with others at various stages in their lives, where they may depend more or less on others. She argues that being less abled is an inherent characteristic of humans (Kittay 2011). She states: "From this perspective, we reason that our societies should be structured to accommodate inevitable dependency within a dignified, flourishing life – both for the cared for and for the carer. Finally, if we see ourselves as always selves-in-relation, we understand that our sense of well-being is tied to the adequate care and well-being of another. Caregiving work is the realization of this conception of self, both when we give care generously and when we receive it graciously" (Kittay 2011, p. 54). Her argument of seeing ourselves in relation to others and other things is both interesting and relevant for this work: we design not only for ourselves, but also for others.

Finally, this salutogenic approach to talking about, thinking, discussing, and designing for abilities is opposed to the pathogenic view, where we focus on the disabilities of individuals. The concept of situated abilities is intended to support us as a conceptual tool for enabling us towards a salutogenic way of thinking, talking, and discussing human beings' abilities, and their everyday interactions with and use of digital technologies. This way of talking about how human beings relate to everyday interactions with and the use of digital technologies would not be possible if we did not focus on human experiences or anchor the approach in the phenomenological work of Heidegger. Since his work, and especially the concept of *Befindlichkeit*, is essential to the overall theme of this thesis of situated abilities, this connection between *Befindlichkeit* and situated abilities is discussed in greater detail in the following chapter, Ch. 10.

Chapter 9 DISCUSSION

"There must be a way of promoting human values without involving religion, based on common sense, experience, and recent scientific findings."

— Dalai Lama (1935-)

This chapter reflects on and discusses the elements of the research and how they fit together, by re-visiting the initial research questions, looking back at the data collected and the theme which has emerged from the two cases included in this thesis, namely that of situated ability. The chapter also reflects on how the research questions were answered. Moreover, in this chapter, the situated abilities concept is explored through the lenses of phenomenology and Heidegger's *Befindlichkeit*, but also in the context of the concept of available models in Universal Design, and the perspectives of other design fields, namely HCI, HRI, and CSCW. Before ending the chapter, the implications of the concept of situated abilities for design, and its implications stepping outside of the design fields are explored; for example, as seen through the lenses of current laws and regulations, and ethical values, issues which the concept inherently brings to the fore are considered.

9.1 Elements of the research

Elements in research can be represented through different models. However, models do not represent the complexity of the research but can contain elements which are related to one another, and which help to structure the complex reality (Holter and Kalleberg 1996). One simplified model representing the complex reality of research is the model from Holter and Kalleberg (1996), containing the following elements: research questions, data material, analytical categories (or concepts), and answers. Different elements of the research structure need to fit each other and form a coherent perspective on the final research. The model is represented in Figure 9-1.

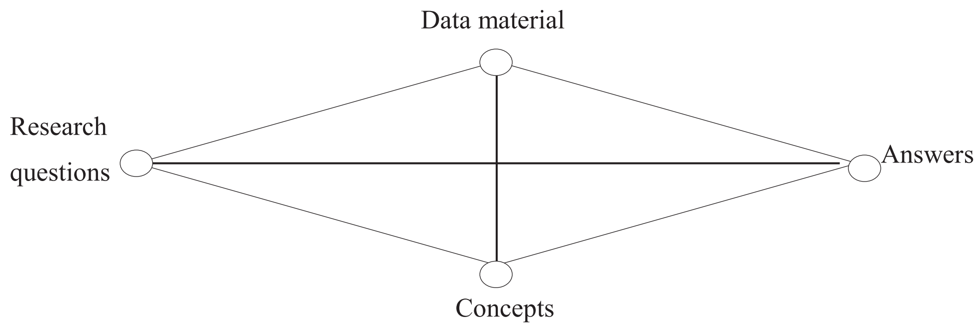


Figure 9-1 Elements in a research structure (Kalleberg 1992, p. 16; Holter and Kalleberg 1996, p. 33)

The model shown in Figure 9-1 was followed, in the next section, in order to explain how the research questions were initially addressed and how they hang together in the context of the data material, concepts used, and finally, how these were answered.

9.2 Revisiting the research questions: how these were answered

This thesis began by addressing the initial research questions:

> ***RQ1:*** *How do human beings understand and experience situations from their everyday use of ICTs?*

> ***RQ2:*** *How can human beings' abilities and their relation with ICT's design be defined and talked about without focusing on human beings' disabilities?*

While the first research question was a descriptive one, about understanding everyday interactions with and use of ICTs, the second research question was formulated as a descriptive philosophical research question, which was inherently critical and constructive, and intended to explore alternative ways of talking about designing for human abilities and human beings' relationships with digital technology. Below is a description of how each of the research questions was answered.

9.2.1 How RQ1 was answered

The first research question was answered through the papers included in this thesis as part of Case 1 and Case 2, whereas the second research question was partially answered through some of the papers included in Case 1 (Paper I, Paper IV) and Case 2 (Paper VII), and particularly answered in the rest of the thesis.

Further, the first research question was mainly answered through the empirical studies, Case 1 and Case 2. The second research question was answered through instrumental use of these two studies, Case 1 and Case 2, in the form of an instrumental collective case study, as explained in the Paradigm, Methodology, and Methods chapter. As described in that chapter, qualitative methods were used to collect the data material and analyze it. The main data collection method was interview, whereas the main data analysis unit was everyday situations experienced by the participants in their interactions with and use of ICTs, e.g., domestic robots and DLEs. However, the research was also documented through a number of other qualitative methods, as explained in the Paradigm, Methodology, and Methods – Chapter 5.

In addition, it was argued that design fields are interdisciplinary in themselves. Further, it was asserted that we need methodological pluralism and interdisciplinarity, along the lines of

Walsham (2012). Thus, Case 1 and Case 2 were strategically chosen as representative cases for our everyday interactions with and use of digital technology or "things" that move in our homes, such as robots, and digital technologies were used to represent the desktop metaphor, such as Digital Learning Environments. The contexts for each of these cases were presented in Ch. 1, whereas the specific background, study design, concepts, methods, a summary of papers, and detailed findings for each case were presented in dedicated chapters, Ch. 6 and Ch. 7 respectively.

9.2.2 How RQ2 was answered

The compressed key findings (answers) to the first research question were presented in Ch. 8. These were:

1) Both cases involve empirical data based on the lived experiences of the participants.

2) The majority of the participants, although they were not medically diagnosed with any kind of cognitive disabilities, encountered challenges in interacting with ICTs, both with the robots and with Digital Learning Environments.

3) The participants encountered challenging situations in their everyday interactions with and use of ICTs.

4) The participants' abilities in their everyday interactions with and use of ICTs depended on the design of the ICTs and the situations at hand.

5) Although the participants were abled, in general, in their everyday lives, they found themselves less abled in certain given situations when interacting with and using ICTs.

6) Many of the participants were often not able to comprehend how to interact with and use the ICTs due to their design and their own situated abilities.

7) Many of the participants were often not able to manage their interactions with and use of the ICTs, due to their design and their own situated abilities.

8) Finally, many of the participants found the everyday interactions and use not meaningful, at times even frustrating, when the design of the interaction with ICTs was neither suitable nor did it enable them in certain situations, but was, instead, rather faulty.

Moreover, the process of how the overall theme of this thesis emerged, namely of situated abilities, has also been explained. An entire chapter, namely Ch. 8, has been dedicated to explaining the overall theme and the concept of situated abilities. However, in order to anchor the arguments and answer the second research question with regard to the current debates, certain additional aspects still need to be considered. First, the concept of situated abilities must be situated in the literature, from a Universal Design perspective. Second, the situated abilities concept needs to be discussed from an ethical perspective. Third, the concept needs to be anchored, and it must be considered from a phenomenological perspective, through *Befindlichkeit*. Moreover, the concept must also be situated in the fields of HCI, HRI, and CSCW, and it is necessary to explain how it is useful in these fields. Finally, the concept of situated abilities concept must be justified as important, relevant, and timely.

9.3 Phenomenology and situated abilities

Phenomenology, or "to the things themselves!" (Heidegger 2010, pp. 26, 32), the study of experience is especially relevant to the concept of situated abilities. The reason is that the situated abilities of a human being can only be understood through the first-person experience, also in the same way that phenomenology is understood, according to Gallagher (2012). Moreover, we can only understand situated abilities if we understand "the *being* of *beings"* to use Heidegger's (2010, p. 27) words. How is the *being* of the human being *ability* understood by the human being himself or herself? Is it understood, experienced, and lived as a low or high ability on the ability continuum? The human being's situated ability can only be understood through the human being's lived experience of the ability by "showing itself" or "manifesting itself" (Heidegger 2010, p. 27) in a situation in which the human being is part of, and not detached from. The ontology of this experience can only be understood through phenomenology, according to the *ontology* (Heidegger 2010, p. 33).

Moreover, Husserl's idea of phenomenology as a structure of consciousness characterized by intentionality is not enough to describe situated abilities. It is not enough because we cannot understand situated abilities simply from an analytical point of view, such as by regarding abilities as a characteristic of our bodies, limited to what our bodies can or cannot do, or regarding the abilities of human beings as some form of abstract structure. However, we could perhaps use his notions of noesis and noema: noesis as the aspect of the mental act of consciousness including perception, thinking, judgment, desire, and/or intention simultaneously, modulating amongst these (Gallagher 2020); and noema as the individual's experience about something. These two concepts can eventually be useful as tools for talking or theorizing about situated abilities. However, these notions are not sufficient.

For instance, Gallagher (2020) explains Husserl's notion of noesis as how "something appears" in one's experience. He gives the example of an apple. He explains that the human being can understand the object viewed as an apple, while at the same time, the human being can manipulate it by turning it around, or give meanings to it, associate it with previous experiences, take a bite from it, thus changing its appearance, touch it, feel it, or conceptualize it – all at the same time. In other words, Husserl asserts that the apple is in light of a human being's act of consciousness about that apple. If we translate this experience for situated abilities into an act of consciousness, this answers questions such as: *What is a situation? What is the ability of the human being? What is situated abilities as a concept? What perspectives can we have on situatedness or abilities?* In this sense, we can play with the concept and drift it theoretically. However, it will perhaps exceed the boundaries of abilities, and we can easily risk entering a dichotomous debate of ability vs. disability, a pathogenic one. However, it is important to reassert that the concept of situated abilities is meant to be seen from a salutogenic perspective, and therefore this noesis aspect can be dangerous from this point of view *if* we do not set its limitations.

Further, the noematic aspect of situated abilities can only be referred to as someone's experiences about something. This is regarded from a theoretical point of view, where we try to distinguish analytically between the human being's abilities and the situation by separating them.

If we focus instead on understanding situated abilities through Merleau-Ponty's embodiment, we can only understand the world through our bodies and bodily actions (Gallagher 2020). Focusing only on Merleau-Ponty's notion of *Leib* – the lived body and body as a subject, and *Körper* – the objective body and body as an object (Gallagher 2020), would perhaps cause us to miss out the whole *being* of the human's lived experience with its cognitive, bodily, or emotional aspects.

However, we know that a human being always finds himself or herself in a situation with his or her body, cognition, and emotions. I argue, therefore, instead, that situated abilities can be better understood through Heidegger's phenomenology and his "being-in-the-world" by which we try to understand the human experiences through the lived body, feelings, and affect in a context, in an environment, or a situation. Thus, in the next section, the focus is on situated abilities seen through the lens of Heidegger's *Befindlichkeit*.

9.4 **Seeing situated abilities through Befindlichkeit**

Heidegger's neologism and philosophical concept of *Befindlichkeit* posit the human being in a situation or his or her attunement to a situation (Heidegger 2010). Originating from Aristotle's idea of *pathos*, as *Dasein*'s "points of access to life" (Ciborra 2006, p. 136), *Befindlichkeit* teaches us that the human being always finds him/herself in a situation. As Ciborra 2006, p. 135) later points out, the situation is always the situation of *someone*; it cannot exist by itself; it needs to belong to someone. In this way, situated abilities relate well to the concept of *Befindlichkeit*, not only because the concept inherits the notion of situatedness, but also because it refers to one's understanding of one's own existence and experiences, and also abilities, in a given situation, in a similar way to that in which Heidegger's *Befindlichkeit* is framed (Lübcke et al. 1996). Using Gendlin's (1978, p. 2) English translation of *Befindlichkeit*, the "how-are-you-ness" in situated abilities denotes *Dasein*'s individual experience of his or her abilities in a given situation. However, this experience in itself does not reduce itself to *Dasein*'s act of consciousness about his or her abilities in a given situation, but to the whole experience, including the feelings of low or high abilities when interacting or engaging with or using digital technology in the human being's everyday life. It also includes the human being's moods or feelings of frustration, annoyance, stress, or at times joy, as demonstrated in the cases presented. As Heidegger's says, these moods and feelings are fundamental to the existence of the being (Heidegger 2010, p. 130).

In addition, the attunement of *Dasein*'s situated abilities relies on *Dasein*'s ability to *slide* along on the ability continuum: from lower abilities to higher abilities, depending on the lived situation. Moreover, this is a bodily-experiential dimension not only of *Dasein*'s *Befindlichkeit* (Gendlin 1978) but also of *Dasein*'s situated abilities. Moreover, we cannot talk about a human being's situated abilities in his or her everyday interaction and use of digital technologies without talking about both the inner world and the outer world of *Dasein*.

We can understand situated abilities through the human being's reflexivity on his or her individual lived and experienced abilities in the everyday interaction and use of digital technologies, which is their outer world. This inner world of *Dasein* is directly understood through the personal experiences, through the participant's own experiences, as explained in this research, through their own "being-in-the-world," through their "living with others," where the others are both their interaction through digital technologies with other human beings, but also through their own interactions with these digital technologies. In this sense, other human beings and digital technologies are the outer worlds of *Dasein*. As I have also shown in this thesis, a human being's experiences are their "own," not detached from them: these are lived, sensed, made-sense of, by the human beings themselves, without being separated from their bodies.

The only thing that is separated from *Dasein*'s bodies is the "other," being the "other" people or digital technologies. However, *Dasein*'s situated abilities emerge from his or her own "being-in-the-world" through the relationship of *Dasein*'s to the "others." In this way, the situatedness, the *Befindlichkeit* of situated abilities, eliminates this dichotomy between the inner world and the outer world of *Dasein*, between the self and the others, between the cognitive, affective, and bodily part, losing these distinctions, in a similar way to *Befindlichkeit* itself as explained by Gendlin (1978, p. 4). Along the same lines, this is also confirmed by Ciborra (2006), who argues that *Befindlichkeit* removes the barrier between subject-object, capturing several meanings, "the ongoing or emerging circumstances of the surrounding world" and the inner world of *Dasein* (Ciborra 2006, pp. 130, 135).

Finally, anchoring situated abilities in Heidegger's *Befindlichkeit* is both important and relevant in this thesis. As Ciborra (2006) argues, although many researchers refer to situatedness in different forms, from Suchman's (1987) situated actions to Haraway's situated knowledges, to situated learning, and other types of situated "*somethings*," the majority of the researchers never anchor their situatedness in Heidegger's original concept of *Befindlichkeit*. By doing this in this section, Ciborra's (2006) earlier critiques of others' "situatedness" have been addressed, in particular. This is useful and beneficial in this thesis not only for defining and framing situated abilities but also for setting out its conceptual inheritance and limitations. Conceptual inheritance refers, in particular, to the understanding of situated abilities when removing the dichotomy between the human being and his or her abilities, or the human being and a situation, or a human being's abilities and a situation. The conceptual limitations of situated abilities refer specifically to the idea of salutogenesis and a human being's abilities as sliding on a situated ability continuum, rather than there being a dichotomous division between abilities and disabilities, or abled human beings vs. disabled human beings. Finally, adopting Heidegger's phenomenology and his concept of *Befindlichkeit* as a theoretical, philosophical lens for positing situated abilities as a useful concept helps us to better frame the concept in terms of its nucleus and its limitations.

The following sections describe how the concept posits itself with regard to Universal Design, and thereafter with regard to HCI, HRI, and CSCW as design fields.

9.5 The concept of situated abilities from a Universal Design perspective

Ch. 3 discussed related work on Universal Design about various Universal Design models, including the following: the medical model, the expert model, the charity model, the social model, the socially adapted model, the relational (also called Scandinavian or GAP) model, the socio-relational model, the biopsychosocial model, the empowering model, and the economic model. In this section, the aim is to explain how the concept of situated abilities fits the models, and from which perspective the concept subscribes to different models, and which those are.

I argue that the concept of situated abilities should be seen as a concept subscribing first and foremost to the social model, to the relational model, to the socio-relational model, to the biopsychosocial model, and the empowerment model.

First, the concept of situated abilities subscribes to the social model, which argues that the environment must be corrected because it disables and suppresses the individual (Lid 2013; 2014). In this way, the concept of situated abilities rejects the idea that something is wrong with the individual. Instead, the focus is shifted towards the environments in which he/she lives. At the same time, this model calls for political responses to address the issues created by a disabling environment (World Health Organization, 2001). This fits well with the idea behind the concept of situated abilities.

The concept of situated abilities also subscribes to the relational model, sometimes referred to as the Scandinavian or GAP model. It subscribes to this model because it focuses on the relationship between the human being and his/her environments and the experienced or life situations. As discussed when situated abilities were anchored in Heidegger's phenomenological concept of *Befindlichkeit*, a human being is and will always find him/herself in a situation: we can only separate the situation from the human being analytically, but not in practice. The Universal Design relational model focuses on precisely this relationship, ensuring, in contrast to other models such as the medical or social model, that the human being is not separated from experience or lived situations (Lid 2014. Lid (2013) talks about an individual's disability as a human condition. This perspective is useful; however, it adopts a pathogenic perspective on the abilities of human beings. I would rather argue that the ability of humans is a human condition, not something that the human has, but something that emerges in the experienced or lived situations. This idea is also supported by Lid (2013), who rejects the division of humans into abled or disabled, acknowledging the diversity of humans and their individual experiences. Moreover, she argues that humans' abilities emerge from social and material factors (Lid 2013), an idea that is also supported by the concept of situated abilities.

In addition, the concept of situated abilities subscribes to the socio-relational model. As explained in Ch. 3, Lid (2014) describes the socio-relational model as the model where disabilities are theorized; the model is anchored in Carol Thomas' (1999) work on *Female forms.* The idea of the socio-relational model is that an individual in the environment s/he is part of experiences disabilities. However, I would argue that the concept of situated abilities subscribes to this model in a salutogenic way: focusing on the low or high abilities of the individual, rather than on his or her disabilities. According to this model, disabling mechanisms are part of the environment that can be avoided or removed by adopting different measures, including social, political, and physical ones (Carol Thomas 1999 in Lid 2014). Along the same lines, I argue that the individuals' abilities rely on the environment and the situations the individual experiences or lives. If the environment or technology to be used is designed for the abilities of people, what they *can do*, rather than what they cannot do, this approach can enable the individual in his/her everyday interactions with and use of digital technologies.

Further, the concept of situated abilities subscribes to the biopsychosocial model, a model that is adopted by the World Health Organization (2001). This model is described as including both biological, psychological, and social factors (Begnum 2016), specifically focusing on "the interaction between a person's health conditions and the contextual factors and the environments they are living in" (pp. 2-3). Since the concept of situated abilities emerged from the two cases, originating from my readings of Antonovsky's (1996) work, as explained in Ch. 9, I find the idea of this model that the individual finds himself or herself in an environment he or she lives in, to be relevant. Although the model is preferred by the WHO, when talking about disabilities (World Health Organization 2001), the model is also useful when talking about abilities and how one's abilities are situated.

Last but not least, the concept of situated abilities subscribes to the empowering model.

The empowering model focused on the individual as an expert on his or her own body and lived experiences; this is in contrast to some other models which suppress the individual, such as the medical model or the charity one. This model is useful for the concept of situated abilities because the model trusts the individual's autonomy, decision power, and control, and the professionals come in only as advisors rather than experts (Begnum 2016). The model regards the individual him/herself as the expert on his/her own body; he/she is the one who can decide on appropriate measures for treatment (Begnum 2016). Thinking about situated abilities as part of this model is interesting and relevant because it puts the human being and his/her lived experiences in focus, in a similar way to phenomenology, especially Heidegger's "being-in-the-world."

9.6 Setting the concept of situated ability within the perspectives of design fields

In Ch.3, I positioned this thesis across the following design fields: Human-Computer Interaction (HCI), Human-Robot Interaction (HRI), and Computer-Supported Cooperative Work (CSCW). Later, in the chapters dedicated to each of the cases, Ch. 6 and Ch. 7 respectively, information on the papers belonging to each of the cases and their appurtenance to these fields was included. However, the opportunity has not previously arisen to set out the overall theme that emerged from these two cases and to position the concept of situated abilities within the perspective of these fields. This will now be done in the next sub-sections by revisiting each of the design fields: HCI, HRI, and CSCW, with this aim in mind.

9.6.1 Situated abilities in Human-Computer Interaction: a useful concept to be infused in the 4th HCI wave?

In Ch 2, the field of HCI was described in detail with a particular focus on its generative metaphors (Agre 1997) or waves (Bødker 2006; 2015), as they are preponderantly called in HCI. In addition, a detailed description of each of these waves and their specificities was given. An overview of these fields is presented in Table 2-1, in Ch. 2, Section 2.1.

A particular debate that drew my attention was the latest writings of Frauenberger (2019) and Ashby et al. (2019) on an eventual new HCI wave, namely the 4th wave. On the one hand, Frauenberger (2019) chose to describe it as the entanglement HCI wave, whereby HCI researchers should focus on the relationships developed between humans and digital technologies, bringing into play philosophical questions and debates. The author argues that we should focus on ethics, the individual's and society's responsibilities. On the other hand, Ashby et al. (2019) formulated an HCI manifesto, within which the authors argue that an HCI 4th wave should focus on activism at all levels, pushing beyond institutional levels. The same authors also argue that HCI researchers should focus on accessibility, diversity, policies, and laws. In addition, Stephanidis and colleagues, a well-known name amongst UD researchers and communities, argues that accessibility is one of the current challenges of HCI (Stephanidis et al. 2019).

Positioning situated abilities in the HCI field, it seems clear that the concept fulfills the challenging requirements of an eventual 4th HCI wave. It is a theoretical concept anchored in Heidegger's existentialism and phenomenological concept of *Befindlichkeit*, thus fulfilling some of the 4th HCI wave specificities identified by Frauenberger (2019). In addition, it focuses on the relationship between humans and digital technologies, in an attempt to understand this relationship without separating the human being from his/her experienced abilities in everyday interactions with and use of digital technologies. From this point of view, the concept is in line with Frauenberger's (2019) concern to focus on the human "entangled" relationships with things.

Further, situated abilities have emerged as an alternative way to talk about Universal Design in the context of current pathogenic debates, adopting a salutogenic perspective instead, inspired by the work of Antonovsky (1996). This relates directly to Ashby et al.'s (2019) suggestions regarding accessibility and the UD debate. In addition, Ashby et al. (2019) urge activism at all levels, pushing beyond the institutional levels, is indirectly fulfilled. Activism is strongly related to critical research and constructive methodologies such as action research or participatory design. This thesis was framed instead as an instrumental collective case study, subscribing mainly to an interpretive paradigm. Although the activism and the aim of pushing beyond the institutional level as a result of this thesis was not a point of departure *per se*, indirectly, it became a result of this thesis. Beginning with an interpretive approach, whereby the everyday interactions with and use of digital technologies are understood, investigating this aim throughout the first research question and the two cases included, the answer to the second research question seems now, finally, to have a critical intent. Moreover, historically, Universal Design is a critical field, debating the rights of individuals with disabilities vs. those with abilities, including activist movements of various kinds. However, this thesis does not include activism in that sense, focusing rather on the theoretical debate about how we can shift the focus of Universal Design and disabilities, to human beings' abilities. Although activism is not present in the same way as perhaps other Universal Design-studies in HCI which focus on designing for people with various cognitive or physical disabilities, it can be sensed in an indirect way. Specifically, the activism and the "pushing of institutional boundaries" from Ashby et al. (2019) can be sensed through laws and regulations related to discrimination and equality law in Norway (Norwegian: Diskriminering og likestilling loven), with regard to the Universal Design of robots to be used in the home and home care services, and with regard to digital learning environments in Higher Education. However, this debate, although relevant for the HCI 4th wave, is beyond the scope of HCI and its core topics. However, it is important to remember, as demonstrated in this thesis, that the concept of situated abilities, within a philosophical frame for discussing human relations with digital things, helps us to advance our ways of talking about, thinking about, reflecting upon, or discussing human beings' situated abilities in everyday interactions with and use of digital things. Moreover, adopting such an approach does not ignore or dis-acknowledge the previous HCI waves or their specificities, in terms of discussing interaction, interaction goals, scientific movements, theories, methodologies and methods, relationships between the human being and digital technology, values and types of questions (see Table 2-1 in Ch. 2 on the Epistemological commitments of the HCI waves). Instead, a 4th wave and the concept of *situated abilities* allow us to evolve our understanding of HCI's core and values by supporting our rationale with new ways of thinking about human beings' abilities. Nevertheless, the implications of such an approach involve challenging adjacent fields, including current laws and regulations with regard to Universal Design. I reflect on this in Section 9.7, since these implications step outside the bounds of HCI and design fields.

Finally, in order to re-focus the core values and foci of HCI in an eventual 4th wave, following up on the work of Frauenberger (2019) and Ashby et al. (2019), my colleagues and I have proposed a NordiCHI workshop (Bratteteig et al. 2020, in press). The workshop will focus on strengthening the human autonomy in the era of autonomous technology, with the aim of discussing contemporary perspectives on interaction with 'autonomous things' (Bratteteig et al. 2020, in press). This represents, in other words, a call for us to shift our focus from digital technology's autonomy in the era of technology to human beings' autonomy. This view opposes that of Farooq and Grudin (2016) and Mueller et al. (2020), who argue instead for a shift of focus and values drifting around human-computer integration and human-computer symbiosis in HCI. Since this debate is too important to be left out of the discussion, it is included in more detail in Section 9.6.3 on situated abilities in CSCW. But first, the next section considers situated abilities in HRI.

9.6.2 Situated abilities in Human-Robot Interaction (HRI)

In Ch. 2, HRI was discussed as a field emerging from HCI. However, at that point, there was no opportunity to integrate situated abilities from the HRI perspective. When is the concept of situated abilities relevant and useful in HRI, and why?

If we go back to the core HRI, which involves studying the interaction between humans and a robot, which is a physical object that manifests itself in a physical space (Goodrich and Schultz 2007), it can be observed that the desktop metaphor cannot offer the same opportunities to study interaction, as a robot does. Similarly, Case 1 in this thesis was intended to provide opportunities for studying human-technology interaction distributed or co-located in both physical space and time; the forms of interaction offered are slightly different from those offered by the desktop metaphor.

In addition, I indicated that the definition of a robot, according to the ISO standards, is: "an actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment to perform intended tasks" (International Organization for Standardization, 2017). However, Case 1 demonstrated that the robot did not perform the "intended tasks" of cleaning, at least, not without human support (see Papers II and III) (Saplacan and Herstad 2019; Saplacan et al.

2020b). At the same time, such domestic robots are classified as welfare technologies, according to the Nordic Centre for Welfare and Social Issues (2017). Thus, the work presented as part of Case 1 is an exemplification of situations from the everyday lives of the participants and their interactions with and use of robots. Although both the elderly and non-elderly participants were abled individuals, the situations posed by the interactions with the robot made them perceive themselves as less abled. In other words, their abilities were strongly connected with the situation at hand. Situations such as installation issues, not understanding the technical error messages given by the robot, the random navigation patterns of the robot often not understood by the human user, the humans' feelings of stress and annoyance, as well as the feelings of personalization towards the robot, along with breakdown situations such as the robot getting stuck in cables or under the bed, breaking lamps, escaping the boundaries of the participants' homes, or starting randomly by itself, are just a few of the situations illustrated in Case 1.

Talking about situated abilities and HRI in this context can be helpful and relevant when we wish to explore such human-robot joint work activity situations, or when we need to design, plan, and assign work tasks to the robot. This has also been demonstrated in Paper III (Saplacan et al. 2020b) and in Paper IV (Saplacan et al., 2020, forthcoming). Moreover, this is particularly helpful when designing robots for use in public services, such as health or home care services. Although no current laws, legal regulations, or standards exist to regulate these aspects, the future design of robots should be prepared to encounter the kinds of challenges which may be imposed by legal frameworks. This argument is also supported by the current Vulnerability in Robot Society (VIROS) research project, funded by the Research Council of Norway, ongoing at the University of Oslo.

At the same time, other studies indicating the issue of situated abilities, confirming the findings in this thesis, are available in the HRI literature.

One such illustrative example is the study by Mutlu and Forlizzi (2008). The study talks about introducing a robot in two different hospital departments: one medical and one post-partum. The paper demonstrates that a robot can be perceived differently depending on the workflow in the department and other social and environmental factors. According to the article, the acceptance of the robot seemed to be related to the workflow, political, social/emotional, and environmental factors – in other words, the context and situatedness of the human-robot interaction. Specifically, the paper demonstrates that the medical department had a low tolerance for situations where the robot interrupted or disrupted the workflow and created a lot of clutter. This made the staff in the medical department feel resistant towards accepting the robot. Moreover, they did not see the benefit of having such a robot in an environment or in situations where people were seriously ill. Further, the paper explains that the medical department acquired a robot to improve the efficiency of deliveries, e.g., of the hospital linen. However, the staff perceived the introduction of the robot in their context and situatedness as degrading their services. They also saw it as a conflict of interest between the management and the medical units. In general, the article explained how, in the medical units, the patients were seriously ill and needed a calm environment without disturbances. In addition, the staff felt that their situatedness was represented by a stressful environment, with a low tolerance for interruptions. Having the robot around was perceived as annoying. On the other hand, in the post-partum environment, the robot was perceived as being positive. In the post-partum department, people were more prone to accept the robot and its interruptions in the workflow. The post-partum department was often associated with the positive news of becoming a parent. This created a type of situatedness that enabled the staff and people to take their time interacting with the robot. All in all, although the physical settings of the two units (e.g., medical and post-partum) were similar, it seems that the situatedness of the departments was manifested through different interaction dynamics (e.g., high traffic in the corridor in the medical unit compared to the post-partum unit). This led to a situation where the medical units associated eventual breakdowns with the robot, whereas the post-partum units associated eventual breakdowns with the management.

Another example confirming the findings from this thesis is the study by Forlizzi and DiSalvo (2006). Whilst, the study does not talk about situatedness or situated abilities *per se*, it illustrates situations where the introduction of service robots, e.g., a Roomba Discovery vacuum cleaner, in homes changes the activities and interactions between the people living in the home. The authors saw the "home" as an ecology of products, people, activities, a social and cultural context of use, and a place – a bounded environment. The study illustrates situations where the robot adopted a random navigation pattern, and it was not capable of learning, to the surprise of one of the participants. This finding was also confirmed by the findings in this thesis. Moreover, the study also presents situations connected with the abilities of people, where the use of the robot also influenced the practice of housekeeping: in some households, the male participants were in charge of setting up the robot; in others, only the women used it; other households thought that using the Roomba was a nice way for children to learn more about robots. In a similar way to the data from Case 1 in this thesis, this study illustrated situations where decluttering and "pre-cleaning" needed to be done before running the robot. As some participants in the study pointed out, one had to "partner up" with the robot when doing the cleaning work. Moreover, the data presented in this study demonstrates that the participants attributed a gender and name to the robot, and sometimes perceived the robot as having its own personality. The participants also talked to the robot and formed certain social relationships. Moreover, it also seems that the robot is a value-laden symbol, having functionality, aesthetics, and potential. Similar findings were also presented in Forlizzi (2007a), Mutlu and Forlizzi (2008), and Forlizzi (2007b). Some of these findings are also confirmed in this thesis, however, through the lens of situatedness, situations, and situated abilities, rather than through an ecology of products, as in these studies.

Further, an article by Lee et al. (2010) discusses two types of robots: the Snackbot, a humanoid robot able to inform through speech, and the HERB robot. Specifically, the study considered mitigation strategies, such as apologies, compensation, and options for the user, when a breakdown in the human-robot interaction occurred. The arguments put forward by the authors related to recovery strategies in case of breakdowns. Based on a 317-participant sample, the authors argue that people that have a relational orientation respond best to an apology-based recovery strategy, while people with a utilitarian orientation respond best to a compensational recovery strategy. Although the article does not discuss situated abilities per se, it indicates situations where the robot's recovery strategies are seen relating to the politeness of the robot. The authors argue that robots that may embed the theory of regulatory fit, i.e., adopting recovery strategies in breakdown situations that are suitable for the service orientation of the user: relational/social, or utilitarian. This is an example of how high situated abilities on an ability continuum can be facilitated by the design of the robot itself. Further, the authors also explain that sometimes incorrect expectations are imposed on technology: for instance, when a robot can transmit some information through speech, the user may assume that the robot is able to talk, to interact through speech, and has social skills. When the user is not informed in advance of the robot's limitations, the user may feel frustrated and angry. Service breakdown may also cause the user to perceive the situation as a *loss of control* or *lost autonomy.* The perceived autonomy of the human is, in this sense, strongly connected with the abilities of the human to interact with the robot. Although the paper does not talk about situated abilities, there is justification for asserting that it has this conceptual lens.

In addition, another example of a study indirectly confirming the findings from this thesis, and especially the findings from Case 1, is the study on human adaptation to a robot by Verne (2020). An autoethnographic study, the article showcases situations where the adoption of a lawnmower robot, used for automating the maintenance work in the home garden, generates more and different work tasks for the humans using it. The work tasks presented in the article indicate situations where the humans' ability to interact with the robot required a technical understanding and situations where the humans had to modify the outdoor environment to make the robots' work "work," for example, by picking up apples as soon as they fell down, in order to avoid the robot getting stuck in them. At the same time, the abilities of humans to interact with the robot were conditioned upon their technical abilities, their understanding of how to use the robot, and the experienced situations in their interaction with it.

Finally, based on the arguments described above, the concept of situated abilities seems both relevant and useful for the HRI community. It is relevant because it helps researchers in the design field or designers to plan, design, and assign work tasks to the robot in such a way that the automation of work does not impose more work on the human, but facilitates the user. It is also useful because it helps the design of robots to be seen in concrete situations represented by the interactions with and use of the robot, without regarding the human and the robot as two separate entities.

9.6.3 Situated abilities in Computer-Supported Cooperative Work (CSCW)

In Ch. 2, CSCW was discussed as a field. However, at that point, there was no opportunity to integrate the concept of situated abilities with the CSCW perspective. When is the concept of situated abilities relevant and useful in CSCW, and why?

As explained previously, CSCW refers to supporting cooperative work via computers, according to Schmidt and Bannon (1992). At the same time, CSCW is described as an interdisciplinary field emerging from multiple disciplines, including social psychology, anthropology, organizational theory, education, and economy – mainly fields that can help in understanding group work (Grudin 1994). Studies covering applications investigated from a CSCW perspective include, amongst others, distance learning (Grudin 1994). Similarly, in Case 2 of this thesis, the focus on the interaction with and use of DLEs in Higher Education has been presented. Further, I analyzed the cross-use of DLEs from the Common Information Spaces' perspective in Paper V (Saplacan 2020a), where I argued that one of the values and key points refers to how DLEs are differentiated from LMS. In other words, DLEs encompass LMS, but in addition, they may include dashboards, webpages, social media, and other online forms that are used in teaching/learning activities by course instructors and students. In addition, I have also argued that Higher Education institutions should be seen as cooperative ensembles that use CSCW systems, where the "product" of the organization is the work-force (Saplacan 2020a).

Moreover, in Ch. 2, the cooperative ensembles were explained as often being transient formations emerging to handle a particular situation, after which they dissolve again. In Higher Education institutions, such examples of temporary cooperative formations are courses where the members of the cooperative ensemble come together in order to teach or learn a course. The pattern of interaction amongst the members of this type of cooperative ensemble changes dynamically with the requirements and constraints of the situation, similarly to other cooperative ensembles. At the same time, its cooperative work is distributed logically in terms of control, where the agents are semi-autonomous in their partial work. In Case 2 of this thesis, the agents were represented by both students, course instructors, and DLEs.

Certain studies which were similar to Case 2 presented in this thesis were identified. However, although these studies are similar, none of them specifically covers Higher Education studies from a CSCW perspective.

For instance, the cooperative work in the context of Higher Education institutions is distributed physically in time and space. This argument is also supported by Carstensen and Schmidt (1999), who argue that distributed activities that make up cooperative work vary in time, space, and complexity (Carstensen and Schmidt 1999). At the same time, the authors argue that, with increasingly complex work, the complexity of the articulation work also increases (Carstensen and Schmidt 1999). This was confirmed in Case 2 of this thesis, especially in the findings presented in Paper VI on fragmented information awareness (Saplacan, Herstad, and Pajalic 2020). In addition, according to Carstensen and Schmidt (1999), such systems should support the management of task interdependencies and provide some sort of mutual awareness amongst the actors (p. 11). While an integrated system should allow the users to: communicate, interact, cooperate, and contain shared workspaces (Carstensen and Schmidt 1999), Case 2 explained that DLEs allowed for this type of communication. However, the communication became fragmented due to Rudin the fact that it was distributed over several channels, as explained in Paper VI (Saplacan, Herstad, and Pajalic 2020) and in this thesis.

At the same time, cooperative design work refers to a specific and situated environment (Carstensen and Schmidt 1999), and sometimes this type of cooperative design refers to the identification of conflicting requirements, referred to as a "wicked problem" (Rittel and Webber, 1973 in Carstensen and Schmidt 1999, p. 4). In a wicked problem, the complexities are high: multiple actors are involved, and there are different interdependencies between problems. In other words, CSCW researchers study "organizational memory," how the organization, a cooperative ensemble, leaves work traces behind. However, such a system may also provide workflows which support the automation of tasks (Carstensen and Schmidt 1999). Moreover, it may also monitor activities and processes (Carstensen and Schmidt 1999). These functions serve to improve systems that support cooperative work. In addition, CSCW addresses more or less cooperation between designers and other actors (Carstensen and Schmidt 1999). A number of empirical studies have been carried out with this aim. Case 2 in this thesis also fulfills these requirements and exemplifies this type of wicked problem, where different actors, e.g., the Higher Education institution, course instructors, and students, have, at times, conflicting requirements. However, the organizational memory, in the case of Case 2, seems to be distributed and fragmented.

Another issue that emerged from both Case 1 and Case 2 was the use of the English language and of technical language. In line with this consideration, an article by Beyene, Hinds, and Cramton (2009) discusses the issue of using English as the official language in an organization, as the "lingua franca" to use the authors' words (Beyene, Hinds, and Cramton 2009, p. 2). Although the article does not talk about the language used in the design of the technology itself, the issue of using a foreign language in an organization, regardless of whether it is used in direct or mediated communication, seems to remain a relevant issue. Specifically, the article describes a qualitative study, including interviews and observations of 145 individuals working on global projects across the US, Germany, and India. It seems that language barriers issues highly interfered with collaborative work and led to cycles of negative emotions. They identified four (4) strategies for coping with language barriers or uneven language proficiency: withdrawal, exclusion, code-switching, and engagement (ibid). However, all of them led to negative emotions (ibid). Organizational change relating to the lingua franca is often based on a specific decision, but there is rarely any allocated process that continuously supports this change (Hildebrandt, 1973; Marschan Welch & Welch, 1997, in Beyene, Hinds, and Cramton 2009, p. 3). As I understand it, this can cause a problem of power-relations, access to information, and, at some level, indirect discrimination. In addition, even this study demonstrates that using English as the official language added feelings of stress, anxiety, and frustration to employees' work; it was time-consuming; they felt they needed to remain silent; they perceived that they did not have enough English language; it led to fatigue; it felt strange to talk to other native Germans in English; they found it a hindrance in their work; and it led to avoidance behavior (Beyene, Hinds, and Cramton 2009, pp. 12-15). On the other hand, the English speakers felt feelings of exclusion and felt "ostracized" (Beyene, Hinds, and Cramton 2009, p. 17). One concrete example was given by the authors – when an email thread was originally written in German, and a non-native German speaker was included later in the thread and expected to understand and follow the communication loop (ibid, p. 17). Similarly, in this thesis, similar situations could be observed. For instance, Case 1 demonstrated that the use of English or technical language in the design of technology created stress and anxiety amongst the senior participants. In other words, they did not feel comfortable interacting with technology in a non-native or non-official language. Moreover, the senior participants also wished for features in robots, such as voice recognition and speech interaction, to be specifically available in Norwegian, not in English. In addition, in Case 2, the student participants pointed out that there are two official languages in Norway, the old language, e.g., Bokmål, and the new language, e.g., Nynorsk. Some of the students argued that some of the DLEs they were using were not available in both languages, while others were only available in English. At the same time, course instructors explained how some of the DLEs used by international students were not available in English, and how the user needed to log in before being able to change the language of the system to English (Saplacan 2020b). In addition, Case 2 also indicated that even after changing the official language of the DLE to English, some of the words were still not translated, and Norwegian words remained.

A third issue that emerged, especially from Case 2, with regard to CSCW systems, was that most of the CSCW studies focus on single CSCW systems. Along the same lines, an article by Monteiro et al. (2013) challenges the CSCW boundaries by proposing that the CSCW field should widen its agenda by taking into consideration Information Infrastructures. With a non-localist perspective, the authors raise some good points regarding the role of design and its implications in CSCW systems; these are explained in the following paragraphs. They are described as potential grand solutions which could solve or facilitate the issues of cross-use of DLEs that often result in fragmented information awareness and make learning and teaching through DLEs less accessible in some situations.

Monteiro et al. (2013) assert that the CSCW field is currently limited to the locality or physically or temporally bounded situatedness of a system or artifact (Monteiro et al. 2013). The authors suggest that CSCW should take into consideration when systems need to cross the boundaries of an organization, at which point the design of systems or artifacts become important for standardization, whereby they suit only certain sites, and embeddedness, where technologies are very entangled although apparently, they are not (Monteiro et al. 2013). Specifically, the authors also talk about *CSCW-in-use* as the main focus of CSCW, and the *esposed-CSCW* – an open CSCW agenda that they subscribe to. In other words, the authors propose that CSCW should also take into account Information Infrastructures, which they describe as a system of CSCW systems, but which, in addition, is challenged by the standardization and embeddedness of each of the individual systems. This is in line with the arguments raised in Case 2, where it was noted that only certain DLEs are standardized through Universal Design. However, the majority of DLEs used are not official systems for the Higher Education institutions, and they are often not universally designed, thus not standardized to be accessible and used by as many people as possible. This argument is also in line with the ideas proposed by Vanderheiden and Treviranus (2011) and Vanderheiden et al. (2014) on creating a Global Public Inclusive Infrastructure (GPII).

In addition, Monteiro et al. (2013) explain that the spatial and temporal span of Information Infrastructures is also much greater: geographically or globally distributed as well as being distributed over the decades. This type of spatial and temporal distribution lays the ground for multiple ecological layers, i.e., a standard which is built upon old standards. Hence, the authors provoke the reader to think beyond the "usual" boundaries of CSCW, instead focusing on the "locality" of a system with its "local sensibility" and some kind of situatedness (Monteiro et al. 2013). Further, the authors talk about the *tailoring* and *rework* that needs to be done in order to adapt or reconfigure systems, to make them useful (Monteiro et al. 2013). Information Infrastructures, as opposed to systems with a project time duration of three to five years, are evolving over decades; they have *longue durée*, or as Braudel (1949) in Monteiro et al. (2013, p. 7) states, The Long Now.

At the same time, the authors recognize the challenges that may arise with such standardization. For instance, they discuss the *domestication* of the technology, in a case when an Electronic Patient Record system (EPR), developed by Siemens, was introduced at several hospitals, within and outside Norway, and which challenged the nurses, psychologists, or doctors who encountered it. When a subsystem, DocuLive, was integrated into the main system, with the purpose of moving the patient records digitally, the EPR ended up being documented both digitally and in paper format. The paper had to be archived, and after a few years, some of the papers could not even be found. This kind of challenge is, of course, anticipated even in the case of establishing a GPII, in Higher Education or in other public sectors.

Further, the authors also talk about *generification* in the process of *standardization.* This refers to the fact that for standards which are implemented across multiple sites (e.g., Africa, Europe, and the US), the systems need to be designed accordingly so that they fit or suit both sites. They exemplify this through the implementation of an ERP system in Higher Education, where different sites had different work-practices, but also different needs and technical requirements on the ERP system. Generification is achieved by defragmenting different user needs, segmenting them based on their "homologies of practices," and yet targeting a wider community. In these circumstances, developers need to create bridges between the main system and the system used by each of the target groups. These recommendations could potentially be beneficial even for the standardization of DLEs with regard to the Universal Design of DLEs used in Higher Education, at a national, European, or Global level.

Finally, based on the arguments described above, the concept of situated abilities seems both relevant and useful for the CSCW community. It is relevant because it allows situatedness and the abilities of human beings to be considered from various perspectives. First, it can regard the situated abilities of human beings from an individual perspective, local or organizational perspective, or even a national or global perspective. It is also useful because it helps CSCW researchers and designers to look at the human experience of digital technology when using multiple digital systems, not only individual digital systems or technologies.

9.7 Ethical implications on situated abilities, stepping outside of design fields

Digital technologies and systems surrounding us in our everyday lives should be designed to ensure a "good life" for the human beings who use them (Bergsjø and Bergsjø 2019, p. 9) and the welfare of their societies. This also implies that digital technologies should be used in a good and correct way, by understanding their social use and effects on individuals (Bergsjø and Bergsjø 2019), groups of people, or societies. An understanding of the development and usage of technologies has certain ethical implications. Bergsjø and Bergsjø (2019) ask how technology can contribute to the "good life" (p. 12). At the same time, the authors explain that there is a "rule vacuum" along with a "concept vacuum" and invisible technology, all of which pose ethical challenges (ibid, p. 14).

While this thesis cannot fill these vacuums and create new rules, it can, at least, through the findings presented, point to an existing legal vacuum. This is sometimes referred to as normative ethics. First, this thesis can point to a legal vacuum with regard to Universal Design and the design and use of robots in the public sector. Second, this thesis also identifies a lack of regulations and standardization regarding the Universal Design of DLEs used in Higher Education institutions, although some attempts to apply UD to ICT solutions have been made. These include the Universal Design of DLEs used in Higher Education (Kommunal- og moderniseringsdepartementet 2013; 2017), and the more recent ongoing discussion around WAD (Kulturdepartementet 2020). Although these legal measures have been put in place, a legal framework addressing the cross-use of these types of digital technologies and systems, which addresses their low accessibility in some situations, is not available. These arguments are also supported by the earlier idea on GPII proposed by Vanderheiden and Treviranus (2011) and Vanderheiden et al. (2014), but also the idea of Information Infrastructures, as proposed by Monteiro et al. (2013).

Further, this thesis fills the concept vacuum, as discussed by Bergsjø and Bergsjø (2019), to some degree. I argue that through the concept of situated abilities proposed in this thesis, the concept vacuum is filled with a conceptual apparatus. This conceptual apparatus enables us, researchers, designers, or human beings, to talk about, discuss, reflect upon, and design for human beings' experiences when they feel less abled to use digital technologies or systems, although they are not medically diagnosed as disabled.

The types of ethics subscribed to by the concept of situated abilities, in this case, can be referred to as both applied ethics and meta-ethics.

The concept subscribes to applied ethics in the form of situational ethics or situation ethics that refer to what is ethically correct in the "here and now," as explained in Bergsjø and Bergsjø (2019, p. 25). Moreover, the concept seems to be both relevant and useful, especially in Norway and other Nordic countries, since situational ethics and discretion (Norwegian juridical term *skjønn*) are extensively employed in the public sector, in different situations. One of the reasons for the extensive use of discretion in Norway is that the laws and regulations which are formulated are deliberately brief to allow for discretion (Bergsjø and Bergsjø 2019, p. 26). However, this kind of discretion used in the public sector may be threatened in the age of automation, where digital systems and algorithms make the decisions, as demonstrated in the Danish study by Petersen, Christensen, and Hildebrandt (2020). While automation can potentially create more opportunities for equity amongst citizens, both abled people and those less abled, it may also potentially introduce or widen the digital divide, as also indicated in several previous studies (see Norris 2001; Dijk and Hacker 2003; Stoerger 2009; Wu et al. 2015; Delello and McWhorter 2017; Burgstahler 2017). Thus, situatedness and the situated abilities of people become even more important and relevant in the Scandinavian context, particularly now in the age of automation. In this sense, together with my colleagues, I have proposed a workshop at NordiCHI 2020 to discuss how to strengthen human autonomy in the era of autonomous technology (Bratteteig et al., 2020).

Finally, the concept of situated abilities fills the concept vacuum by addressing meta-ethics that answers the second RQ posed in this thesis. Meta-ethics refers to the grand philosophical and abstract questions. In Norway, Europe, and in general, in Western culture, these questions are in line with Greek philosophy inherited from Plato (427-347 BC) and Aristotle (384-323 BC) (Bergsjø and Bergsjø 2019). Their philosophy asserts that the human being should avoid hurting oneself or others, and those who have decision-making powers are responsible for those that are powerless (Bergsjø and Bergsjø 2019). As shown in this thesis, the concept of situated abilities is anchored in Heidegger's philosophy, e.g., phenomenology, which, in turn, is based on Aristotle's work, as explained in Ch. 4 on Theory. Finally, the concept of situated abilities as meta-ethics enables discourses in Universal Design from a salutogenic perspective, focusing on what human beings can do, rather than focusing on their disabilities.

Chapter 10 CONCLUSION

"If I have seen further it is by standing on the shoulders of Giants."

— Isaac Newton's (1642-1727) letter to Sir Robert Hooke (1675)[23]

This chapter summarizes this thesis, giving an overview of the contributions of the thesis. Thereafter, the chapter presents the concluding remarks. The chapter concludes with some suggestions for further work.

10.1 Summary and contributions

This thesis began by addressing two main research questions. The first research question was ***RQ1:*** *How do human beings understand and experience situations from their everyday use of ICTs?* This was answered through two cases, Case 1 and Case 2, respectively. Case 1 investigated human beings' everyday interactions with and use of "moving things," i.e., robots in the home, whereas Case 2 investigated human beings' everyday interactions with and use of the desktop metaphor, i.e., the cross-interaction and use of Digital Learning Environments in Higher Education, as opposed to single Learning Management Systems. The second research question was ***RQ2:*** *How can human beings' abilities and their relationships with ICT design be defined and talked about without focusing on human beings' disabilities?* This was answered by some of the papers included as part of Case 1 and Case 2 but also throughout the main part of this thesis.

Further, the contributions in this thesis are multifaceted. They consist of a main and several smaller contributions. The main contribution is the concept of situated abilities that emerged in response to the findings from both cases. The concept of situated abilities is defined, framed, explained in Ch. 8, dedicated to a discussion on that topic. The anatomy of situated abilities is explained together with the situated ability continuum, which includes low- and high-end abilities. Further, the concept of situated abilities is anchored in phenomenology, in Ch. 9, Discussion, and Heidegger's concept of *Befindlichkeit*, which has been used as a lens through which to understand and better explain the concept of situated abilities. Moreover, the concept and the main contribution of this thesis are discussed from a Universal Design perspective, but also from the perspectives of other design research fields, including Human-Computer Interaction, Human-Robot Interaction, and Computer-Supported-Cooperative Work.

At the same time, the smaller contributions consist of an identification of the value of a salutogenic approach for design and the processes for concept development, of introducing qualitative data analysis methods well established in the medical field to the design fields, as well

[23] Source:Digital Library, https://digitallibrary.hsp.org/index.php/Detail/objects/9792, last accessed 28.09.2020

as introducing a new workshop method for both data collection and analysis introduced to the HCI community.

10.2 **Concluding remarks**

The following concluding remarks can be drawn based on the work presented in this thesis. First, a shift in perspective from disabilities to people's abilities is proposed in order to enable the design and development of products and services that accommodate human beings' situated abilities. Second, the Universal Design discourse should also take into account the situated abilities of individuals, not only their disabilities. This is a salutogenic approach. Lastly, situated abilities can broaden our understanding of the everyday use of digital technologies and systems, including welfare technologies, by contributing to an understanding of the experienced and lived situations of the users as human beings.

10.3 **Suggestions for further work**

This work can be relevant in several areas as a point of departure for further research. The individual findings from each of the cases, or from the overall theme which emerged from both cases and the concept foregrounded in this thesis, namely situated abilities, can be beneficial going forward. Based on the work presented in this thesis, I make the following suggestions for further work:

- There is a need for legal frameworks, standards, guidelines, and recommendations for designing and regulating robots to be used in the public sector, including healthcare, homecare, and education.
- Studies in Universal Design should take into account the abilities and situatedness of individuals when using multiples digital technologies or systems and not simply the design and use of single individual digital technologies or systems.
- Applying the concept of situated abilities can be further explored in philosophical and theoretical questions about human being's autonomy and relations with digital technologies, along with the development of contemporary technologies, based on Artificial Intelligence and Machine Learning. This may include robots, chatbots, and other digital technologies or systems that can delegate tasks to humans.

References

Abdolrahmani, Ali, Ravi Kuber, and Amy Hurst. 2016. “An Empirical Investigation of the Situationally-Induced Impairments Experienced by Blind Mobile Device Users.” In *Proceedings of the 13th Web for All Conference*, 21:1–21:8. W4A ’16. New York, NY, USA: ACM. https://doi.org/10.1145/2899475.2899482.

Agre, Philip. 1997. *Computation and Human Experience*. Learning in Doing. Cambridge ; New York: Cambridge University Press.

Amirabdollahian, F., R. op den Akker, S. Bedaf, R. Bormann, H. Draper, V. Evers, G. J. Gelderblom, et al. 2013. “Accompany: Acceptable RobotiCs COMPanions for AgeiNG Years — Multidimensional Aspects of Human-System Interactions.” In *2013 6th International Conference on Human System Interactions (HSI)*, 570–77. https://doi.org/10.1109/HSI.2013.6577882.

Antonovsky, Aaron. 1996. “The Salutogenic Model as a Theory to Guide Health Promotion.” In *Health Promotion International*, 1:11–18. Great Britain: Oxford University Press.

Ashby, Simone, Julian Hanna, Sónia Matos, Callum Nash, and Alexis Faria. 2019. “Fourth-Wave HCI Meets the 21st Century Manifesto.” In *Proceedings of the Halfway to the Future Symposium 2019*, 1–11. HTTF 2019. Nottingham, United Kingdom: Association for Computing Machinery. https://doi.org/10.1145/3363384.3363467.

Bai, Aleksander, Camilla Heidi Mørk, Till Hallbach, Kristin Skeide Fuglerud, Wolfgang Leister, and Trenton Schulz. 2016. “A Review of Universal Design in Ambient Intelligence Environments.” In *SMART ACCESSIBILITY 2016 : The First International Conference on Universal Accessibility in the Internet of Things and Smart Environments*.

Baltes, Paul B., and Jacqui Smith. 2003. “New Frontiers in the Future of Aging: From Successful Aging of the Young Old to the Dilemmas of the Fourth Age.” *Gerontology* 49 (2): 123–35. https://doi.org/10.1159/000067946.

Bannon, Liam. 1989. “Discovering the Human Actors in Human Factors.” In *Proceedings of the 13th IRIS Conference*. Skagen, Denmark. https://www.researchgate.net/publication/260344330_Discovering_the_Human_Actors_in_Human_Factors.

———. 1992. “From Human Factors to Human Actors: The Role of Psychology and Human-Computer Interaction Studies in System Design.” In *Design at Work: Cooperative Design of Computer Systems*, 25–44. USA: L. Erlbaum Associates, Inc.

Bedaf, Sandra, Heather Draper, Gert-Jan Gelderblom, Tom Sorell, and Luc de Witte. 2016. “Can a Service Robot Which Supports Independent Living of Older People Disobey a Command? The Views of Older People, Informal Carers and Professional Caregivers on the Acceptability of Robots.” *International Journal of Social Robotics* 8 (3): 409–20. https://doi.org/10.1007/s12369-016-0336-0.

Bedaf, Sandra, Gert Jan Gelderblom, and Luc De Witte. 2015. “Overview and Categorization of Robots Supporting Independent Living of Elderly People: What Activities Do They Support and How Far Have They Developed.” *Assistive Technology: The Official Journal of RESNA* 27 (2): 88–100. https://doi.org/10.1080/10400435.2014.978916.

Bedaf, Sandra, and Luc de Witte. 2017. “Robots for Elderly Care: Their Level of Social Interactions and the Targeted End User.” *Studies in Health Technology and Informatics* 242: 472–78.

Beer, Jenay M., Cory-Ann Smarr, Tiffany L. Chen, Akanksha Prakash, Tracy L. Mitzner, Charles C. Kemp, and Wendy A. Rogers. 2012. “The Domesticated Robot: Design Guidelines for Assisting Older Adults to Age in Place.” In *Proceedings of the Seventh Annual ACM/IEEE International Conference on Human-Robot Interaction*, 335–342. HRI ’12. New York, NY, USA: ACM. https://doi.org/10.1145/2157689.2157806.

Begnum, M. E. N. 2018. *Ensuring Universal Design of ICT: Triggering the Triggers!* IOS Press. https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/2595543.

Begnum, M.E.N. 2016a. “Methodology for Universal Design of ITs; Epistemologies Among Norwegian Experts.” In *Computers Helping People with Special Needs*, edited by Klaus Miesenberger, Christian Bühler, and Petr Penaz, 121–28. Lecture Notes in Computer

Science. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-41264-1_17.

———. 2016b. "VIEWS ON UNIVERSAL DESIGN AND DISABILITIES AMONG NORWEGIAN EXPERTS ON UNIVERSAL DESIGN OF ICT." In *Paper Presented at NOKOBIT 2016 28-30 November*. Vol. 24 no. 1. Bergen, Norway: NOKOBIT, Bibsys Open Journal Systems.

Begnum, Miriam. 2017. "Universal Design Approaches among Norwegian Experts." In *Universal Access in Human-Computer Interaction. Design and Development Approaches and Methods: 11th International Conference, UAHCI 2017, Held as Part of HCI International 2017, Vancouver, BC, Canada, July 9–14, 2017, Proceedings, Part I*, edited by Margherita Antona and Constantine Stephanidis. Information Systems and Applications, Incl. Internet/Web, and HCI. Springer International Publishing. //www.springer.com/us/book/9783319587059.

Begnum, Miriam Eileen Nes. 2019. "Facilitating and Advancing Universal Design of ICT." Ph.D. Thesis, Gjövik, Norway: NTNU. https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/2634423.

Bellotti, Victoria, and Sara Bly. 1996. "Walking Away from the Desktop Computer: Distributed Collaboration and Mobility in a Product Design Team." In *Proceedings of the 1996 ACM Conference on Computer Supported Cooperative Work*, 209–218. CSCW '96. New York, NY, USA: ACM. https://doi.org/10.1145/240080.240256.

"Ben Goertzel: Here's How Sophia the Robot Works." 2018. *ANewDomain* (blog). June 11, 2018. http://anewdomain.net/ben-goertzel-how-sophia-the-robot-works/.

Benz, Carina, Torill Bull, Maurice Mittelmark, and Lenneke Vaandrager. 2014. "Culture in Salutogenesis: The Scholarship of Aaron Antonovsky." *Global Health Promotion* 21 (4): 16–23. https://doi.org/10.1177/1757975914528550.

Berget, Gerd, Jo Herstad, and Frode Eika Sandnes. 2016. "Search, Read and Write: An Inquiry into Web Accessibility for People with Dyslexia." *Studies in Health Technology and Informatics* 229: 450–60.

Berget, Gerd, and Frode Eika Sandnes. 2016. "Do Autocomplete Functions Reduce the Impact of Dyslexia on Information-Searching Behavior? The Case of Google." *Journal of the Association for Information Science and Technology* 67 (10): 2320–28. https://doi.org/10.1002/asi.23572.

Bergsjø, Onarheim Leonora, and Håkon Bergsjø. 2019. *Digital Etikk - Big data, algoritmer og kunstig intelligens*. Oslo, Norway: Universitetsforlaget. https://www.universitetsforlaget.no/digital-etikk-1.

Beyene, Tsedal, Pamela J. Hinds, and Catherine Durnell Cramton. 2009. "Walking Through Jelly: Language Proficiency, Emotions, and Disrupted Collaboration in Global Work." SSRN Scholarly Paper ID 1414343. Rochester, NY: Harvard Business School Organizational Behavior Unit, Social Science Research Network. https://papers.ssrn.com/abstract=1414343.

Bødker, Susanne. 2006. "When Second Wave HCI Meets Third Wave Challenges." In *Proceedings of the 4th Nordic Conference on Human-Computer Interaction: Changing Roles*, 1–8. NordiCHI '06. Oslo, Norway: Association for Computing Machinery. https://doi.org/10.1145/1182475.1182476.

———. 2015. "Third-Wave HCI, 10 Years Later—Participation and Sharing." In *Interactions.ACM.Org*, 24–31. http://interactions.acm.org/archive/view/september-october-2015/third-wave-hci-10-years-later-participation-and-sharing.

Bossen, Claus. 2002. "The Parameters of Common Information Spaces:: The Heterogeneity of Cooperative Work at a Hospital Ward." In *Proceedings of the 2002 ACM Conference on Computer Supported Cooperative Work - CSCW '02*, 176. New Orleans, Louisiana, USA: ACM Press. https://doi.org/10.1145/587078.587104.

Bossen, Claus, Lars Rune Christensen, Erik Grönvall, and Lasse Steenbock Vestergaard. 2013. "CareCoor: Augmenting the Coordination of Cooperative Home Care Work." *International Journal of Medical Informatics* 82 (5): e189–99. https://doi.org/10.1016/j.ijmedinf.2012.10.005.

Brandt, Eva, Thomas Binder, Lone Malmborg, and Tomas Sokoler. 2010. "Communities of Everyday Practice and Situated Elderliness As an Approach to Co-Design for Senior Interaction." In *Proceedings of the 22Nd Conference of the Computer-Human Interaction Special Interest Group of Australia on Computer-Human Interaction*, 400–403. OZCHI '10. New York, NY, USA: ACM. https://doi.org/10.1145/1952222.1952314.

Bratteteig, Tone, Diana Saplacan, Rebekka Soma, and Johanne Svanes Oskarsen. 2020. "Strengthening Human Autonomy in the Era of Autonomous Technology: Contemporary Perspectives on Interaction with 'Autonomous Things.'" In *NORDICHI'20 Workshop Proceedings*, 6. Tallinn, Estonia: ACM Press.

Bratteteig, Tone, and Ina Wagner. 2014. "Design Decisions and the Sharing of Power in PD." In *Proceedings of the 13th Participatory Design Conference: Short Papers, Industry Cases, Workshop Descriptions, Doctoral Consortium Papers, and Keynote Abstracts - Volume 2*, 29–32. PDC '14. New York, NY, USA: ACM. https://doi.org/10.1145/2662155.2662192.

Braun, Virginia, and Victoria Clarke. 2006. "Using Thematic Analysis in Psychology." *Qualitative Research in Psychology* 3 (2): 77–101. https://doi.org/10.1191/1478088706qp063oa.

Bue Lintho, Oda, and Miriam Begnum. 2018. "Towards Inclusive Service Design in the Digital Society: Current Practices and Future Recommendations." DS 91: Proceedings of NordDesign 2018, Linköping, Sweden, 14th - 17th August 2018. 2018. https://www.designsociety.org/publication/40964/Towards+Inclusive+Service+Design+in+the+Digital+Society%3A+Current+Practices+and+Future+Recommendations.

Burgstahler, Sheryl. 2017. "Bridging the Digital Divide in Postsecondary Education: Technology Access for Youth with Disabilities (NCSET Information Brief)," January. http://unicatalog.mediu.edu.my:8080/xmlui/handle/123456789/63479.

Caine, Kelly, Selma Šabanovic, and Mary Carter. 2012. "The Effect of Monitoring by Cameras and Robots on the Privacy Enhancing Behaviors of Older Adults." In *Proceedings of the Seventh Annual ACM/IEEE International Conference on Human-Robot Interaction*, 343–350. HRI '12. New York, NY, USA: ACM. https://doi.org/10.1145/2157689.2157807.

Calvo, Rafael A., and Dorian Peters. 2014. *Positive Computing: Technology for Well-Being and Human Potential*. The MIT Press.

Carstensen, Peter H., and Kjeld Schmidt. 1999. "Computer Supported Cooperative Work: New Challenges to Systems Design." *In K. Itoh (Ed.), Handbook of Human Factors*, 619–636.

CEN, CENELEC, and ETSI, eds. 2018. "Harmonised European Standard - Accessibility Requirements for ICT Products and Services." European Telecommunications Standards Institute. https://www.etsi.org/deliver/etsi_en/301500_301599/301549/02.01.02_60/en_301549v020102p.pdf.

Center for Universal Design, North Carolina State University. 2008. "Center for Universal Design NCSU - About the Center - Ronald L. Mace." 2008. https://projects.ncsu.edu/design/cud/about_us/usronmace.htm.

Cesta, Amedeo, Gabriella Cortellessa, Andrea Orlandini, and Lorenza Tiberio. 2016. "Long-Term Evaluation of a Telepresence Robot for the Elderly: Methodology and Ecological Case Study." *International Journal of Social Robotics* 8 (3): 421–41. https://doi.org/10.1007/s12369-016-0337-z.

Chalmers, Alan. 2013. *What Is This Thing Called Science?* 4. ed. Maidenhead: McGraw-Hill Education.

Christians, G. Clifford. 2005. "Ethics and Politics in Qualitative Research (Chapter 6)." In *The Sage Handbook of Qualitative Research Ed. by Yvonna S. Lincoln, Norman K. Denzin*, 139–64. SAGE Publications Ltd.

Ciborra, Claudio. 2006. "The Mind or the Heart? It Depends on the (Definition of) Situation." *Journal of Information Technology* 21 (3): 129–39. https://doi.org/10.1057/palgrave.jit.2000062.

Clark, Mike, and Nick Goodwin. 2010. "Sustaining Innovation in Telehealth and Telecare: WSDAN Briefing Paper." England: WSD Action Network.

Coates, Hamish, Richard James, and Gabrielle Baldwin. 2005. "A Critical Examination Of The Effects Of Learning Management Systems On University Teaching And Learning."

Tertiary Education and Management 11 (1): 19–36. https://doi.org/10.1007/s11233-004-3567-9.

Coeckelbergh, Mark. 2011. "Humans, Animals, and Robots: A Phenomenological Approach to Human-Robot Relations." *International Journal of Social Robotics* 3 (2): 197–204. https://doi.org/10.1007/s12369-010-0075-6.

Crang, Mike, and Ian Cook. 2007a. *Doing Ethnographies*. SAGE Publications, Inc.

———. 2007b. *Doing Ethnographies*. SAGE Publications, Inc.

Creswell, John W. 2007. *Qualitative Inquiry & Research Design: Choosing among Five Approaches*. 2nd ed. Thousand Oaks: Sage Publications.

Delello, Julie A., and Rochell R. McWhorter. 2017. "Reducing the Digital Divide: Connecting Older Adults to IPad Technology." *Journal of Applied Gerontology* 36 (1): 3–28. https://doi.org/10.1177/0733464815589985.

Dijk, Jan van, and Kenneth Hacker. 2003. "The Digital Divide as a Complex and Dynamic Phenomenon." *The Information Society* 19 (4): 315–26. https://doi.org/10.1080/01972240309487.

Doelling, Kris, Jeongsik Shin, and Dan O. Popa. 2014. "Service Robotics for the Home: A State of the Art Review." In *Proceedings of the 7th International Conference on PErvasive Technologies Related to Assistive Environments*, 35:1–35:8. PETRA '14. New York, NY, USA: ACM. https://doi.org/10.1145/2674396.2674459.

Dourish, Paul. 2001. *Where the Action Is: The Foundations of Embodied Interaction*. Cambridge, Mass: MIT Press.

Dreyfus, Hubert L. 1991. *Being- in – the – World – A Commentary on Heidegger's Being and Time, Division 1*. Cambridge, MA: MIT Press.

Duarte, Emanuel Felipe, and M. Cecília C. Baranauskas. 2016. "Revisiting the Three HCI Waves: A Preliminary Discussion on Philosophy of Science and Research Paradigms." In *Proceedings of the 15th Brazilian Symposium on Human Factors in Computing Systems*, 1–4. IHC '16. São Paulo, Brazil: Association for Computing Machinery. https://doi.org/10.1145/3033701.3033740.

Ess, Charles. 2015. "New Selves, New Research Ethics?" In *Internet Research Ethics, Fossheim, Hallvard, and Ingjerd, Helene.*, 48-76/175. https://press.nordicopenaccess.no/index.php/noasp/catalog/book/3.

Ess, Charles, and Hallvard Fossheim. 2013. "Personal Data: Changing Selves, Changing Privacies." In *Digital Enlightenment Yearbook*, 40–55. IOS Press. http://ebooks.iospress.nl/publication/35131.

EUR-LEX. 2016. *Directive (EU) 2016/2102 of the European Parliament and of the Council of 26 October 2016 on the Accessibility of the Websites and Mobile Applications of Public Sector Bodies (Text with EEA Relevance). 327*. Vol. OJ L. http://data.europa.eu/eli/dir/2016/2102/oj/eng.

European Commission. 2018a. "Digital Education Action Plan - Education and Training - European Commission." Education and Training. January 8, 2018. https://ec.europa.eu/education/initiatives/european-education-area/digital-education-action-plan_en.

———. 2018b. "Digital Learning & ICT in Education." Text. Shaping Europe's Digital Future - European Commission. January 15, 2018. https://ec.europa.eu/digital-single-market/en/policies/digital-learning-ict-education.

European Commission. 2016a. "Digital Inclusion for a Better EU Society." Digital Single Market. 2016. https://ec.europa.eu/digital-single-market/en/digital-inclusion-better-eu-society.

———. 2016b. "Opening Up Education." Digital Single Market. October 18, 2016. https://ec.europa.eu/digital-single-market/en/opening-education.

European Union. 2018. "The 2018 Ageing Report: Policy Challenges for Ageing Societies." Institutional Report 079. Economic & Budgetary Projections for the 28 EU Member States (2016-2070). https://ec.europa.eu/info/news/economy-finance/policy-implications-ageing-examined-new-report-2018-may-25_en.

Evenson, Shelley, Justin Rheinfrank, and Hugh Dubberly. 2010. "Ability-Centered Design: From Static to Adaptive Worlds." *Interactions* 17 (6): 75–79. https://doi.org/10.1145/1865245.1865263.

Fällman, Daniel. 2003. "In Romance with the Materials of Mobile Interaction : A Phenomenological Approach to the Design of Mobile Information Technology." Ph.D. Thesis, Umeå University. http://urn.kb.se/resolve?urn=urn:nbn:se:umu:diva-170.

Fallman, Daniel. 2011. "The New Good: Exploring the Potential of Philosophy of Technology to Contribute to Human-Computer Interaction." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1051–1060. CHI '11. Vancouver, BC, Canada: Association for Computing Machinery. https://doi.org/10.1145/1978942.1979099.

Farooq, Umer, and Jonathan Grudin. 2016. "Human-Computer Integration." *Interactions* 23 (6): 26–32. https://doi.org/10.1145/3001896.

Felzmann, Heike, Kathy Murphy, Dympna Casey, and Oya Beyan. 2015. "Robot-Assisted Care for Elderly with Dementia: Is There a Potential for Genuine End-User Empowerment?" In *The Emerging Policy and Ethics of Human-Robot Interaction*. Portland, Oregon, USA.

Fernaeus, Ylva, Sara Ljungblad, Mattias Jacobsson, and Alex Taylor. 2009. "Where Third Wave HCI Meets HRI: Report from a Workshop on User-Centred Design of Robots." In *Proceedings of the 4th ACM/IEEE International Conference on Human-Robot Interaction*, 293–294. HRI '09. La Jolla, California, USA: Association for Computing Machinery. https://doi.org/10.1145/1514095.1514182.

Field, D., and M. Minkler. 1988. "Continuity and Change in Social Support between Young-Old and Old-Old or Very-Old Age." *Journal of Gerontology* 43 (4): P100-106.

Flyvbjerg, Bent. 2006. "Five Misunderstandings About Case-Study Research." *Qualitative Inquiry* 12 (2): 219–45. https://doi.org/10.1177/1077800405284363.

Forlizzi, Jodi. 2007a. "How Robotic Products Become Social Products: An Ethnographic Study of Cleaning in the Home." In *Proceedings of the ACM/IEEE International Conference on Human-Robot Interaction*, 129–136. HRI '07. New York, NY, USA: ACM. https://doi.org/10.1145/1228716.1228734.

———. 2007b. "Product Ecologies: Understanding the Context of Use Surrounding Products." Doctoral Thesis, U.S.: Carnegie Mellon University, School og Computer Science. https://jodiforlizzi.com/sites/default/files/ForlizziDoctoralDissertation.pdf.

———. 2018. "Moving beyond User-Centered Design." *Interactions* 25 (5): 22–23. https://doi.org/10.1145/3239558.

Forlizzi, Jodi, and Carl DiSalvo. 2006. "Service Robots in the Domestic Environment: A Study of the Roomba Vacuum in the Home." In *Proceedings of the 1st ACM SIGCHI/SIGART Conference on Human-Robot Interaction*, 258–265. HRI '06. New York, NY, USA: ACM. https://doi.org/10.1145/1121241.1121286.

Frauenberger, Christopher. 2007. "Ears))): A Methodological Framework for Auditory Display Design." In *CHI '07 Extended Abstracts on Human Factors in Computing Systems*, 1641–1644. CHI EA '07. San Jose, CA, USA: Association for Computing Machinery. https://doi.org/10.1145/1240866.1240872.

———. 2015. "Rethinking Autism and Technology." *Interactions* 22 (2): 57–59. https://doi.org/10.1145/2728604.

———. 2018. "Session Details: Designing for Different Abilities." In *Proceedings of the 17th ACM Conference on Interaction Design and Children*. IDC '18. Trondheim, Norway: Association for Computing Machinery. https://doi.org/10.1145/3247767.

———. 2019. "Entanglement HCI The Next Wave?" *ACM Transactions on Computer-Human Interaction* 27 (1): 2:1–2:27. https://doi.org/10.1145/3364998.

Frauenberger, Christopher, Judith Good, and Wendy Keay-Bright. 2010. "Phenomenology, a Framework for Participatory Design." In *Proceedings of the 11th Biennial Participatory Design Conference*, 187–190. PDC '10. Sydney, Australia: Association for Computing Machinery. https://doi.org/10.1145/1900441.1900474.

Fuchs, Christian, and Marianna Obrist. 2010. "HCI and Society: Towards a Typology of Universal Design Principles." *International Journal of Human-Computer Interaction* 26 (6): 638–56. https://doi.org/10.1080/10447311003781334.

Fuglerud, Kristin Skeide. 2014. "Inclusive Design of ICT: The Challenge of Diversity." Oslo, Norway: University of Oslo. https://www.researchgate.net/publication/270508482_Inclusive_design_of_ICT_The_challenge_of_diversity.

Gallagher, Shaun. 2012. "What Is Phenomenology?" In *Phenomenology*, edited by Shaun Gallagher, 7–18. Palgrave Philosophy Today. London: Palgrave Macmillan UK. https://doi.org/10.1057/9781137283801_2.

———. 2020. *Phenomenology*. https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/phenomenology.

Gaver, Bill, Tony Dunne, and Elena Pacenti. 1999. "Design: Cultural Probes." *Interactions* 6 (1): 21–29. https://doi.org/10.1145/291224.291235.

Gendlin, Eugene T. 1978. "Befindlichkeit: Heidegger and the Philosophy of Psychology." *Review of Existential Psychology & Psychiatry: Heidegger and Psychology* XVI (I, 2 & 3). http://previous.focusing.org/gendlin_befindlichkeit.html.

Giannoumis, G. Anthony. 2016. "Framing the Universal Design of Information and Communication Technology: An Interdisciplinary Model for Research and Practice." *Studies in Health Technology and Informatics* 229: 492–505.

Gibson, J. 1979. *The Ecological Approach to Visual Perception*. Boston: Houghton-Mifflin.

Giusti, L., and P. Marti. 2006. "Interpretative Dynamics in Human-Robot Interaction." In *ROMAN 2006 - The 15th IEEE International Symposium on Robot and Human Interactive Communication*, 111–16. https://doi.org/10.1109/ROMAN.2006.314403.

González-Jiménez, J., C. Galindo, and J. R. Ruiz-Sarmiento. 2012. "Technical Improvements of the Giraff Telepresence Robot Based on Users' Evaluation." In *2012 IEEE RO-MAN: The 21st IEEE International Symposium on Robot and Human Interactive Communication*, 827–32. https://doi.org/10.1109/ROMAN.2012.6343854.

Goodrich, Michael A., and Alan C. Schultz. 2007. "Human-Robot Interaction: A Survey." *Foundations and Trends in Human-Computer Interaction* 1 (3): 203–275. https://doi.org/10.1561/1100000005.

Graf, B. 2001. "Reactive Navigation of an Intelligent Robotic Walking Aid." In *Proceedings 10th IEEE International Workshop on Robot and Human Interactive Communication. ROMAN 2001 (Cat. No.01TH8591)*, 353–58. https://doi.org/10.1109/ROMAN.2001.981929.

Graf, Birgit, Matthias Hans, and Rolf D. Schraft. 2004. "Care-O-Bot II—Development of a Next Generation Robotic Home Assistant." *Autonomous Robots,* 16 (2): 193–205. https://doi.org/10.1023/B:AURO.0000016865.35796.e9.

Graf, Sabine. 2007. "Adaptivity in Learning Management Systems Focussing on Learning Styles." Ph.D. Thesis, Vienna, Austria: Vienna University of Technology, Faculty of Informatics, Institute for Software Technology and Interactive Systems. http://sgraf.athabascau.ca/publications/PhDthesis_SabineGraf.pdf.

Graneheim, U. H, and B Lundman. 2004. "Qualitative Content Analysis in Nursing Research: Concepts, Procedures and Measures to Achieve Trustworthiness." *Nurse Education Today* 24 (2): 105–12. https://doi.org/10.1016/j.nedt.2003.10.001.

Grudin, Jonathan. 1994. "Computer-Supported Cooperative Work: History and Focus." *Computer* 27 (5): 19–26. https://doi.org/10.1109/2.291294.

Grue, Jan. 2011. "Interdependent Discourses of Disability - A Critical Analysis of the Social/Medical Model Dichotomy." Ph.D. Thesis, Oslo, Norway: University of Oslo. https://www.duo.uio.no/handle/10852/26291.

Guba, E.G., and Y. S. Lincoln. 2005. "Paradigmatic Controversies, Contradictions, and Emerging Confluences." In *Denzin, N.K. and Lincoln, Y.S., Eds., The Sage Handbook of Qualitative Research*, 3rd ed., 191–215. Sage, Thousand Oaks.

Haavardsholm, Oscar, Haakon Vennemo, and Siri Kessel. 2018. "Samfunnsøkonomiske Konsekvenser Av Nye Krav Om Tilgjengelighet Til Nettsider Og Mobilapplikasjoner." 2018/01. Kommunal- og moderniseringsdepartementet. https://vista-analyse.no/no/publikasjoner/samfunnsokonomiske-konsekvenser-av-nye-krav-om-tilgjengelighet-til-nettsider-og-mobilapplikasjoner/.

Harrison, Steve, Phoebe Sengers, and Deborah Tatar. 2007. “The Three Paradigms of HCI.” In *In Proceedings of Alt.Chi [Online]. Available: Http://People.Cs.vt.Edu/ Srh/Downloads/Hci%20journal%20thethreeparadigms Ofhci.Pdf*.
Hartman, Jan. 2004. *Vetenskapligt Tänkande - Från Kunskapsteori till Metodteori*. Lund, Sweden: Studentlitteratur AB.
Heath, Christian, and Paul Luff. 1991. “Collaborative Activity and Technological Design: Task Coordination in London Underground Control Rooms.” In *Proceedings of the Second Conference on European Conference on Computer-Supported Cooperative Work*, 65–80. ECSCW’91. Norwell, MA, USA: Kluwer Academic Publishers. http://dl.acm.org/citation.cfm?id=1241910.1241915.
Heidegger, Martin. 2010. *Being and Time*. Edited by Joan Stambaugh and Dennis J. Schmidt. SUNY Series in Contemporary Continental Philosophy. Albany: State University of New York Press.
Herstad, Jo, and Harald Holone. 2012. “Making Sense of Co-Creative Tangibles Through the Concept of Familiarity.” In *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design*, 89–98. NordiCHI ’12. New York, NY, USA: ACM. https://doi.org/10.1145/2399016.2399031.
Hewett, Thomas T, Ronald Baecker, Stuart Card, Tom Carey, Jean Gasen, Marilyn Mantei, Gary Perlman, Gary Strong, and William Verplank. 1992. “ACM SIGCHI Curricula for Human-Computer Interaction : 2. Definition and Overview of Human-Computer Interaction.” ACM SIGCHI. http://old.sigchi.org/cdg/cdg2.html#2_1.
Hoefinghoff, Jens, Astrid Rosenthal-von der Pütten, Josef Pauli, and Nicole Krämer. 2015. “‘Yes Dear, That Belongs into the Shelf!’ - Exploratory Studies with Elderly People Who Learn to Train an Adaptive Robot Companion.” In *Social Robotics*, edited by Adriana Tapus, Elisabeth André, Jean-Claude Martin, François Ferland, and Mehdi Ammi, 235–44. Lecture Notes in Computer Science. Springer International Publishing.
Hoffman, Guy. 2007. “Ensemble: Fluency and Embodiment for Robots Acting with Humans.” Ph.D. Thesis, Cambridge, MA, USA: Massachusetts Institute of Technology.
———. 2015. “Designing Fluent Human-Robot Collaboration.” In *Proceedings of the 3rd International Conference on Human-Agent Interaction*, 1–1. HAI ’15. New York, NY, USA: ACM. https://doi.org/10.1145/2814940.2815016.
Holter, Harriet, and Ragnvald Kalleberg, eds. 1996. *Kvalitative metoder i samfunnsforskning*. *Norbok*. 2. utg. Universitetsforlagets metodebibliotek. Oslo: Universitetsforl. https://urn.nb.no/URN:NBN:no-nb_digibok_2010041305025.
Höök, Kristina. 2018. *Designing with the Body - Somaesthetic Interaction Design*. https://mitpress.mit.edu/books/designing-body.
Iachello, Giovanni, and Jason Hong. 2007. “Understanding, Building, and Evaluating Privacy in Interactive Systems (Chapter 3) in End-User Privacy in Human-Computer Interaction.” In *Found. Trends Hum.-Comput. Interact.*, 1:1–137. Hanover, MA, USA: Now Publishers Inc. http://dx.doi.org/10.1561/1100000004.
International Organization for Standardization. 2017. “ISO 10218-1:2011 - Robots and Robotic Devices -- Safety Requirements for Industrial Robots -- Part 1: Robots.” International Organization for Standardization. July 2017. https://www.iso.org/standard/51330.html.
ISO/IEC. 2019. “ISO/IEC 30071-1:2019(En), Information Technology — Development of User Interface Accessibility — Part 1: Code of Practice for Creating Accessible ICT Products and Services.” 2019. https://www.iso.org/obp/ui/#iso:std:iso-iec:30071:-1:ed-1:v1:en.
Joshi, Suhas Govind. 2015. “Designing for Experienced Simplicity. Why Analytic and Imagined Simplicity Fail in Design of Assistive Technology.” *International Journal On Advances in Intelligent Systems* 8 (3 and 4): 324–38. https://www.thinkmind.org/index.php?view=article&articleid=intsys_v8_n34_2015_9.
———. 2017. “Designing for Capabilities: A Phenomenological Approach to the Design of Enabling Technologies for Older Adults.” https://www.duo.uio.no/handle/10852/58738.
Joshi, Suhas Govind, and Tone Bratteteig. 2016. “Designing for Prolonged Mastery. On Involving Old People in Participatory Design.” *Scandinavian Journal of Information Systems* 28 (1). https://www.duo.uio.no/handle/10852/58736.

Jupp, Julie, Patrick Langdon, and Simon Godsill. 2007. "Mobile Computing in Maintenance Activities: A 'Situational Induced Impairments and Disabilities' Perspective." In *Universal Acess in Human-Computer Interaction. Coping with Diversity*, edited by Constantine Stephanidis, 696–705. Lecture Notes in Computer Science. Berlin, Heidelberg: Springer. https://doi.org/10.1007/978-3-540-73279-2_77.

Kalleberg, Ragnvald. 1992. "A Constructive Turn in Sociology." 19. Oslo, Norway: Department of Sociology, University of Oslo.

Kaptelinin, Victor, Bonnie Nardi, Susanne Bødker, John Carroll, Jim Hollan, Edwin Hutchins, and Terry Winograd. 2003. "Post-Cognitivist HCI: Second-Wave Theories." In *CHI '03 Extended Abstracts on Human Factors in Computing Systems*, 692–693. CHI EA '03. Ft. Lauderdale, Florida, USA: Association for Computing Machinery. https://doi.org/10.1145/765891.765933.

Kittay, Eva Feder. 2011. "The Ethics of Care, Dependence, and Disability*." *Ratio Juris* 24 (1): 49–58. https://doi.org/10.1111/j.1467-9337.2010.00473.x.

Knorr, D. Karin. 1979. "Tinkering toward Success: Prelude to a Theory of Scientific Practice." In *Theory and Society*, 3:347–76. Springer. https://www.jstor.org/stable/656764.

Kommunal- og moderniseringsdepartementet. 2013. "Forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger - Lovdata." 2013. https://lovdata.no/dokument/SF/forskrift/2013-06-21-732?q=universell%20utforming.

———. 2017. "Forskrift Om Endring i Forskrift Om Universell Utforming Av Informasjons- Og Kommunikasjonsteknologiske (IKT)-Løsninger - Lovdata." September 20, 2017. https://lovdata.no/dokument/LTI/forskrift/2017-09-13-1417.

Kommunal-og moderniseringsdepartemenet. 2016. "Meld. St. 27 (2015–2016)." Stortingsmelding. Regjeringen.no. regjeringen.no. April 15, 2016. https://www.regjeringen.no/no/dokumenter/meld.-st.-27-20152016/id2483795/.

Kuhn, Thomas S. 1970. *The Structure of Scientific Revolutions*. Fourth edition. Chicago: The University of Chicago Press. https://nemenmanlab.org/~ilya/images/c/c5/Kuhn-1970.pdf.

Kulturdepartementet. 2020. "Spørsmål og svar om WAD." Innhold. Regjeringen.no. regjeringen.no. March 31, 2020. https://www.regjeringen.no/no/aktuelt/dep/kud/nyheter/2020/efta-prosess-forsinker-nasjonal-gjennomforing-av-eus-regler-om-universell-utforming-av-ikt2/sporsmal-og-svar-om-wad/id2694878/.

Labonte, R., J. Feather, and M. Hills. 1999. "A Story/Dialogue Method for Health Promotion Knowledge Development and Evaluation." *Health Education Research* 14 (1): 39–50.

Labonté, Ronald. 2011a. "Reflections on Stories and a Story/Dialogue Method in Health Research." *International Journal of Social Research Methodology* 14 (2): 153–63. https://doi.org/10.1080/13645579.2010.492131.

———. 2011b. "Reflections on Stories and a Story/Dialogue Method in Health Research." *International Journal of Social Research Methodology* 14 (2): 153–63. https://doi.org/10.1080/13645579.2010.492131.

Labonte, Ronald, and Joan Feather. 1996. *Handbook on Using Stories in Health Promotion Practice*. The University of Saskatchewan.

Lanterman. 2011. "Universal Design for Learning (UDL) Guidelines: Full-Text Representation, Version 2.0." http://nau.edu/uploadedFiles/Academic/SBS/IHD/Research/Lanterman,%20UDL_Guidelines_Version_2.0_(Final).pdf.

Latour, B. 1999. "Circulating Reference - Sampling the Soil in the Amazon Forest." *In Pandoras Hope. Essays on the Reality of Science Studies. Ch. 2*, 24–79. Harvard University Press.

Laverack, G., and R. Labonte. 2000. "A Planning Framework for Community Empowerment Goals within Health Promotion." *Health Policy and Planning* 15 (3): 255–62.

Lee, Min Kyung, Sara Kiesler, Jodi Forlizzi, Siddhartha Srinivasa, and Paul Rybski. 2010. "Gracefully Mitigating Breakdowns in Robotic Services." *2010 5th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, March, 203–10. https://doi.org/10.1109/HRI.2010.5453195.

Lid, Inger Marie. 2013. “Developing the Theoretical Content in Universal Design.” *Scandinavian Journal of Disability Research* 15 (3): 203–15. https://doi.org/10.1080/15017419.2012.724445.

———. 2014. “Universal Design and Disability: An Interdisciplinary Perspective.” *Disability and Rehabilitation* 36 (16): 1344–49. https://doi.org/10.3109/09638288.2014.931472.

Ljungblad, Sara, Jirina Kotrbova, Mattias Jacobsson, Henriette Cramer, and Karol Niechwiadowicz. 2012. “Hospital Robot at Work: Something Alien or an Intelligent Colleague?” In *Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work*, 177–186. CSCW ’12. New York, NY, USA: ACM. https://doi.org/10.1145/2145204.2145233.

Lonn, Steven, and Stephanie D. Teasley. 2009. “Saving Time or Innovating Practice: Investigating Perceptions and Uses of Learning Management Systems.” *Computers & Education* 53 (3): 686–94. https://doi.org/10.1016/j.compedu.2009.04.008.

Lovdata. 2017. “Lov Om Likestilling Og Forbud Mot Diskriminering (Likestillings- Og Diskrimineringsloven) - Lovdata.” June 16, 2017. https://lovdata.no/dokument/NL/lov/2017-06-16-51?q=diskriminering.

Lübcke, Poul, Arne Grøn, Jørgen Husted, Peter Sandøe, and C. Niels Stefansen. 1996. *Filosofileksikon*. Edited by Paul Lübcke. Oslo: Zafari forlag.

Machado, Michael, and Eric Tao. 2007. “Blackboard vs. Moodle: Comparing User Experience of Learning Management Systems.” In *2007 37th Annual Frontiers In Education Conference - Global Engineering: Knowledge Without Borders, Opportunities Without Passports*, S4J-7-S4J-12. https://doi.org/10.1109/FIE.2007.4417910.

Macpherson, Kerr, Garreth W. Tigwell, Rachel Menzies, and David R. Flatla. 2018. “BrightLights: Gamifying Data Capture for Situational Visual Impairments.” In *Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility*, 355–357. ASSETS ’18. New York, NY, USA: ACM. https://doi.org/10.1145/3234695.3241030.

Malpas, Jeff. 2016. “Hans-Georg Gadamer.” In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta, Winter 2016. Metaphysics Research Lab, Stanford University. https://plato.stanford.edu/archives/win2016/entries/gadamer/.

Malterud, Kirsti. 2012. “Systematic Text Condensation: A Strategy for Qualitative Analysis.” *Scandinavian Journal of Public Health* 40 (8): 795–805. https://doi.org/10.1177/1403494812465030.

Manen, Max van. 2006. “Writing Qualitatively, or the Demands of Writing.” *Qualitative Health Research* 16 (5): 713–22. https://doi.org/10.1177/1049732306286911.

Markham, Annette N. 2005. “The Methods, Politics, and Ethics of Representation in Online Ethnography.” In *The Sage Handbook of Qualitative Research, SAGE, Thousand Oaks, CA*, 793–820.

Markham, Annette N., and Elizabeth Buchanan. 2012. “Ethical Decision-Making and Internet Research: Recommendations from the AoIR Ethics Working Committee (Version 2.0).” Association of Internet Researchers (AoIR). https://aoir.org/reports/ethics2.pdf.

Matsuhira, Nobuto, Junko Hirokawa, Hideki Ogawa, and Tatsuya Wada. 2009. “Universal Design with Robots for the Wide Use of Robots - Core Concept for Interaction Design between Robots and Environment -.” In *2009 ICCAS-SICE*, 1654–57.

Matsuhira, Nobuto, Junko Hirokawa, Hideki Ogawa, and Tatsuya W. 2008. “Universal Design with Robots Toward the Wide Use of Robots in Daily Life Environment.” In *Advances in Service Robotics*, edited by Ho Seok. InTech. https://doi.org/10.5772/5941.

McGlynn, Sean A., Shawn Kemple, Tracy L. Mitzner, Chih-Hung Aaron King, and Wendy A. Rogers. 2017. “Understanding the Potential of PARO for Healthy Older Adults.” *International Journal of Human-Computer Studies* 100 (April): 33–47. https://doi.org/10.1016/j.ijhcs.2016.12.004.

McGrath, Kathy. 2005. “Doing Critical Research in Information Systems: A Case of Theory and Practice Not Informing Each Other*.” *Information Systems Journal* 15 (2): 85–101. https://doi.org/10.1111/j.1365-2575.2005.00187.x.

"Meet Sophia, the Female Humanoid Robot and Newest SXSW Celebrity." 2016. PCWorld. March 17, 2016. https://www.macworld.com/article/3045299/meet-sophia-the-female-humanoid-robot-and-newest-sxsw-celebrity.html.

Merleau-Ponty, Maurice. 1962. *Phenomenology of Perception*. Psychology Press.

Ministry of Education and Research. 2017. "Meld. St. 16 (2016–2017)." Stortingsmelding. Government.No. regjeringen.no. January 27, 2017. https://www.regjeringen.no/en/dokumenter/meld.-st.-16-20162017/id2536007/.

Ministry of Local Government and Modernisation. 2019. "One Digital Public Sector." Plan. Government.No. regjeringen.no. June 11, 2019. https://www.regjeringen.no/en/dokumenter/one-digital-public-sector/id2653874/.

Monteiro, Eric, Neil Pollock, Ole Hanseth, and Robin Williams. 2013. "From Artefacts to Infrastructures." *Computer Supported Cooperative Work (CSCW)* 22 (4): 575–607. https://doi.org/10.1007/s10606-012-9167-1.

Moore, Stephanie L., 2007. Review of *Review of Teaching Every Student in the Digital Age: Universal Design for Learning*, by David H. Rose and Anne Meyer. *Educational Technology Research and Development* 55 (5): 521–25. http://www.jstor.org/stable/30220506.

Mori, Masahiro. 2012. "The Uncanny Valley: The Original Essay by Masahiro Mori." IEEE Spectrum: Technology, Engineering, and Science News. June 12, 2012. https://spectrum.ieee.org/automaton/robotics/humanoids/the-uncanny-valley.

Mott, Martez E., and Jacob O. Wobbrock. 2019. "Cluster Touch: Improving Touch Accuracy on Smartphones for People with Motor and Situational Impairments." In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, 27:1–27:14. CHI '19. New York, NY, USA: ACM. https://doi.org/10.1145/3290605.3300257.

Mueller, Florian Floyd, Pedro Lopes, Paul Strohmeier, Wendy Ju, Caitlyn Seim, Martin Weigel, Suranga Nanayakkara, et al. 2020. "Next Steps for Human-Computer Integration." In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–15. CHI '20. Honolulu, HI, USA: Association for Computing Machinery. https://doi.org/10.1145/3313831.3376242.

Mutlu, Bilge, and Jodi Forlizzi. 2008. "Robots in Organizations: The Role of Workflow, Social, and Environmental Factors in Human-Robot Interaction." In *Proceedings of the 3rd ACM/IEEE International Conference on Human-Robot Interaction*, 287–294. HRI '08. New York, NY, USA: ACM. https://doi.org/10.1145/1349822.1349860.

Newaz, Fahd, and Diana Saplacan. 2018. "Exploring the Role of Feedback on Trust for the Robots Used in Homes of the Elderly." In *Proceedings of the 10th Nordic Conference on Human-Computer Interaction*, 681–685. NordiCHI '18. New York, NY, USA: ACM. https://doi.org/10.1145/3240167.3240248.

Nordic Centre for Welfare and Social Issues. 2017. "Welfare Technology." Nordic Centre for Welfare and Social Issues. http://www.nordicwelfare.org/PageFiles/5488/Velferdsteknologi_eng.pdf.

———. n.d. "Welfare Technology." Nordic Centre for Welfare and Social Issues. Accessed December 10, 2017. http://www.nordicwelfare.org/PageFiles/5488/Velferdsteknologi_eng.pdf.

Norman, Donald A. 2013. *The Design of Everyday Things*. Revised and Expanded Edition. New York, New York: Basic Books.

Norris, Pippa. 2001. "Digital Divide: Civic Engagement, Information Poverty, and the Internet Worldwide." http://ictlogy.net/bibliography/reports/projects.php?idp=826.

Nygaard, Kristen. 1992. "How Many Basic Choices Do We Really Make? How Many Are Difficult?" *Proceedings from Software Development and Reality Construction*, 1992, Springer-Verlag edition. http://hannemyr.com/cache/kn_sdrc92.pdf.

Oborn, Eivor, Michael Barrett, and Ara Darzi. 2011. "Robots and Service Innovation in Health Care." *Journal of Health Services Research & Policy* 16 (1): 46–50. https://doi.org/10.1258/jhsrp.2010.010001.

OECD. 2009. "Higher Education to 2030" 2 Globalisation: 4. https://www.oecd.org/education/ceri/44101074.pdf.

OED. 2017. "Robot | Definition of Robot in English by Oxford Dictionaries." In *Oxford Dictionaries | English*. Oxford University Press. https://en.oxforddictionaries.com/definition/robot.
Oskarsen, Johanne Svanes. 2018. "Human-Supported Robot Work." Master Thesis, Oslo, Norway: the University of Oslo, Department of Informatics, Faculty of mathematics and natural sciences. https://www.duo.uio.no/handle/10852/62808.
Østerberg, Dag. 2011. *Kritisk situasjonsfilosofi*. *NFFO*. Oslo: Gyldendal akademisk. https://urn.nb.no/URN:NBN:no-nb_digibok_2015102008006.
Ottenberg, S. 1990. "Thirty Years of Fieldnotes: Changing Relationships to the Text." In *The Making of Anthropology, R. Sanjek*, 139–60. Cornell University Press.
Oxford English Dictionary. 2020a. "Ability, n." In *Oxford English Dictionary Online*. Oxford University Press. https://www.oed.com/view/Entry/313.
———. 2020b. "Theory, n." In *OED Online*. Oxford University Press. https://www.oed.com/view/Entry/200431.
Ozkil, A. G., Z. Fan, S. Dawids, H. Aanes, J. K. Kristensen, and K. H. Christensen. 2009. "Service Robots for Hospitals: A Case Study of Transportation Tasks in a Hospital." In *2009 IEEE International Conference on Automation and Logistics*, 289–94. https://doi.org/10.1109/ICAL.2009.5262912.
Pantofaru, Caroline, Leila Takayama, Tully Foote, and Bianca Soto. 2012. "Exploring the Role of Robots in Home Organization." In *Proceedings of the Seventh Annual ACM/IEEE International Conference on Human-Robot Interaction*, 327–334. HRI '12. New York, NY, USA: ACM. https://doi.org/10.1145/2157689.2157805.
Petersen, Anette C. M., Lars Rune Christensen, and Thomas T. Hildebrandt. 2020. "The Role of Discretion in the Age of Automation." *Computer Supported Cooperative Work (CSCW)* 29 (3): 303–33. https://doi.org/10.1007/s10606-020-09371-3.
Petrie, Helen, and Jenny Darzentas. 2017. "Older People and Robotic Technologies in the Home: Perspectives from Recent Research Literature." In *Proceedings of the 10th International Conference on PErvasive Technologies Related to Assistive Environments*, 29–36. PETRA '17. New York, NY, USA: ACM. https://doi.org/10.1145/3056540.3056553.
Picard, R.W. 1995. "Affective Computing in M.I.T Media Laboratory Perceptual Computing Section Technical Report." Technical Report 321. Cambridge, MA 02139: MIT Media Laboratory, Perceptual Computing. http://affect.media.mit.edu/pdfs/95.picard.pdf.
Pigini, Lucia, David Facal, Lorenzo Blasi, and Renzo Andrich. 2012. "Service Robots in Elderly Care at Home: Users' Needs and Perceptions as a Basis for Concept Development." *Technology and Disability* 24 (4): 303–11. https://doi.org/10.3233/TAD-120361.
PROBA samfunnsanalyse. 2018. "Barrierer i høyere utdanning for personer med nedsatt funksjonsevne." 2018–02, Project number 17040. PROBA Samfunnsanalyse. https://www.bufdir.no/Bibliotek/Dokumentside/?docId=BUF00004579.
Randall, Dave, R. Harper, and M. Rouncefield. 2007. "Ethnography and How to Do It, Chapter 6." In *Fieldwork for Design*, 169–97. Springer London. http://link.springer.com/chapter/10.1007/978-1-84628-768-8_6.
Riek, Laurel D. 2017. "Healthcare Robotics." In *ACM Communications*, 11th ed., 60:68–78. https://m-cacm.acm.org/magazines/2017/11/222171-healthcare-robotics/fulltext?mobile=true.
Robertson, Toni. 2002. "The Public Availability of Actions and Artefacts." *Computer Supported Cooperative Work (CSCW)* 11 (3): 299–316. https://doi.org/10.1023/A:1021214827446.
Rose, David H., Wendy S. Harbour, Catherine Sam Johnston, Samantha G. Daley, and Linda Abarbanell. 2006. "Universal Design for Learning in Postsecondary Education: Reflections on Principles and Their Application." *Journal of Postsecondary Education and Disability* 19 (2): 135–51. https://eric.ed.gov/?id=EJ844630.
Rose, David H., and Anne Meyer. 2002. *Teaching Every Student in the Digital Age: Universal Design for Learning*. Association for Supervision and Curriculum Development, 1703 N.
———. 2006. *A Practical Reader in Universal Design for Learning*. Harvard Education Press.
Rossi, Alessandra, Kerstin Dautenhahn, Kheng Lee Koay, and Joe Saunders. 2017. "Investigating Human Perceptions of Trust in Robots for Safe HRI in Home Environments." In *Proceedings of the Companion of the 2017 ACM/IEEE International Conference on*

Human-Robot Interaction, 375–376. HRI '17. New York, NY, USA: ACM. https://doi.org/10.1145/3029798.3034822.

Saplacan, D. 2020a. "Cross-Use of Digital Learning Environments in Higher Education: A Conceptual Analysis Grounded in Common Information Spaces." In *Proceedings of The Thirteenth International Conference on Advances in Computer-Human Interactions ACHI 2020*, 10. Valencia, Spain: Technische Informationsbibliothek (TIB) - German National Library of Science and Technology.

———. 2020b. "Situated Ability: A Case from Higher Education on Digital Learning Environments." In *Lecture Notes in Computer Science, Springer, Ch. 19*, edited by M Antona and C. Stephanidis, HCII 2020:1–19. LNCS 12189. Springer Nature, Switzerland. https://doi.org/10.1007/978-3-030-49108-6_19.

Saplacan, D., and J. Herstad. 2019. "An Explorative Study on Motion as Feedback: Using Semi-Autonomous Robots in Domestic Settings:" *International Journal On Advances in Software* 12 (1 & 2): 23.

Saplacan, D., J. Herstad, and Z. Pajalic. 2020. "An Analysis of Independent Living Elderly's Views on Robots - A Descriptive Study from the Norwegian Context." In *Proceedings of The International Conference on Advances in Computer-Human Interactions (ACHI)*. Valencia, Spain: IARIA Conferences.

Saplacan, D., J. Herstad, and T. Schulz. 2020. "Situated Abilities within Universal Design - A Theoretical Exploration: The Case of The Robotic Wood Table." *Int. Journal of Advances in Intelligent Systems* 13 (3 & 4): 14.

Saplacan, D., J. Herstad, J. Tørresen, and Z. Pajalic. 2020a. "Division of Work Tasks between Humans and Robots: An Instrumental Analytical Study from the Home." *Multimodal Technologies and Interactions Journal*.

Saplacan, D., and Jo Herstad. 2018. "Fear, Feedback, Familiarity... How Are These Connected? - Can Familiarity as a Design Concept Applied to Digital Feedback Reduce Fear?" In *Proceedings of The Eleventh International Conference on Advances in Computer-Human Interactions (ACHI)*.

Saplacan, D., Jo Herstad, Nikoline Marthe Elsrud, and Zada Pajalic. 2018. "Reflections on Using Story-Dialogue Method in a Workshop with Interaction Design Students." In *Proceedings of Fifth International Workshop on Cultures of Participation in the Digital Age - CoPDA 2018, International Conference on Advanced Visual Interfaces (AVI 2018)*, 2101:33–43. CoPDA. Castiglione Della Pescaia, Grosetto, Italy: CEUR Workshop Proceedings. http://ceur-ws.org/Vol-2101/paper5.pdf.

Saplacan, D., Jo Herstad, Anders Mørch, Anders Kluge, and Zada Pajalic. 2018. "Inclusion Through Design and Use of Digital Learning Environments: Issues, Methods, and Stories." In *Proceedings of the 10th Nordic Conference on Human-Computer Interaction*, 956–959. NordiCHI '18. New York, NY, USA: ACM. https://doi.org/10.1145/3240167.3240264.

Saplacan, D., Jo Herstad, Jim Tørresen, and Zada Pajalic. 2020b. "A Framework on Division of Work Tasks between Humans and Robots in the Home." *Multimodal Technologies and Interaction* 4 (3): 44. https://doi.org/10.3390/mti4030044.

Saplacan, Diana, Jo Herstad, and Zada Pajalic. 2018. "Feedback from Digital Systems Used in Higher Education: An Inquiry into Triggered Emotions - Two Universal Design Oriented Solution for a Better User Experience." In *Transforming Our World Through Design, Diversity, and Education*, 256:421–30. Studies in Health Technology and Informatics. IOS Press. http://www.ebooks.iospress.com/volumearticle/50590.

———. 2020. "Use of Multiple Digital Learning Environments: A Study About Fragmented Information Awareness." Edited by Stefania Manca, Matthias Rehm, Jelle Saldien, and Carlo Giovannella. *Interaction Design & Architecture Journal (ID&A)*, Smart Learning Ecosystems - Design as cornerstone of smart educational processes and places, 20. http://ixdea.uniroma2.it/inevent/events/idea2010/index.php?s=9&a=5.

Sarsenbayeva, Zhanna. 2018. "Situational Impairments During Mobile Interaction." In *Proceedings of the 2018 ACM International Joint Conference and 2018 International Symposium on Pervasive and Ubiquitous Computing and Wearable Computers*, 498–503. UbiComp '18. New York, NY, USA: ACM. https://doi.org/10.1145/3267305.3267310.

"Saudi Arabia Bestows Citizenship on a Robot Named Sophia | TechCrunch." 2019. May 13, 2019. https://techcrunch.com/2017/10/26/saudi-arabia-robot-citizen-sophia/?guccounter=1&guce_referrer_us=aHR0cHM6Ly9lbi53aWtpcGVkaWEub3JnLw&guce_referrer_cs=PhNovmGDFjRa0rhnGuHgxA.

Saulynas, Sidas, and Ravi Kuber. 2018. "Towards Supporting Mobile Device Users Facing Severely Constraining Situational Impairments." In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*, LBW540:1–LBW540:6. CHI EA '18. New York, NY, USA: ACM. https://doi.org/10.1145/3170427.3188642.

Schmidt, Kjeld, and Liam Bannon. 1992. "Taking CSCW Seriously." *Computer Supported Cooperative Work (CSCW)* 1 (1): 7–40. https://doi.org/10.1007/BF00752449.

Schrader-Frechette, Kristin. 1994. "Ch. 1 The Importance of Research Ethics: History and Introduction." In *Ethics and Scientific Research*, 1–21. ROWMAN & LITTLEFIELD PUBLISHERS, Inc.

Schwaninger, Isabel, Geraldine Fitzpatrick, and Astrid Weiss. 2019. "Exploring Trust in Human-Agent Collaboration." *ECSCW 2019: Proceedings of the 17th European Conference on Computer Supported Cooperative Work ECSCW 2019 Exploratory Papers*. https://doi.org/10.18420/ecscw2019_ep08.

Shibata, T., K. Wada, K. Tanie, Wan Kyun Chung, and Youngil Youm. 2004. "Subjective Evaluation of Seal Robot in Gyeonju, Korea." In *30th Annual Conference of IEEE Industrial Electronics Society, 2004. IECON, 2004*, 1:140-145, Vol. 1. https://doi.org/10.1109/IECON.2004.1433299.

Sjøberg, S. 2002. "Science and Technology in Education: Current Challenges and Possible Solutions in Innovations in Science and Technology Education, Paris, UNESCO." 2002. http://folk.uio.no/sveinsj/STE_paper_Sjoberg_UNESCO2.htm.

Sjøberg and Schreiner. 2010. "The ROSE Project (The Relevance of Science Education) Overview and Key Findings." http://folk.uio.no/sveinsj/ROSE-overview_Sjoberg_Schreiner_2010.pdf.

Soma, Rebekka, Vegard Dønnem Søyseth, Magnus Søyland, and Trenton Schulz. 2018. "Facilitating Robots at Home: A Framework for Understanding Robot Facilitation." In, 1–6. https://www.thinkmind.org/index.php?view=article&articleid=achi_2018_1_10_20085.

Soma, Rebekka, and Jo Herstad. 2018. "Turning Away from an Anthropocentric View on Robotics." In *Envisioning Robots in Society – Power, Politics, and Public Space: Proceedings of Robophilosophy 2018 / TRANSOR 2018*, edited by M. Coeckelbergh, J. Loh, and M. Funk, 311:53–62. Frontiers in Artificial Intelligence and Applications. Wien, Austria: IOS Press. http://ebooks.iospress.nl/volumearticle/50782.

Søyland, Magnus, and Vegard Dønnem Søyseth. 2017. "'Hey, I'm Walking Here!' An Explorative Study of Spatial Encounters between Older Adults and Autonomous Robots." Oslo: the University of Oslo, Department of Informatics, Faculty of mathematics and natural sciences.

Stake, E. Robert. 2005. "Qualitative Case Studies, Chapter 17." In *The Sage Handbook of Qualitative Research*, 2005th ed., 443–66. SAGE Publications Ltd.

Stephanidis, Chairs Constantine, Gavriel Salvendy, Members of the Group Margherita Antona, Jessie Y. C. Chen, Jianming Dong, Vincent G. Duffy, Xiaowen Fang, et al. 2019. "Seven HCI Grand Challenges." *International Journal of Human-Computer Interaction* 35 (14): 1229–69. https://doi.org/10.1080/10447318.2019.1619259.

Stephanidis, Constantine. 2020. "Design for All." In *The Encyclopedia of Human-Computer Interaction*. 2nd Edition. https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/design-4-all.

Stoerger, Sharon. 2009. "The Digital Melting Pot: Bridging the Digital Native-Immigrant Divide." *First Monday* 14 (7). https://doi.org/10.5210/fm.v14i7.2474.

Story, Molly Follette, James L. Mueller, and Ronald L. Mace. 1998. *The Universal Design File: Designing for People of All Ages and Abilities. Revised Edition*. Center for Universal Design, NC State University, Box 8613, Raleigh, NC 27695-8613 ($24). https://eric.ed.gov/?id=ED460554.

Subasi, Özge, Geraldine Fitzpatrick, Lone Malmborg, and Britt Östlund. 2013. "Design Culture for Ageing Well: Designing for 'Situated Elderliness.'" In *Human Factors in Computing and Informatics*, edited by Andreas Holzinger, Martina Ziefle, Martin Hitz, and Matjaž Debevc, 581–84. Lecture Notes in Computer Science. Berlin, Heidelberg: Springer. https://doi.org/10.1007/978-3-642-39062-3_36.

Suchman, L. 1987. *Plans and Situated Actions: The Problem of Human-Machine Communication*. Cambridge University Press.

Suchman, Lucy. 1985. *Plans and Situated Actions: The Problem of Human-Machine Communication*. Palo Alto, California 94304: Xerox Corporation Palo Alto Research Centers.

Sung, Ja-Young, Henrik Iskov Christensen, and Rebecca Grinter. 2009. "Robots in the Wild: Understanding Long-Term Use." In *HRI '09 Proceedings of the 4th ACM/IEEE International Conference on Human-Robot Interaction*, 45–52. New York, NY, USA: ACM. https://doi.org/10.1145/1514095.1514106.

Sung, JaYoung, Rebecca E. Grinter, and Henrik I. Christensen. 2010. "Domestic Robot Ecology." *International Journal of Social Robotics* 2 (4): 417–29. https://doi.org/10.1007/s12369-010-0065-8.

Sung, Ja-Young, Lan Guo, Rebecca E. Grinter, and Henrik I. Christensen. 2007. "'My Roomba Is Rambo': Intimate Home Appliances." In *UbiComp 2007: Ubiquitous Computing*, edited by John Krumm, Gregory D. Abowd, Aruna Seneviratne, and Thomas Strang, 4717:145–62. Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-74853-3_9.

Super, S., M. a. E. Wagemakers, H. S. J. Picavet, K. T. Verkooijen, and M. A. Koelen. 2016. "Strengthening Sense of Coherence: Opportunities for Theory Building in Health Promotion." *Health Promotion International* 31 (4): 869–78. https://doi.org/10.1093/heapro/dav071.

Svanaes, Dag. 2000. "Understanding Interactivity - Steps to a Phenomenology of Human-Computer Interaction." Ph.D. Thesis, Trondheim, Norway: Norwegian Technical University (NTNU). https://folk.idi.ntnu.no/dags/interactivity.pdf.

Svanæs, Dag. 2013. "Interaction Design for and with the Lived Body: Some Implications of Merleau-Ponty's Phenomenology." *ACM Transactions on Computer-Human Interaction* 20 (1): 8:1–8:30. https://doi.org/10.1145/2442106.2442114.

Svenaeus, Fredrik. 2013. "The Relevance of Heidegger's Philosophy of Technology for Biomedical Ethics." *Theoretical Medicine and Bioethics* 34 (1): 1–15. https://doi.org/10.1007/s11017-012-9240-2.

Thrun, Sebastian. 2004. "Toward a Framework for Human-Robot Interaction." *Hum.-Comput. Interact.* 19 (1): 9–24. https://doi.org/10.1207/s15327051hci1901&2_2.

Tigwell, Garreth W., David R. Flatla, and Rachel Menzies. 2018a. "It's Not Just the Light: Understanding the Factors Causing Situational Visual Impairments During Mobile Interaction." In *Proceedings of the 10th Nordic Conference on Human-Computer Interaction*, 338–351. NordiCHI '18. New York, NY, USA: ACM. https://doi.org/10.1145/3240167.3240207.

———. 2018b. "It's Not Just the Light: Understanding the Factors Causing Situational Visual Impairments During Mobile Interaction." In *Proceedings of the 10th Nordic Conference on Human-Computer Interaction*, 338–351. NordiCHI '18. New York, NY, USA: ACM. https://doi.org/10.1145/3240167.3240207.

Turner, Phil. 2008a. "Being-with: A Study of Familiarity." *Interacting with Computers* 20 (4): 447–54. https://doi.org/10.1016/j.intcom.2008.04.002.

———. 2008b. "Towards an Account of Intuitiveness." *Behaviour & Information Technology* 27 (6): 475–82. https://doi.org/10.1080/01449290701292330.

———. 2011. "Everyday Coping: The Appropriation of Technology." In *Proceedings of the 29th Annual European Conference on Cognitive Ergonomics*, 127–133. ECCE '11. New York, NY, USA: ACM. https://doi.org/10.1145/2074712.2074738.

Turner, Phil, and Guy van de Walle. 2006. "Familiarity as a Basis for Universal Design." In, 5, No 3:150–59. Gerontechnology Journal.

http://teilab.tamu.edu/quek/Classes/Aware+EmbodiedInteraction/EmbodiedInteractionPAPERS/TurV06_Familiarity_as_a_basis_for_universal_design.pdf.

Unbehaun, David, Konstantin Aal, Felix Carros, Rainer Wieching, and Volker Wulf. 2019. "Creative and Cognitive Activities in Social Assistive Robots and Older Adults: Results from an Exploratory Field Study with Pepper." *ECSCW 2019: Proceedings of the 17th European Conference on Computer Supported Cooperative Work ECSCW 2019 Demos, Posters and Panels*. https://doi.org/10.18420/ecscw2019_p07.

United Nations. 2018. "SDG 4 - Quality Education." 2018. https://www.un.org/sustainabledevelopment/education/.

The University of Cambridge. 2017. "What Is Inclusive Design?" Inclusive Design Toolkit. 2017. http://www.inclusivedesigntoolkit.com/whatis/whatis.html#nogo.

U.S. Government. 1998. "Assistive Technologies Act, Public Law 105–394." Congress.gov. congress.gov/105/plaws/publ394/PLAW-105publ394.pdf.

Vanderheiden, Gregg. 2020. *Keynote Speech*. Mp4. The University of Maryland, College of Information Studies. https://ischool.umd.edu/news/gregg-vanderheiden-delivers-keynote-international-human-computer-interface-conference.

Vanderheiden, Gregg C., Jutta Treviranus, Manuel Ortega-Moral, Matthias Peissner, and Eva de Lera. 2014. "Creating a Global Public Inclusive Infrastructure (GPII)." In *Universal Access in Human-Computer Interaction. Design for All and Accessibility Practice*, edited by Constantine Stephanidis and Margherita Antona, 506–15. Lecture Notes in Computer Science. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-07509-9_48.

Vanderheiden, Gregg, and Jutta Treviranus. 2011. "Creating a Global Public Inclusive Infrastructure." In *Universal Access in Human-Computer Interaction. Design for All and inclusion*, edited by Constantine Stephanidis, 517–26. Lecture Notes in Computer Science. Berlin, Heidelberg: Springer. https://doi.org/10.1007/978-3-642-21672-5_57.

Vasunilashorn, Sarinnapha, Bernard A. Steinman, Phoebe S. Liebig, and Jon Pynoos. 2012. "Aging in Place: Evolution of a Research Topic Whose Time Has Come." *Journal of Aging Research*, 6. https://doi.org/10.1155/2012/120952.

Vavik, Tom, ed. 2009. *Inclusive Buildings, Products & Services: Challenges in Universal Design*. Trondheim, Norway: Tapir Academic Press.

Verne, Guri. 2015. "'The Winners Are Those Who Have Used the Old Paper Form.' On Citizens and Automated Public Services." Oslo, Norway: University of Oslo. https://www.duo.uio.no/handle/10852/46133.

Verne, Guri B. 2020. "Adapting to a Robot: Adapting Gardening and the Garden to Fit a Robot Lawn Mower." In *Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction*, 34–42. HRI '20. Cambridge, United Kingdom: Association for Computing Machinery. https://doi.org/10.1145/3371382.3380738.

Verne, Guri, and Tone Bratteteig. 2016. "Do-It-Yourself Services and Work-like Chores: On Civic Duties and Digital Public Services." *Personal and Ubiquitous Computing* 20 (4): 517–32. https://doi.org/10.1007/s00779-016-0936-6.

Vygotsky, Lev S. 1978. "Interaction between Learning and Development, from Mind in Society." In *Readings on the Development of Children*, Cambridge, MA Harvard University Press, 79-81 (29-36). Edited by Mary Gauvain and Michel Cole, University of CaliforniaW.H. Freeman and Company New York.

Wada, K., and T. Shibata. 2007. "Robot Therapy in a Care House - Change of Relationship among the Residents and Seal Robot during a 2-Month Long Study." In *RO-MAN 2007 - The 16th IEEE International Symposium on Robot and Human Interactive Communication*, 107–12. https://doi.org/10.1109/ROMAN.2007.4415062.

Wada, K., Y. Takasawa, and T. Shibata. 2014. "Robot Therapy at Facilities for the Elderly in Kanagawa Prefecture - a Report on the Experimental Result of the First Month." *The 23rd IEEE International Symposium on Robot and Human Interactive Communication*, 193–98. https://doi.org/10.1109/ROMAN.2014.6926252.

Walsham, Geoff. 2006. "Doing Interpretive Research." *European Journal of Information Systems* 15 (3): 320–30. https://doi.org/10.1057/palgrave.ejis.3000589.

———. 2012. "Are We Making a Better World with ICTs? Reflections on a Future Agenda for the IS Field." *Journal of Information Technology* 27 (2): 87–93. https://doi.org/10.1057/jit.2012.4.

Weller, Chris. 2019. "Meet the First-Ever Robot Citizen — a Humanoid Named Sophia That Once Said It Would 'Destroy Humans.'" Business Insider. May 13, 2019. https://www.businessinsider.com/meet-the-first-robot-citizen-sophia-animatronic-humanoid-2017-10.

Winograd, Terry, and Fernando Flores. 1986. *Understanding Computers and Cognition: A New Foundation for Design*. Intellect Books.

Wobbrock, Jacob O. 2017. "SIGCHI Social Impact Award Talk – Ability-Based Design: Elevating Ability over Disability in Accessible Computing." In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, 5–7. CHI EA '17. New York, NY, USA: ACM. https://doi.org/10.1145/3027063.3058588.

———. 2019. "Situationally Aware Mobile Devices for Overcoming Situational Impairments." In *Proceedings of the ACM SIGCHI Symposium on Engineering Interactive Computing Systems*, 1:1–1:18. EICS '19. New York, NY, USA: ACM. https://doi.org/10.1145/3319499.3330292.

Wobbrock, Jacob O., Krzysztof Z. Gajos, Shaun K. Kane, and Gregg C. Vanderheiden. 2018. "Ability-Based Design." *Communications of the ACM* 61 (6): 62–71. https://doi.org/10.1145/3148051.

Wobbrock, Jacob O., Shaun K. Kane, Krzysztof Z. Gajos, Susumu Harada, and Jon Froehlich. 2011. "Ability-Based Design: Concept, Principles and Examples." *ACM Transactions on Accessible Computing (TACCESS)* 3 (3): 9:1–9:27. https://doi.org/10.1145/1952383.1952384.

Wolf, Flynn, Priyanka Soni, Ravi Kuber, Dianne Pawluk, and Brian Turnage. 2019. "Addressing the Situational Impairments Encountered by Firefighters Through the Design of Alerts." In *Proceedings of the 16th Web For All 2019 Personalization - Personalizing the Web*, 22:1–22:10. W4A '19. New York, NY, USA: ACM. https://doi.org/10.1145/3315002.3317556.

World Economic Forum. 2016. "New Vision for Education: Fostering Social and Emotional Learning Through Technology." Industry Agenda 040316. Cologny/Geneva, Switzerland: World Economic Forum in cooperation with The Boston Consulting Group. http://www3.weforum.org/docs/WEF_New_Vision_for_Education.pdf.

World Health Organization, ed. 2001. *International Classification of Functioning, Disability, and Health: ICF*. Geneva: World Health Organization.

Wu, Ya-Huei, Souad Damnée, Hélène Kerhervé, Caitlin Ware, and Anne-Sophie Rigaud. 2015. "Bridging the Digital Divide in Older Adults: A Study from an Initiative to Inform Older Adults about New Technologies." *Clinical Interventions in Aging* 10 (January): 193–201. https://doi.org/10.2147/CIA.S72399.

Yamazaki, Keiichi, Michie Kawashima, Yoshinori Kuno, Naonori Akiya, Matthew Burdelski, Akiko Yamazaki, and Hideaki Kuzuoka. 2007. *Prior-to-Request and Request Behaviors within Elderly Day Care: Implications for Developing Service Robots for Use in Multiparty Settings*. ECSCW 2007: Proceedings of the 10th European Conference on Computer-Supported Cooperative Work. Springer, London. https://doi.org/10.1007/978-1-84800-031-5_4.

Zevenbergen, Bendert, Brent Mittelstadt, Carissa Veliz, Chris Detweiler, Corinne Cath, Julian Savulescu, and Meredith Whittaker. 2015. "Philosophy Meets Internet Engineering: Ethics in Networked System Research. (GTC Workshop Outcomes Paper)." Oxford Internet Institute, University of Oxford. http://ensr.oii.ox.ac.uk/wp-content/uploads/sites/41/2015/09/ENSR-Oxford-Workshop-report.pdf.

Ziman, John. 1996. "Is Science Losing Its Objectivity?" *Nature*, August 29, 1996. http://www.uio.no/studier/emner/matnat/ifi/MNSES9100/v12/undervisningsmateriale/reading-material/Ziman%20Nature.pdf.

Part IV Publications

PAPER I

An Analysis of Independent Living Elderly's Views on Robots

A Descriptive Study from the Norwegian Context

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***Abstract*—This study illustrates the independent living elderly's (≥65 years) views on robots. The data was documented through audio recordings of interviews, photos, and written logs. The analysis was done through qualitative manifest and latent content analysis. The results of the analysis were sorted into three categories: aging during the technological renaissance, domestic robots, and the elderly's expectations of robots. The overall resulted theme was: integrating robots in the elderly's everyday life. The results were discussed through the lenses of the Sense-of-Coherence (SOC) theoretical construct and its belonging elements: *comprehensibility*, *manageability*, and *meaningfulness*. The relevance of this paper contributes to giving an understanding of the domestic robots' requirements specifications and the elderly's expectation of human-robot interaction.**

Keywords-robot; comprehensibility; manageability; meaningfulness; healthy aging; independent living elderly; Norway; Sense-of-Coherence (SOC) theory; salutogenesis; elderly; human-robot interaction, domestic robots.

I. Introduction

We were interested in this study to investigate how robots are seen by the independent living elderly, before integrating the robots in their homes. Specifically, the study aimed to illustrate the elderly's (≥65 years) views on robots. The research question addressed in this study was: what is the elderly's understanding of robots, and how can these be better integrated into their daily lives?

Studies show that western countries face an increase in individuals' lifespan, and this, in turn, puts pressure on the healthcare systems [1]. Non-digital personal health records have been earlier widely used [2]. However, lately, the elderly prefer to live independently in their homes. To support the elderly's independent living, various welfare technologies have been used. In the past years, robots for supporting independent living got special attention [3][4]. In general, most of the elderly have a hard time accepting and learning new modern technologies. At the same time, earlier research shows that the elderly are not interested in devices designed especially for their age group [5]. However, modern technologies often let the elderly feeling they cannot keep up with those; their design does not always suit the elderly. For instance, a study from the U.K. talked about the mismatch between the technologies and services that are available for supporting the elderly's needs and their real needs [6]. The authors mean that, for designing and providing better technologies, we first need to understand in-depth the elderly's needs [6].

Further, Koelen et al. [7] say that in the next couple of years, it will be not only vital aging in place, i.e., aging in the home of choice, but also "healthy aging." According to Eriksson [8], every individual, even those considered healthy, might have moments when they feel ill. Furthermore, there are still uncertainties about how robots could accommodate aging in place since these technologies are still in development. Moreover, we are still not sure how these technologies could be better integrated into the elderly's homes since they already have a hard time accepting the existing technologies.

The rest of the paper is structured as follows. This section continues by giving a background on this study. Section II presents the theoretical construct of Sense-of-Coherence (SOC) and its elements of *comprehensibility, manageability,* and *meaningfulness.* Section III presents our data collection and analysis methods, the setting of the study, and the participants. Section IV presents our findings. Section V continues with a discussion by using the theoretical construct and its elements presented earlier in Section II. Section VI presents the conclusion. Acknowledgments close the paper.

A. Background

This study is part of the Multimodal-Elderly Care Systems (MECS) project. MECS aims to develop knowledge around a caring safety robot alarm for the elderly. The elderly are defined as old adults (≥ 65 years), according to gerontology [9][10]. The insights gotten during this study are intended to contribute to the design of the MECS safety alarm robot. However, before going further, we want to define the concepts of a *robot* as a welfare technology.

Welfare is defined as something *doing* or *being* well [11]. Within the Nordic countries, The Nordic Welfare Center describes the notion of *welfare technology* as technology either compensating due to a disability or supporting it [12]. This definition of welfare technologies includes: "assistive devices, consumer goods, home adaptation solutions, educational equipment, tools" [12]. Among such examples, there are games consoles used for rehabilitation and physical therapy, mobile care systems, smart home environments, and automation solutions, robot vacuum cleaners, and safety alarms connected to a healthcare system. Amongst these technologies, a safety alarm robot can be considered as a welfare technology of the future. A *robot* is defined as a programmable machine that can conduct a complex set of actions on its own [13][14]. The term was coined from the Czech "robota" in the '20s and had the meaning of "forced labor" [13]. Robots are similar to other types of modern technologies, wearables, or personal devices. Besides, this type of welfare technology also has the *motion element* which is needed to be taken into consideration [15].

We have seen that the digitalization of care services for the elderly can be done with wearable sensors and through self-monitoring devices, or personal safety alarms. While body sensor networks are considered intrusive and often not readily accepted, users would instead opt for self-monitoring devices [16]. These include ambient intelligence techniques [17], such as wearables, or mobile devices, as shown in Chiauzzi et al., Petersen et al., and Laidlaw et al. [18]–[20]. Besides, personal alarms are usually used in the form of bracelets or pendant alarms. For instance, almost 20% of the total safety alarm installations used in the U.K. were necklace alarms [6]. Very few of these or other devices were actively used by the elderly [6]. However, these types of alarms can be effective in detecting falls among the elderly, if these are used effectively [21]. It seems like the elderly use of this type of assistive living technologies is often done in wrong ways, such as pressing the button of a pendant alarm when feeling lonely instead of when needing medical help [6]. These types of devices also are often not used when showering, while most of the falls amongst the elderly happen while they shower.

Moreover, these types of devices are not afforded by some of the users, whereas for some, other alternatives should be considered when personal devices are likely to be misused, or not used at all [21]. One alternative is the use of robots, through "connected and secure assistive robots ecosystems" [22]. However, introducing robots in the homes of the elderly requires scrutiny, both of the user and the current use of modern technologies, of the *home* context, and of the technology itself. Previous studies show that a few robots for the independent living elderly are available on the market, whereas the use of robots in homes has excellent potential and could prolong independent living [23][24].

Furthermore, Norway, a welfare state, has its healthcare system partially subsidized by the government [25]. For instance, elderly people that are over 90 years old and may live in nursing homes cost the state around 800 000 Norwegian crowns (NOK) per year (ca 84 000 euros, or 98 000 US dollars) per individual [25]. However, only half of the elderly wish to live in such nursing homes, while some choose to stay in their own homes, and others wish to move in accommodation facilities for the elderly [25]. Furthermore, according to Ramm [26], at the start of 2013, 13% of Norway's population was 65 years old or older, whereas, by 2050, this percentage is forecasted to increase to 21%.

In addition, a similar study of quantitative nature was performed in Norway. The study was based on 1000 phone survey interviews lasting, on average, about 13-14 minutes each [28]. The focus of the research was mainly on the use of Information Communication Technologies (ICT's) and did not include any questions regarding robots [28]. Helsevakta (eng. Health Watch, HW) is another example of a project that was created for investigating the challenges that are met in healthcare [29]. The study was performed in Trondheim, Norway showing so far that the Norwegian healthcare system was not prepared for the upcoming demographic challenges, such as an increasing number of the elderly [29]. Extensive empirical qualitative studies on integrating robots in the homes of the independent living elderly, from the Norwegian context, have not so far been identified.

II. Theoretical Lenses

We chose to discuss our findings through the theoretical lenses of Aaron Antonovsky's work [30]. The theoretical construct was chosen to discuss the findings. Antonovsly was a sociologist that challenged the pathologic view on healthcare, focusing on salutogenesis [29][30]. Salutogenesis is viewed as a health promoter [32]. His theoretical model is based on the Sense-of-coherence (SOC) of an individual. He defined it as:

> "a global orientation that expresses the extent to which one has a pervasive, enduring though dynamic feeling of confidence that (1) the stimuli, deriving from one's internal and external environments in the course of living are structured, predictable and explicable; (2) the resources are available to one to meet the demands posed by these stimuli; and (3) these demands are challenges, worthy of investment and engagement" (Antonovsky, 1987, p. 19 in Super et al. [33]).

The theoretical construct includes three elements: *comprehensibility*, *manageability*, and *meaningfulness*. *Comprehensibility,* as an element of SOC, is illustrated as the motivation behind the challenge of coping with the situation at hand. *Manageability* is depicted as the availability of resources to cope with the situation, whereas *meaningfulness* is represented as understanding the challenge [30]. The theoretical construct, however, was developed to reflect on how one can deal with life stressors [33]. We borrowed these concepts for this study since robots are seen as assistive technologies for independent and healthy living. We argue that having such lenses when designing and integrating these technologies in the elderly's home, could be beneficial for reflecting over the process of understanding their views on technologies. The concepts are also beneficial to understand the acceptance of modern technologies by the elderly.

There are a few studies that have the same salutogenic perspective on health using Aaron Antonovky's theory. According to [32], studies based on this theoretical construct seem to be quantitative, and just a few qualitative ones are available. Some similar studies are from Lahttiranta et al. [34][35]. Another similar study is from Svaneus [36], where the author takes the approach towards health as "homelike being-in-the-world." The author also asserts that this perspective on modern technologies can be made visible through *medical technologies* [36] – in our case, the robots used in the homes of independent living elderly. We argue that it is essential to make visible the salutogenic approach inbuild in a safety alarm robot for the elderly. Moreover, yet again, the question we ask is: how do they understand the concept of a robot, in order to better integrate it into their daily lives?

III. Method

The present study had a qualitative inductive research design. Next, we present the study context, participants, and data collection.

A. *Study context*

The study was performed in the southern-east part of Norway, in the area of Oslo. Norway has a population of approximately 5.2 million inhabitants [37], where the elderly represent about 14.6% of this number [38]. In Oslo, the capital area, live about 660 000 inhabitants. This study has been performed in a subarea of the old Oslo district area. The district has a total population of roughly 53 000, out of which nearly 3000 are senior citizens over 67 years old. Some of these citizens have home-care; some live in the nursery cares, whereas some live in accommodation facilities for the independently living elderly. The accommodation facilities usually include apartments that can be rented individually by the elderly, or together with their partner. The facilities also include a reception available 24/7, where at least two personnel staff are available at all times. The facilities also include a gym, a restaurant available for non-residents, an open area where various social events are taking place, and a library. The building is equipped with various sensors: WiFi, light and heating sensors, motion sensors, but also tablets installed in each of the apartments. The residents can use computer tablets, for instance, for seeing the menu available at the restaurant in the building, ordering food, or navigating the Internet. Similar studies have been performed in such accommodation facilities, but none of them involving robots [39]–[44].

B. *Participants*

The participants in this study were recruited through an accommodation facility, which has 91 apartments. Ninety (90) residents were living as of April 2017. Fifty-two (52) of them were females, with an average age of 84, and 38 males, with an average age of 80. The residents were spending at the time, on average, around 577 days, in the accommodation facility – according to an internal document.

Sixteen participants participated in three group interviews and one pilot interview. Four researchers involved in this project (two senior researchers and two junior researchers, including the authors SD, HJ) had a meeting with the two management representatives at our partner organization, before the first two group interviews. We documented the meeting through a log report, followed by a visit of the junior researchers (including author SD) at the elderly's facilities, and a presentation about the project held for the elderly and the employees (including the authors SD, HJ). Some of the elderly signed up for the group interviews at the presentation, whereas others joined during the presentation itself. The participants were self-selected, i.e., entered the study based on voluntary choice. For the third group interview, the elderly were informed approximately one month before the activity, and they participated, this time as well, voluntarily. The third group interview was part of a half-day workshop. Two of the participants taking part in the first group interviews also took part in the third group interview.

The participants' background was mixed: they have worked in the public sector (library, university, military, other public authorities), arts and handcraft, and industry (including office work that requires the use of computers, but also factory work). All were over 67 years old, with ages ranging up to 90 years old. Some of the participants used walkers and some wheelchairs. During the interviews, they explained that several of them experienced balance problems, and they sometimes fall. Three hundred five (305) falls were reported amongst all the facility's residents between 2015-2017. Other health-related issues pointed out were: impaired or weak vision and hearing and memory loss. Table I below gives an overview of the participants and their background experience with computers.

TABLE I. OVERVIEW PARTICIPANTS.

#	Gender (Female F, male M)	Age	Comment on the participants' work experience (Not available N/A)
1	F	>65	Public sector
2	F	84	Arts and Craft
3	M	81	Arts and Craft
4	M	>65	Worked with computers.
5	F	94	Private- and public sector. Worked with computers.
6	F	>65	Public sector
7	F	90	Private sector
8	F	>65	N/A
9	F	>65	She worked previously in the private sector.
10	M	>65	N/A
11	M	>65	N/A
12	M	>65	N/A
13	F	89	Public sector.
14	M	>65	Public sector.
15	M	>65	Public sector.
16	F	90	Public sector. She had experience with computers before.

C. *Data collection*

Our primary data gathering method was group interviews. A research interview aims to develop an understanding of the investigated phenomena surrounding the persons and situations in their contexts and social reality [45]. All three group interviews were semi-structured. All the interviews included some demographic questions, where the participants were asked to share, based on free will, their name, age, and background. Moreover, the interviews contained questions regarding the participants' familiarity with digital technology, including smartphones, computers, and robots. The author (SD) has also participated in multiple meetings, one public discussion, together with the author (HJ). Further, we give details on group interviews one and two, a pilot interview that took place after the first two group interviews, and a third group interview. The pilot interview and the third group interview was based on the findings first two group interviews. Some photos from the group interviews are illustrated in Figure 1.

Figure 1. Sample photos from group interviews 1 and 3.

All the details regarding the group interviews and the pilot interview are available in Table II below.

TABLE II. OVERVIEW OF THE DATA COLLECTION.

Group interview #	**Number of participants and their gender**	**Time for data collection**	**Type and duration of data collected**
1	5 females, 2 males	Spring 2017	Interview 60 minutes, Photos
2	2 female 3 males	Spring 2017	Interview 60 minutes, Photos
1 Individual Pilot	1 female	Spring 2017	Interview 60 minutes, Photos
3 (part of a half-day workshop)	1female 2 males	Spring 2017	Interview 45 minutes, Photos
Total	16 participants (9 Female and 7 Males)		

D. *Analysis*

The textual data was fully transcribed. The author (SD) has listened to the audio recording and written logs for the two parallel-group interviews, and the pilot interview, immediately after those took place, to help her remember better the context. She also took unstructured notes during the first and third group interview. After listening through the transcriptions, the authors have discussed their understanding of the data, making the analysis more reliable. The data was transcribed verbatim and was coded through open-coding. The authors have later decided to leave the data for a while before coming back to it. At this stage, both conscious and unconscious reflection took place. After a few months of an incubation stage, we have chosen to analyze the data by using qualitative manifest and latent content analysis [46]. The analysis was performed through the following steps: first, the whole transcripts were read through several times to get a sense of the content. The next step was decontextualization of text with the identification of meaning units. We identified in total (n= 132) meaning units. The next step was condensation and coding of meaning units (n = 13). The systematic grouping of codes to sub-categories and categories, with reflective discussions with the aim of the study as the base, was performed together by authors (SD, PZ). The analyzing process towards the formation of categories was the result of manifest content analysis. The latent analysis started with the reading of the transcript again and trying to capture what text was talking about. The result of the final step was the theme "Integrating robots and welfare technology in the elderly's everyday life." The process between the group interviews is shown in Figure 2.

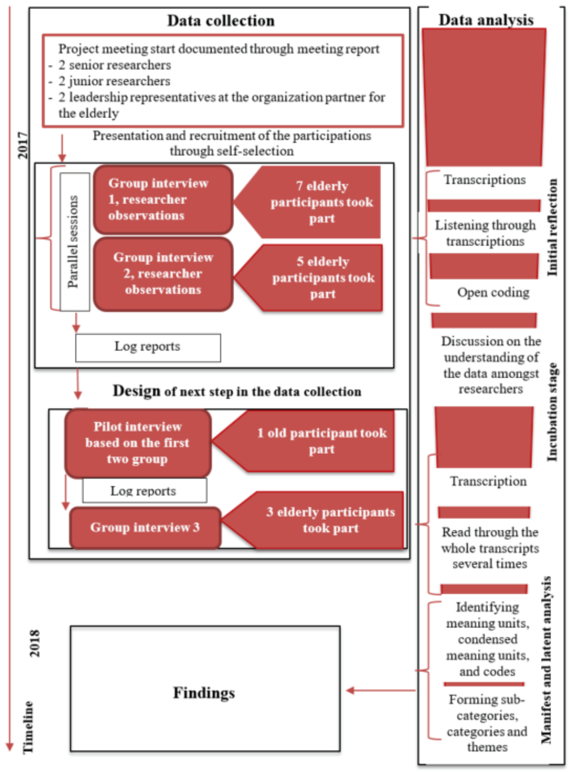

Figure 2. Overview of the process.

E. *Ethical considerations*

The project was conducted accordingly to the ethical guidelines from the Norwegian Center for Research Data (NSD) Ref. Nr: 50689). This work was performed on the Services for Sensitive Data (TSD) facilities, owned by the University of Oslo, Norway, operated and developed by the TSD service group at the University of Oslo, IT-Department (USIT). The participants were self-selected. The participants were given detailed information about the study, and they could withdraw at any time without giving any explanation and without any consequences for them. All the participants willing to participate signed informed consent before taking part in the study.

IV. FINDINGS

A. *Integrating welfare technology in the everyday life of the elderly*

The overall theme of this study that emerged is: "*Integrating welfare technology in the elderly's everyday life*.". The theme comprises the elderly's daily experiences with personal devices (smartphones, computers) and modern technologies used in homes (sensors in a smart home, semi-autonomous robots). In general, the use of personal devices by the elderly would be minimal and limited to their needs, such as using internet banking, for checking the account balance. Some of the participants did not own a smartphone, and some even a mobile phone, *but* a fixed home phone. Only a few of the participants owned both a smartphone and a tablet. These participants were also those who were highly interested in the use of modern technologies and to influence rules or policies, at some level. They were often engaged in other types of organizations for the elderly. Although some of them were highly engaged with this type of personal devices, the majority had limited knowledge about the use of robots in homes. The general impression was that they could not follow up with the fast development of technologies. In general, they felt left out, as one participant expressed it: *"for me, it goes too fast… for me, it goes too fast… I cannot keep up with it.. unfortunately".*

The findings also showed that, besides the fast technological advancements, the elderly need to keep up with, the authorities need to develop legislation accordingly, at the same pace, in order to have a functioning and inclusive society. They viewed this as especially important when trying to introduce domestic robots in their homes. Detailed results are presented descriptively, as follows.

B. *Aging during the technological renaissance*

We started by asking the participants to talk about their relationship to the use of modern technology (e.g., computers, tablets, and smartphones) in their homes. The majority of the participants answered that they use modern technologies for checking their bank account balance – internet banking was a common motivation for using computers. Regarding the autonomous technology used in homes, they would recognize this type of electronic technology from the building they were living in, as it has light and motion detection sensors.

The majority would describe their interactions as being limited to computers for writing emails and checking the account balance, TV, phone (home phone, mobile phone, smartphone), and printers. However, one of the participants expressed a high interest in "*everything new*." This participant also used more advanced terms that their peers did not know about, such as *cloud computing* and *bitcoin*. Bitcoin, for instance, had to be explained by one of the female participants to others as "*valuta in the cloud*." The same participant confessed that she uses modern technology for solving crosswords, sending emails, search on Google, and using Facebook.

Regarding the price of modern technologies, such as robots, the elderly found those expensive. Hence, they did not recognize themselves as being the *right* target-group/consumer group. They were also reluctant to robots that are big due to taking too much space in their apartments, usually consisting of a small living room integrated with an open kitchen, a small bedroom, and a bathroom. Robots were viewed by them in general as inferior, subordinates to people, as one participant says: "he is *just* a robot." Specifically, companion robots, such as an AIBO robot, were not interesting enough for the participants, as they were "*nothing to cuddle with*," as one participant described it. They rated robots from a cost-benefit perspective, always seeking a *practical perspective/benefit*. However, they admitted that such a robot could decrease some of the feelings of loneliness. The participants agreed that a companion robot could supply some daily dialogical interaction-when they do not have anyone else to talk to.

Four of the participants (two males and two females) pointed out that they cannot follow and keep up with the fast development of modern technology, feeling surpassed. They expressed feelings of hopelessness, exclusion, and technological illiteracy, as one of them pointed out:

> "*I feel like I am in another world, you know.. I do not know so much about these things we discuss now… and this has to do with the [world] we grew up within… a different one, yes. What I mean is that we start getting so old, that there is so much surpassing us. We are not able to keep up the pace. However, the authorities do not take this into account*."

In general, they felt anxious about dealing with modern technologies, due to *fear of doing something wrong,* or *failure.* This, despite the majority that was willing to learn about modern technologies. In this sense, they mentioned that having an own pre-understanding and familiarity towards those (e.g., having used modern technologies before), and a *clear objective of the use*, as one points out: *"When I should learn something new, I am asking – what's the point?*", is imperative. They also specified that they often rely on help from their family members (children and grandchildren). However, to trust a robot, they mentioned that they need to have some control over it. They suggested that this could be done through, for instance, control via voice recognition. One female participant pointed out that such a safety alarm robot would make her feel safe in situations where they do not have the safety alarm wristband on them, such as when using the shower. The robot should also have *predictable* ways of moving in order to feel safe around it.

C. Domestics robots

At the start of the discussions, the participants did not know "*what a robot is*" and said that they had seen robots only on TV. However, immediately after starting the conversation about the robots, they were wondering if an autonomous vacuum cleaner or a lawnmower is counted as robots. They found this type of home appliances, so-called *domestic robots*, more familiar for them, and could place them in their understanding. However, some of them were familiar with industrial robots: robots that are used in factories and robots used in hospitals.

Their description of the robots used in homes fitted under the description of *assistive* and *servant robots*, as a female participant points out, about what a robot should do:

"*To fix the TV when it gets stuck. Or the computer when something went wrong. It would have been nice to have such a robot for this"*. Another participant explained: *"The robots have to have a practical aim. I think many feel ill and do not have the energy to bring food from downstairs... This could be something a robot could do."*

When we showed pictures of various robots, we also showed pictures of *companion* robots. It was clear that the elderly sought some practical attributions of the robots, and they were less interested in safety alarm robots. The majority of the participants agreed that the robots need to have some practical function for them to use those. Only one participant brought attention to the implications of introducing such a robot in their homes, such as potentially reducing their physical activity. Regarding the appearance of a robot versus the functionality, it was a difference between the female and male participants: whereas for the female participants, the robot appearance was necessary, for the male participants were not. However, both female and male participants agreed that functionality is more important than appearance.

Among the functionalities of the *domestic robots*, they named that they would like to have semi-autonomous robots (e.g., servant robots, assistive robots) that help them clean or wash the floor. To be able to interact with the robot via voice recognition, and specifically being able to interact in Norwegian, were essential for the participants. Physical interaction, such as having a stop button, was also vital to them. The feedback received from the robots should be, according to them, auditive, visible, and visual, as they have learned from their interaction with the industrial robots, i.e., signalizing with red and green blinking lamps.

Besides these types of functionalities, robot navigation within the elderly's homes has also been discussed. The participants found problematic the robot-human encounter, especially if they had to move with the help of a walker, or a wheelchair. They were also concerned about the obstacles they had in their homes, such as furniture. Some of the participants compared the behavior of a robot when navigating inside the home, with the driving of a car – the robot should behave in a similar fashion when encountering humans.

D. The elderly's expectations of the legislation and regulations around robots

The participants pointed out some expectations regarding the well-functioning of laws and regulations in practice. For instance, one female participant gave an example where the laws and regulations at a national level do not always match on an organizational level. She ended: "*It is not ready… the laws are not ready yet.. for these.. which is quite advanced.*". The same participant, in a later interview, says that, although the laws and regulations are not fully developed, *they* still have to *adapt* to the use of modern technology, because "*the authorities do not allow resignation*." In addition to their perceived control regarding laws and regulations, the participants also expressed the need for having *autonomy* over the robot itself.

Although the focus of the MECS project is around developing a safety alarm robot, for the majority of the participants, it seemed important that the robot would help them with physical activities in homes.

V. DISCUSSION

Integrating robots in the homes of the elderly should be done gradually, where the acceptance of these technologies is taken into consideration. Studies support this idea, saying that these types of technologies cannot be introduced only when the elderly need extensive care [47]. Moreover, domestic robots, such as care robots, should not be introduced in the home of the elderly, solely to reduce society's care burden with the aging of the population, as shown by [48]. However, integrating robots in their homes means that these technologies also need to be comprehensible, manageable, and meaningful, for the elderly. We base further our discussion on the SOC from Aaron Antonovsky earlier described (Section 2).

A. Comprehensibility and manageability of robots in the homes of the elderly

This study shows that the majority of the participants used modern technology for simple everyday tasks, such as checking the bank account balance. However, not many of them felt that they were skilled enough to using these technologies. This indicates that the elderly do have limited *comprehensibility* of these technologies. They were familiar mostly with robots used in the industry.

Moreover, they were unsure if an autonomous vacuum cleaner or a lawnmower are also robots. This indicates their limited understanding (comprehensibility) of domestic robots. They also considered using in-motion technologies, such as robots, only if this type of technology had a practical benefit. This indicates that they sought some manageability in those.

A study showed that people are afraid of interacting with technology that they do not understand [49]. While the participants mentioned the importance of using their natural language in the interaction with robots, Sciutti et al. [49] emphasize the importance of mutual understanding: not only concerning language, but the robots should consider the people around them. In literature, robots are being portrayed as agential actors with emotions and autonomy [50]. If we strictly refer to a robot, a robot is autonomous through, for instance, independently moving around. In this case, the additional element to be considered and understood by the elderly is the motion element. This adds to the complexity of the manageability of a robot. After all, a care robot, an in-motion technology, would be a new element in the elderly's homes that will move around. Facilitations and adjustments of the home, to adapt the robot would probably need to be made. This is nevertheless a question of autonomy: of the person him- or herself, and the technology. In the case of in-motion technologies, such as robots, the elderly may loose from his-/her autonomy if they cannot master the robot.

Further, the participants also indicated that they could not keep up with the technological advancements, as they often were afraid of doing something wrong when they interact with it. To be able to interact independently with such systems, they suggested being able to interact with the robots via voice recognition. Moreover, they specifically suggested that this should be available in their mother tongue, Norwegian. This indicates that such systems should be manageable by them, in their mother tongue (manageability). At the same time, studies recommend that it should be of high priority to make scalable care systems that support voice recognition [1]. They recommend systems that are socially aware, but at the same time, that do not need the user to interact with the system continuously [1].

Moreover, another study showed that the robots used in hospitals were expected to be able to talk [51]. However, even advanced build-in ways of interactions, such as talking, may still not lead to the acceptance of a robot [51]. Based on the findings presented in this study, we consider that this point is also valid for robots used for supporting the elderly's independent living in their own homes.

Further, introducing new emerging technology for health monitoring in the home may change the relationship amongst people interacting with them [1]. This type of system may have implications beyond the intended use [1]. For the elderly to feel well, it also needs to be considered the broader context of use, including the need for social connectivity [52]. The need for voice interaction could be one aspect of social exchange. However, as one study shows, people may tolerate robots in different ways, depending on the context [51]. Robots, for instance, used in hospitals in different settings, were viewed as: "an alien, a hospital worker, a colleague, a machine, or a mixture of these" [51].

In the same way, this is confirmed by the current study: a robot that would be able to talk might be easier understood by the elderly. However, being able to interact with the robots through voice does not guarantee that domestic robots will be accepted. Although they may be manageable by the elderly, it does not mean that it also will be meaningful for them. However, for integrating these types of technologies, it is not enough to be comprehensible and manageable. These also need to be meaningful.

B. *Meaningfulness in the robots for the elderly*

"When I should learn something new, I am asking – what is the point?" asked one of the participants. Besides finding the welfare technologies and robots *useful* for their health monitoring, the elderly also need to find them *meaningful*. Older adults need to be motivated and get enough time to learn how to use new digital tools [53]. Further, the elderly seem to dislike devices that are "off-putting," i.e., reminding them of medical instruments and monitoring instead of feeling personal and appropriate for their dis-/un-ability (Lehoux et al. in Procter et al. [6]). We have also seen that technologies can support aging in place, through monitoring [52]. However, this solution is somehow limited: monitoring is supporting in the first place the caregiver, not the elderly [52]. Integrating these technologies in their homes also means that they should be *meaningful* for the elderly in the first place.

The present study showed that the participants were familiar with domestic robots, such as semi-autonomous vacuum cleaner, and lawnmower robots. The functionality of robots was more important than appearance, but the appearance had some importance for the female participants. When it comes to robot appearance, literature often discusses the anthropomorphic robotic looks [50][54][55]–[58]. The literature also talks about the notion of the uncanny valley, defined as the look of a robot that may set expectations on its functionality as well [59]. Further, an early study since 2004 was conducted about the use of robots in professional settings on how people would collaborate on tasks with human-like vs. machine-like robots [54]. The study concluded that the participants felt more responsibility when using a machine-like robot, as they saw it more as a tool that helps them fulfilling a task [54]. Furthermore, studies show that human-like robots were preferred in stressful or complex situations, where the participants have to delegate responsibility due to stress and work overload, but also where such robots could perform/process better and faster than a person [54]. At the

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same time, functionality and appearance are interconnected. We have shown that the elderly saw the robots mostly as *servant robots* and that the robots that looked more humanoid-like were "*nothing to cuddle with*," as one participant said. If a safety alarm robot would be designed as a machine-like robot, this, on the other hand, could potentially put more responsibility on the elderly as they would feel more responsible towards the robot. However, they seem to find servant robots more meaningful.

Studies talk about the "domestication" of technology when integrating it into daily lives [53]. To be able to manage these technologies and give them meaning, the elderly seem to adapt them to their own. Small details of the devices' design are significant for the configurability and adaptability of the devices' to the elderly's individual needs [6]. For instance, bricolage is often used to adapt to technological devices to individual needs [6]. This is a way of *domesticating* and integrating the technology in their homes, in such a way that it becomes meaningful for them. According to [53], domestication is a prerequisite for integrating technological devices in the elderly's daily lives. This is also talked about sometimes as *appropriation.* Procter et al. [6] suggest the possibility of customizing the technology itself as a solution to this. This could perhaps contribute to some degree to the meaningfulness of the robots and yet ease the integration of those in their homes.

C. Integration of robots viewed through the Sense-of-Coherence

'*The authorities do not allow resignation*,' as the elderly specified about adopting new robots. However, comprehensible, manageable, and meaningful welfare technologies and robots seem to be still not enough for achieving consistency, e.g., a *sense of coherence*. These should also be aligned with political legislation and regulations. Developing policies by promoting the sense of coherence is done in time, but it requires synergies amongst individuals, groups, organizational- and societal levels [60]. Earlier, the emphasis on the alignment between technologies and governmental regulation was put through the (technical) standardization. Such an example is enabling the exchange of patient records all over Europe (Read in Hanseth et al. [61]). The technology was, at the time, predicted to have a vast potential to improve the Norwegian health care system [61].

Further, The Norwegian Social Ministry has since early 2000, a salutogenic approach on elderly *home* care: they listed 16 regulations regarding the quality of life and well-being for the elderly [62]. Amongst the listed prioritized areas were: *autonomy, self-worth,* and *ways of living*. However, at the time, this referred to homecare (comp. to *independent living*). Besides, in a Norwegian report from 2011 [63], it is pointed out that welfare technology should support, amongst others, self-help, independence, having own control despite eventual impairments [63]. This was in line with the Active Ageing framework from 2002 [64]. Active Ageing was at the time defined as: '[…] the process of optimizing opportunities for health, participation, and security in order to enhance the quality of life as people age.' [64]. However, 'healthy aging' replaced the old term framed in 2002 and is the new framework for 2015-2030 [65]. The new policy focuses on the diversity of people, independently of their health status (whether considering them healthy or not). Light et al. [66] supports this indirectly by addressing the technologies as *enabling,* instead of *'assistive.'* The authors also say that this approach will ease tensions amongst national policies.

Finally, in the independent living accommodations for the elderly, based on our empirical data, it seems we still deal with the same issues: political, institutional, and standardization issues. As another participant pointed out, *"It is not ready… the laws are not ready yet.. for this.. which is quite advanced".* While the global or national standards are already there, we still lack standardization that prioritizes less knowledgeable users, such as independent living elderly with reduced ICT literacy. With the integration of new *living technologies*, such as in-motion robots, in the elderly's homes, we should perhaps consider SOC. We argue that the elderly could achieve a greater SOC, as a result of an increased comprehension, manageability, and eventually meaningfulness of robots. This could facilitate the integration of these technologies in their homes. We also admit that there might be other individual or external factors that contribute to SOC.

VI. CONCLUSION

In this work, we have presented views of the elderly on robots. To analyze the data, we have used a qualitative inductive approach by using the content and latent manifest analysis method. The analysis resulted in three categories: aging during the technological renaissance, domestic robots, and the elderly's expectations of legislation and regulations on robots. The overall resulted theme was integrating robots in everyday life. We have later discussed our findings through the lenses of the SOC theory and its concepts of comprehensibility, manageability, and meaningfulness.

Through this study, we have contributed to the understanding of the integration of robots in the homes of the elderly. We have brought concrete examples of how the elderly seek to understand (*comprehend*) and to be able *to manage* welfare robots. We also drew attention upon the importance of having meaningful technologies for them – that are not only useful (for them and their caregivers).

Further, studies show that in the coming years, people will not only live longer but also be more preoccupied with their "*meaning, purpose, and well-being*" in their later stages of life, while "looser family ties" will be more common [67]. This may yet put more pressure on the welfare system provided by the society's public services [67]. As the authors show, this "*self-empowering*" care approach for the elderly, in Norway, is predicted to be *mostly home-based*, but *enabled by* governments, through municipalities, vendors of welfare technologies, and residents and their families [67]. In another study, it is explained that the population aging, as a global phenomenon, would be addressed through "home-based care and multidisciplinary care," by *meeting the demands of the elderly* for living longer at home [68]. However, aldeen Al-Halhouli et al. [69] notified that while "smart house systems" are taking shape, the elderly "do not have *extra time to learn* new technologies" [69]. We have argued in this paper that we should consider the elements from SOC: *comprehensibility, manageability, and meaningfulness,* for better *integration* of robots in the independent living elderly's homes.

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REFERENCES

[1] J. E. Bardram, C. Bossen, and A. Thomsen, "Designing for transformations in collaboration: A study of the deployment of homecare technology," in Proc. of the 2005 International ACM SIGGROUP Conf. on Supporting Group Work, New York, NY, USA, 2005, pp. 294–303.

[2] D. Detmer, M. Bloomrosen, B. Raymond, and P. Tang, "Integrated personal health records: transformative tools for consumer-centric care," BMC Med. Inform. Decis. Mak., vol. 8, p. 45, Oct. 2008.

[3] D. Fischinger et al., "Hobbit, a care robot supporting independent living at home: First prototype and lessons learned," Robot. Auton. Syst., vol. 75, pp. 60–78, Jan. 2016.

[4] S. A. McGlynn, S. Kemple, T. L. Mitzner, C.-H. A. King, and W. A. Rogers, "Understanding the potential of PARO for healthy older adults," Int. J. Hum.-Comp. Stud., vol. 100, pp. 33–47, Apr. 2017.

[5] A. Light, T. W. Leong, and T. Robertson, "Ageing well with CSCW," in ECSCW 2015: Proc. of the 14th Euro. Conf. on CSCW, 19-23 Sep. 2015, Oslo, Norway, Springer, Cham, 2015, pp. 295–304.

[6] R. Procter et al., "The day-to-day co-production of ageing in place," CSCW, vol. 23, no. 3, pp. 245–267, Jun. 2014.

[7] M. Koelen, M. Eriksson, and M. Cattan, "Older people, sense of coherence and community," in The Handb. of Salutogen., M. B. Mittelmark, S. Sagy, M. Eriksson, G. F. Bauer, J. M. Pelikan, B. Lindström, and G. A. Espnes, Eds. Cham: Springer Intern. Pub., 2017, pp. 137–149.

[8] M. Eriksson, "The Sense of Coherence in the salutogenic model of health," in The Handbook of Salutogenesis, M. B. Mittelmark, S. Sagy, M. Eriksson, G. F. Bauer, J. M. Pelikan, B. Lindström, and G. A. Espnes, Eds. Cham: Springer Intern. Pub., 2017, pp. 91–96.

[9] P. B. Baltes and J. Smith, "New frontiers in the future of aging: from successful aging of the young old to the dilemmas of the fourth age," Gerontology, vol. 49, no. 2, pp. 123–135, Apr. 2003.

[10] D. Field and M. Minkler, "Continuity and change in social support between young-old and old-old or very-old age," J. Gerontol., vol. 43, no. 4, pp. P100-106, Jul. 1988.

[11] OED, "welfare, n.," OED Online. Oxford University Press, 2017, Retrieved Feb. 2020.

[12] Nordic Centre for Welfare and Social Issues, "Welfare technology." Nordic Centre for Welfare and Social Issues, Retrieved Feb. 2020.

[13] OED, "robot", Oxford Dictionaries | English. Oxford University Press, 2017, Retrieved Feb. 2020.

[14] E. Oborn, M. Barrett, and A. Darzi, "Robots and service innovation in health care," J. Health Serv. Res. Policy, vol. 16, no. 1, pp. 46–50, Jan. 2011.

[15] D. Saplacan and J. Herstad, "A quadratic anthropocentric perspective on feedback - Using proxemics as a framework," Conf. Proceed. of BritishHCI 2017, Sunderland, U.K., pp. 1-6, Jul. 2017.

[16] J. M. Alcalá, J. Ureña, Á. Hernández, and D. Gualda, "Assessing human activity in elderly people using non-intrusive load monitoring," Sensors, vol. 17, no. 2, , p. 351-368, Feb. 2017.

[17] G. Acampora, D. J. Cook, P. Rashidi, and A. V. Vasilakos, "A survey on ambient intelligence in healthcare," Proc. IEEE, vol. 101, no. 12, pp. 2470–2494, Dec. 2013.

[18] E. Chiauzzi, C. Rodarte, and P. DasMahapatra, "Patient-centered activity monitoring in the self-management of chronic health conditions," BMC Med., vol. 13, pp. 1-6, Apr. 2015.

[19] M. Petersen and N. F. Hempler, "Development and testing of a mobile application to support diabetes self-management for people with newly diagnosed type 2 diabetes: a design thinking case study," BMC Med. Inform. Decis. Mak., vol. 17, no. 1, pp. 1-10, Jun. 2017.

[20] R. Laidlaw et al., "Using participatory methods to design an mHealth intervention for a low income country, a case study in Chikwawa, Malawi," BMC Med. Inform. Decis. Mak., vol. 17, pp. 1-12, Jul. 2017.

[21] K. Johnston, K. Grimmer-Somers, and M. Sutherland, "Perspectives on use of personal alarms by older fallers," Int. J. Gen. Med., vol. 3, pp. 231–237, Aug. 2010.

[22] P. Caleb-Solly, "A brief introduction to … Assistive robotics for independent living," Perspect. Public Health, vol. 136, no. 2, pp. 70–72, Mar. 2016.

[23] S. Bedaf, G. J. Gelderblom, and L. De Witte, "Overview and categorization of robots supporting independent living of elderly people: What activities do they support and how far have they developed," Assist. Technol. Off. J. RESNA, vol. 27, no. 2, pp. 88–100, 2015.

[24] S. Bedaf and L. de Witte, "Robots for Elderly Care: Their Level of Social Interactions and the Targeted End User," Stud. Health Technol. Inform., vol. 242, pp. 472–478, 2017.

[25] Samfunnkunskap.no, "Welfare state" 2018. [Online]. Retrieved Feb. 2020.

[26] J. Ramm, "Health and care. Use of services among the elderly," ssb.no, 2013. [Online]. Retrieved Feb. 2020

[27] D. Slettemeås, "Eldres bruk av digitale verktøy og internett: En landsdekende undersøkelse av mestring, støttebehov, motivasjon og hindringer," Deltasenteret, Statens Institutt for frobruksforskning (SIFO), 5–2014, Jun. 2014.

[28] B. A. Farshchian, T. Vilarinho, and M. Mikalsen, "From episodes to continuity of care: a study of a call center for supporting independent living," CSCW, vol. 26, no. 3, pp. 309–343, Jun. 2017.

[29] A. Antonovsky, "The salutogenic model as a theory to guide health promotion," Health Promotion International, vol. 1, 11 vols. Oxford University Press, Great Britain, pp. 11–18, 1996.

[30] C. Benz, T. Bull, M. Mittelmark, and L. Vaandrager, "Culture in salutogenesis: the scholarship of Aaron Antonovsky," Glob. Health Promot., vol. 21, no. 4, pp. 16–23, Dec. 2014.

[31] S. Suominen and B. Lindstrom, “Salutogenesis,” Scand. J. Public Health, vol. 36, no. 4, pp. 337–339, Jun. 2008.

[32] S. Super, M. a. E. Wagemakers, H. S. J. Picavet, K. T. Verkooijen, and M. A. Koelen, “Strengthening sense of coherence: opportunities for theory building in health promotion,” Health Promot. Int., vol. 31, no. 4, pp. 869–878, Dec. 2016.

[33] J. Lahtiranta, J. S. S. Koskinen, S. Knaapi-Junnila, and M. Nurminen, “Sensemaking in the personal health space,” Inf. Technol. People, vol. 28, no. 4, pp. 790–805, Nov. 2015.

[34] J. Lahtiranta and J. S. S. Koskinen, “Electronic health services for cardiac patients: a salutogenic approach,” Finn. J. EHealth EWelfare, vol. 5, pp. 96–93, 2013.

[35] H. Dreyfus, Being-in-the-world: A Commentary on Heidegger’s Being and Time, Division I. Massachusetts Institute of Technology, 1991.

[36] F. Svenaeus, “The relevance of Heidegger’s philosophy of technology for biomedical ethics,” Theor. Med. Bioeth., vol. 34, no. 1, pp. 1–15, Feb. 2013.

[37] ssb, “Next million reached set to be the fastest,” ssb.no, 2017. [Online]. Retrieved Feb. 2020.

[38] Statistics Norway, “Population,” (Statistik sentralbyrå, ssb.no, 17-Nov-2016. [Online]. Retrieved Feb. 2020.

[39] S. G. Joshi, “Designing for capabilities: A phenomenological approach to the design of enabling technologies for older adults,” 2017.

[40] A. Woll, “Use of welfare technology in elderly care,” University of Oslo, Oslo, Norway, 2017.

[41] S. G. Joshi and T. Bratteteig, “Assembling fragments into continuous design: On participatory design with old people,” in Nordic Contributions in IS Research, 2015, pp. 13–29.

[42] S. G. Joshi and T. Bratteteig, “Designing for prolonged mastery. On involving old people in participatory design,” Scand. J. Inf. Syst., vol. 28, no. 1, Jul. 2016.

[43] S. G. Joshi, “Designing for experienced simplicity. Why analytic and imagined simplicity fail in design of assistive technology,” Int. J. Adv. Intell. Syst., vol. 8, no. 3 and 4, pp. 324–338, Dec. 2015.

[44] R. B. Rosseland, “Exploring movement-absed rhythmic interaction with senior citizens,” University of Oslo, Department of Informatics, Faculty of mathematics and natural sciences, Oslo, Norway, 2018.

[45] M. Dalen, Intervju som forskningsmetode: en kvalitativ tilnærming, 2. utg. Oslo: Universitetsforl, 2013.

[46] U. H. Graneheim and B. Lundman, “Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness,” Nurse Educ. Today, vol. 24, no. 2, pp. 105–112, Feb. 2004.

[47] S. A. Ballegaard, J. Bunde-Pedersen, and J. E. Bardram, “Where to, Roberta?: Reflecting on the role of technology in assisted living,” in Proc. of the 4th Nordic Conf. on HCI: Changing Roles, New York, NY, USA, 2006, pp. 373–376.

[48] A. Vercelli, I. Rainero, L. Ciferri, M. Boido, and F. Pirri, “Robots in elderly care,” Digit. - Sci. J. Digit. Cult., vol. 2, no. 2, pp. 37–50, Mar. 2018.

[49] A. Sciutti, M. Mara, V. Tagliasco, and G. Sandini, “Humanizing Human-Robot Interaction: On the importance of mutual understanding,” IEEE Technol. Soc. Mag., vol. 37, no. 1, pp. 22–29, Mar. 2018.

[50] E. Cheon and N. M. Su, “Configuring the user: ‘Robots have needs too,’” in Proc. of the 2017 ACM Conf. on CSCW and Soc. Comp., New York, NY, USA, pp. 191–206, 2017.

[51] S. Ljungblad, J. Kotrbova, M. Jacobsson, H. Cramer, and K. Niechwiadowicz, “Hospital robot at work: Something alien or an intelligent colleague?,” in Proc. of the ACM 2012 Conf. on CSCW, New York, NY, USA, pp. 177–186, 2012.

[52] Y. Riche and W. Mackay, “PeerCare: supporting awareness of rhythms and routines for better aging in place,” CSCW, vol. 19, no. 1, pp. 73–104, Feb. 2010.

[53] J. Meurer, C. Müller, C. Simone, I. Wagner, and V. Wulf, “Designing for sustainability: Key issues of ICT projects for ageing at home,” ECSCW 2018, pp. 1-44, 2018.

[54] P. J. Hinds, T. L. Roberts, and H. Jones, “Whose Job is It Anyway? A Study of Human-robot Interaction in a Collaborative Task,” Hum-Comput Interact, vol. 19, no. 1, pp. 151–181, Jun. 2004.

[55] J. Fink, “Anthropomorphism and human likeness in the design of robots and Human-Robot Interaction,” in Soc. Rob., S. S. Ge, O. Khatib, J.-J. Cabibihan, R. Simmons, and M.-A. Williams, Eds. Springer Berlin Heidelberg, pp. 199–208, 2012.

[56] F. Eyssel, D. Kuchenbrandt, S. Bobinger, L. de Ruiter, and F. Hegel, “‘If you sound like me, you must be more human’: on the interplay of robot and user features on human-robot acceptance and anthropomorphism,” in Proc. of the 7th annual ACM/IEEE intern. conf. on HRI, pp. 125–126, 2012.

[57] C. Bartneck, D. Kulić, E. Croft, and S. Zoghbi, “Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots,” Int. J. Soc. Robot., vol. 1, no. 1, pp. 71–81, Jan. 2009.

[58] K. Yogeeswaran et al., “The interactive effects of robot anthropomorphism and robot ability on perceived threat and support for robotics research,” J. Hum.-Robot Interact., vol. 5, no. 2, pp. 29–47, Sep. 2016.

[59] M. Mori, “The uncanny valley [From the Field],” IEEE Robot. Autom. Mag., vol. 19, no. 2, pp. 98–100, Jun. 2012.

[60] M. Eriksson and M. B. Mittelmark, “The Sense of Coherence and its measurement,” in The Handbook of Salutogenesis, M. B. Mittelmark, S. Sagy, M. Eriksson, G. F. Bauer, J. M. Pelikan, B. Lindström, and G. A. Espnes, Eds. Cham (CH): Springer, pp. 97-106, 2017.

[61] O. Hanseth, K. Thoresen, and L. Winner, “The politics of networking technology in health care,” CSCW, vol. 2, no. 1, pp. 109–130, 1993.

[62] T. Bratteteig and I. Eide, “Becoming a good homecare practitioner: Integrating many kinds of work,” CSCW, vol. 26, no. 4, pp. 563–596, Dec 2017.

[63] Norwegian Government Security and Service Organisation (G.S.S.O), “Innovation in care (Original Title: Innovasjon i Omsorg),” NOU (Norway’s public investigations), Oslo, Norway, 2011:11, 2011.

[64] WHO, “Active ageing: a policy framework,” World Health Organization, 2002, Retrieved Feb. 2020.

[65] WHO, “What is Healthy Ageing?,” Ageing and life course, 2018. [Online]. Retrieved Feb. 2020.

[66] A. Light et al., “What’s special about aging,” ACM Interactions, vol. 23, Number 2. pp. 66–69, 2016.

[67] B. Bygstad and G. Lanestedt, “Expectations and realities in welfare technologies: A comparative study of Japan and Norway,” Transform. Gov. People Process Policy, vol. 11, no. 2, pp. 286–303, Apr. 2017.

[68] H. Arai et al., “Toward the realization of a better aged society: Messages from gerontology and geriatrics,” Geriatr. Gerontol. Int., vol. 12, no. 1, pp. 16–22, Jan. 2012.

[69] A. ’aldeen Al-Halhouli et al., “LEGO Mindstorms NXT for elderly and visually impaired people in need: A platform,” Technol. Health Care Off. J. Eur. Soc. Eng. Med., vol. 24, no. 4, pp. 579–585, Jul. 2016.

PAPER II

An Explorative Study on Motion as Feedback: Using Semi-Autonomous Robots in Domestic Settings

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***Abstract*—This paper presents motion as *feedback*. The study is based on empirical data from an explorative study of semi-autonomous robots used in domestic settings. We explore feedback received from stationary technology, e.g., a smartphone, and technology that is self-propelled, e.g., a semi-autonomous robot. The paper has its theoretical foundation in the *familiarity* concept used as a contextual and analytical tool for unpacking *feedback*. The data analysis is done through thematic analysis. The findings are structured in: *feedback* received from a smartphone app technology, *feedback* received from the robot-mediated via an app; and *motion as feedback* received from the robot. *Motion as feedback* is discussed in terms of: (a) what type of emotions feedback triggers in the users, and (b) making sense of the motion as *positive, negative, homeostatic, archival* and *transition feedback*. We argue that having *familiarity* in mind when designing new technologies, can make it easier for the user to *know-how* to *engage with* the technology. Our conclusion is that: a semi-autonomous robot technology can become more familiar to the user if it triggers positive feelings, if its motion is coherent, if its navigation is appropriate to the situation, and if its motion is not disturbing or interrupting the user; and lastly, *familiarity* needs to be considered when designing for a robot for the elderly.**

Keywords – feedback; motion as feedback; semi-autonomous robot; familiarity; emotions.

I. INTRODUCTION

This paper builds further on our reported work on how *feedback* from digital technologies may trigger the feeling of fear for technology when using those [1]. We have in our previous work used fear as an umbrella term for emotions, such as *angst, anxiety, concern, doubt, dread, unease, uneasiness, worry, aversion, fright, phobia,* and *presentiment* [2]. In this paper, we extend this work by looking at the *motion* of robots as a type of *feedback*. We do this by running a study where researchers test out a robot, and by introducing a robot in the homes of the elderly.

The questions that we address are: 1) What kind of emotions are triggered in the user by improper or lack of feedback when *engaging* with digital technology: a smartphone app or a semi-autonomous robot? 2) How is a motion made sense of by the users when *engaging* with a semi-autonomous robot, in their homes? Moreover, if motion is illustrated as a type of feedback – what do we learn from their experiences?

The rest of this paper is organized as follows. We continue by introducing some terminology used in this paper and a short background for the study. Section II gives an overview of the current state of the art on different types of robots used in home and outside the home. Section III elaborates on feedback as understood within Human-Computer Interaction (HCI). We introduce feedback as *visual* and *textual* feedback. Based on the literature, we describe *polarity-*, *homeostatic,* and *archival feedback*, which we later use in our mapping of *motion as feedback.* We continue then by introducing the reader briefly to *motion as feedback* and the robot's navigation. Section IV continues with positing this paper on a theoretical level, elaborating on the *familiarity* concept grounded in literature. Section V gives a detailed account of the methodology and methods for this study. Section VI presents in details the findings based on empirical data. Section VII discusses the findings through the lens of *familiarity* while elaborating on the *motion as feedback*. Finally, Section VIII concludes the paper and gives directions for further work.

A. Terminology

A domestic setting provides the opportunity for those who live there, or are around, to use technologies that are still, such as a smartphone, or technologies that move, such as a semi-autonomous robot.

A smartphone *is still technology.* We define still technology as *a technology that does not move by itself; it is not self-propelled, i.e., it does not change its location without the continuous intervention of a human or another object*. Examples of analog and digital *still* technologies are a table, a sofa, a notebook, a speaker, a lamp, a mobile phone, or a smartphone. One could argue that a smartphone is indeed a mobile technology. We agree with this if we talk about the way it is used. However, when it comes to its form of motion or locomotion, a smartphone or mobile phone does not move around by itself and change its location, unless they are moved by *someone* or *something* that can move. However, a smartphone or a mobile phone can vibrate, and one could argue that vibration is a type of movement. However, this type of movement is not an intended movement of changing its location, or of navigating an environment.

We define a *semi-autonomous robot as an in-motion technology that can move by itself; it can be self-propelled, that follows a locomotion process, i.e., it can change its location without a necessary and continuous intervention of a human or another object*. Examples of in-motion analog and digital technologies are mechanical robots and semi-autonomous robots, which can navigate a place by themselves, such as semi-autonomous vacuum cleaner robots, or lawn mowers.

In this paper, we use this terminology interchangeably: smartphone app technology, in order to refer to still technology; and semi-autonomous robot technology for referring to in-motion technologies, here a semi-autonomous vacuum cleaner robot.

B. Background

According to the literature, robots are defined as: "physically embodied systems capable of enacting physical change in the world." [3]. Following [4], industrial robots refer to robots that move around or transport things, and usually operate on conveyor belts, in packaging, and assembling [4]. Industrial robots usually perform repetitive routine tasks, often having a predefined navigation path. Professional service robots are similar to industrial robots, but they are used outside the industrial setting: they can transport things, by navigating around the environment [4]. To these, robots used in healthcare also add up [3]. They refer to the micro-robotics that are used *inside* the body, protheses robotics that are used *on* the body, and robotics that are used *outside* the body. Other robots are used to support mental or behavioral therapy, such as those used for people with diagnoses on the autism spectrum disorder, those with cognitive impairments, or as companions [3]. However, they usually perform tasks to assists people: cleaning nuclear waste [4], supporting surgeries in hospital settings, or carrying around medicines or instruments, see for example the work from [5] or [6]. The robots that are outside the body and can move semi-autonomously usually have pre-defined paths and navigate in uncluttered environments.

Further, the third wave in HCI discusses digital technology in our homes [7]. However, we still seem to have less knowledge on the use of moving objects in the home than about the use of stationary technology – although several existent projects are studying the use of robots in the home. These are usually included under the category of personal service robots, following [4]. Amongst personal service robots are: robotic vacuum cleaners, lawn mowers, and assistive robots for the elderly or the un-abled [4].

This study is part of the Multimodal Elderly Care Systems (MECS) [8]. The project focuses on the design of a robot for the independently living elderly. We define elderly as old adults (≥ 65 years), according to definitions used in gerontology [9][10]. However, within the frame of the MECS project, this study consists of a qualitative interpretative phenomenological evaluation of the interactive systems as experienced by participants in their daily lives, and the phenomena surrounding them. We followed the HCI definition - a "discipline concerned with the *design*, *evaluation,* and implementation of interactive computing systems *for human use* and with the *study of major phenomena surrounding them*." [11, 15, emphasis added]. The setting for this study was the homes of our participants.

II. State of The Art

According to state of the art in robotics, published in 2016 U.S. Robotics Roadmap, the focus area of the field is currently on: aging well and quality of life, robotics used in the medical field in surgeries and interventions, and the robots used as "clinical workforce support" [3, 73]. The study also says that a *one-size fits all* approach is hard to be achieved in robotics [3].

A thorough overview of the robots used in studies for supporting independent living is given in [12]. There are several projects studying the use of robots in the home. A project concerning the care of the elderly is Acceptable robotiCs COMPanions for AgeiNG Years (ACCOMPANY) [13][14]. ACCOMPANY developed Care-O-Bot robot. Care-O-Bot is amongst one of the robot assistants used for housekeeping and home care [13][14][15][16]. Care-O-Bot is a state-of-the-art robot designed to be used in the home [17]. A couple of other projects studying these type of robots are named in the work of [17], such as Handy 1, Movaid, and Nursebot built for the elderly or the disabled; GuideCane, Hitomi, PAM-AID, PAMM, Smart-Cane PAMM, and Smart-Walker PAMM. These robotic prototypes were built to be walking aid for the blind, elderly, or the disabled [17].

At EU-level, several projects studied the use of robots in the home. Amongst the European Union projects are: Robot-Era Project [3], MARIO Project on Managing active and healthy aging with use of caring service robots, EURON RoboEthics Roadman, EP6, ETHICBOTS, BREATHE, and ICT & Ageing Project [18]. Another project was the Multi-Role Shadow Robotic System for Independent Living (SRS) [19]. The project focused on studying the frail elderly people: the elderly whose Activities of Daily Living (ADL) are limited by their health problems [19]. Many of the frail elderlies use walking chairs, sticks, or wheelchairs [19]. The study shows that teleoperated robots may be accepted in some situations, whereas direct physical interaction with a service robot can be, at times, difficult [19]. It seems that "housing-related needs" are central for learning and adopting the technology *if* these technologies function well [19, 303]. For instance, the study also indicates that men have more difficulties than women with housekeeping tasks, while women have difficulties in reaching things [19]. A similar study to ours talks about introducing personal service robots, a Roomba Discovery vacuum cleaner, in homes [20]. The home is viewed as an ecology of products, people, activities, a social and cultural context of use, and a place – a bounded environment [20]. It seems that the expectations one has of technology are highly related to shaping the initial expectations of technology. The use of the robot also influenced the practice of housekeeping: in some households, the male participants set-up the robot; in others, only the women use it [20].

Companion robots are also used in studies with the elderly. An example of a companion robot is PARO, the seal robot [21][22][23]. The seal robot PARO was used in facilities for the elderly in the Nursing-care Robot Promotion Project, in Japan [22]. An initial study showed that the elderly participants suffering from various mental or behavioral issues, but who interacted with PARO over time improved their communication, reduced their aggression and wandering, as well as improved the sociability of the participants, over time [22]. PARO also seems to be widely accepted across cultures [24]. Other examples of companion robots are Pepper and NAO used in exploratory studies, as shown in [25]. AIBO, Furby, and NeCoRo are a few other robots representing animals that were used in therapy with children, or in nursing homes with the elderly [21][22].

Another project from the EU project within the Ambient Assisted Living (AAL) is Enabling Social Interaction Through Ambient (EXCITE) [26]. The project introduced the Giraff robot in several homes with the purpose of studying "social interaction through robotic telepresence" [26, 827], an idea that stemmed from the RoboCare project [27].

Finally, it seems that "20% of the world's population experience difficulties with physical, cognitive, or sensory functioning, mental health or behavioral health" [3]. In numbers, there are around 190 million people experiencing difficulties with ADL, including physical tasks and cognitive tasks [3]. Further, it seems that the aging of the workforce has consequences within the healthcare field [28][29]. A study from [30] shows that, for instance, in Sweden, the cost for the home care for the elderly would increase between 20 and 35% between 2013 to 2020, whereas this could instead be reduced by 50% as of 2020, with the digitalization of the home care services [30]. In Norway, the elderly population will increase by 21% by 2050 [31]. Furthermore, the active working force will not be able to tackle the healthcare needs imposed by this increase [31] and yet among the action plans taken at the European Union's level, regarding this societal challenge, is the digitalization of health through the use of Information Communication Technologies (ICT's) [32]. Moreover, several studies address directly or indirectly the issue of the digital divide between users with ICT literacy and those, with reduced ICT literacy. Elderly are often included in the group of users with reduced ICT literacy as shown in [33][34][35][36]. Yet, all the above yield at how important it is to make sense of the design of today's technologies, including those that *move*: semi-autonomous robots for the use in the homes of the elderly. Nevertheless, one of the designing principles for designing good smartphone technologies and semi-autonomous robots is to give informative feedback when an error occurs [37][38]. Understanding feedback is, therefore, highly relevant in this context. Next section gives an introduction to the main topic discussed in this paper: feedback.

III. FEEDBACK

In this section, we describe how feedback is currently discussed in the HCI literature.

Feedback is an abstract concept that was used in a number of disciplines. Diverse elaborations and explorations of feedback definitions are encountered from control theory and cybernetics to the definitions used in HCI [1][39]. Before going further, we wish to turn to the definition of feedback, within HCI, as explained by Norman (2013): informing the user, in some way, that the system is working, as a response to the user's action [40].

Feedback in the interaction with a desktop computer interface was well established a long time ago and often already understood by the user [41]. Here are a few examples based on Apple's User Interface Guidelines dating back to 1992: feedback to the user when typing in passwords by displaying a bullet character for each typed character by the user; feedback of a cursor showing a delay after user has moved a big document to the trash bin; a dialogue box feedback informing the user about his or her actions' result; when the user deletes everything from the trash bin, an *empty trash* text should be displayed; when selecting an option in a radio button, the user should see a bullet in the selected option; when an option from a menu is chosen by the user, the option is hoovered or the background color is changed; when an item is selected from a palette of patterns or colors, that option is highlighted or outlined; moving around windows on the desktop is illustrated immediately to the user through the windows new position; an active window is highlighted or outlined; when a user shall be informed about potential dangers, such as an unsafe document to be opened, or a non-reversible action, the user should be informed through a caution alert box, where the user has the possibility to cancel the action or to proceed further; or a button that is clicked or hoovered over shall be highlighted [41].

According to [42], feedback is an important concept that is studied, especially within education. However, within the HCI field, it seems still to remain ambiguous and primitive, and "is oversimplified" [42, 253]. While some of the literature identifies feedback as a response to the user's action [9], others talk about feedback as a way "to communicate the state of the system independently of the user's action" [43, 316]. Feedback can be visual, auditory, haptic, and some talk about it as bio-feedback in HCI studies that measure or self-track the human [1]. Others talk about eco-feedback in sustainability and environmental HCI studies, or affective feedback [1].

Further, language seems to play a central role in HCI, in auditory and textual feedback. However, we have also seen that language *per se* used in the interaction with computers or machines does not always work: see for instance the example of the natural language processing ELIZA used in early days of Artificial Intelligence (AI), mentioned in [44]; or the example of textual feedback using technical language of "it cannot connect to the *cloud services*" [1, 176]. [44] talked about how the HCI field evolved based mainly on conversational and linguistic development, a common language [44]. This was mainly a question of mutual intelligibility through language.

But the HCI field has evolved, and while *visual, auditory and textual feedback* still remain essential, it also seems to become more common to *interact with things that move*. As [45] has earlier put it: the conditions for the possibility that the world as an adjacent to everyday interaction becomes an interface for computation, we could, in his words, through this type of interaction "capitalize our familiarity, skill and experience in dealing with the everyday world around us" [44, 1]. In addition to the development of a *common language*, we also need to develop *a shared understanding*, *mutual intelligibility of the motion* of the robot: "A robot in the real world, however, must consider the execution of the plan as a major part of every task. Unexpected occurrences are not unusual, so that the use of sensory feedback and corrective action are crucial" (Raphael, cited in McCorduck, 1979, p. 224), in [44, 23]. How can then the movement itself of things be applied in order to facilitate human interaction with things? What experience of the robot's movements should be designed for? And what do these movements communicate to the user? How are these movements interpreted by the user as feedback? How do we describe patterns of movements, styles of movement, or ways of moving? How can these movement styles be mapped as feedback to the user?

Before going further, we would like to explain polarity feedback, homeostatic feedback, and archival feedback – types of feedback that we found in the existent literature. This is later our departure point for discussing *motion as feedback*.

A. Polarity Feedback: Positive and Negative

Polarity feedback can be regarded as *positive* or *negative* [42], *depending on how the feedback is interpreted by the user, compared to the user's expectations.* According to [42], feedback as information retrieval, in the broader sense of it, is formed by a message, a cognitive interpretation, and its context. For instance, a user sets the temperature on a thermostat in a room to be 25°C degrees. In this situation, the visual feedback can be translated as positive, if it shows the temperature set by the user, or at least close to what the user has set (23°C degrees, or perhaps 26°C degrees) could still be accepted. However, if the temperature of the room does not seem to be close to what the user has set, say 15°C degrees or 35°C degrees, the feedback is translated as negative feedback. In other words, positive feedback is when the system responds accordingly or at least close enough to the input of the user, meeting the user's expectations. On the other hand, negative feedback is when the system does not respond exactly or close enough to the user's input, resulting in a high difference between the system response and the user's expectations. Negative feedback does not necessarily need to have a negative value, (+)15 °C can still be considered a negative value.

B. Homeostatic Feedback

Feedback has a polarity, positive, and negative, but it can also be homeostatic [46]. *Homeostatic feedback* is a *type of feedback that is constant, regardless if the feedback is positive or negative; the state of the feedback is the same over a longer time period*. Polarity feedback and homeostatic feedback are not *mutually exclusive*: positive or negative feedback can also be at the same time homeostatic [42]. Taking the same example of receiving feedback from a thermostat on a room's temperature homeostatic feedback is when the thermostat shows over a longer period of time exactly 25°C degrees, according to the user's input. But homeostatic feedback can also be negative feedback of 15°C, or 30°C degrees, over a longer period of time. If the thermostat does not start, although the user has pressed a start button, it can also be translated into a homeostatic negative feedback.

C. Archival Feedback

The literature discusses archival feedback [46]. This type of feedback is distinguished from immediate feedback [46]. *Such a type of feedback logs and remembers the system's previous actions, in such a way that it can return to a previous state*. A concrete example is when the user uses the UNDO button: if the actions of the user were logged over time, then the UNDO button performs a positive action, e.g., the system goes back to a previous state. This type of feedback that logs and remembers previous states of the system is called archival feedback. If the UNDO button cannot perform this operation, pressing the UNDO button gives a negative feedback, e.g., nothing changes – the system stays the same. However, the system should inform the user anyway, that nothing was changed. This is then not an archival feedback, but rather the user receives a negative feedback on its input regarding the archival feedback.

D. On Motion - As Feedback

Following Mitcham's (1978) in [47] it seems that a tool is activated by the human agency, while a machine can, to a certain degree, operate independently [47]. Following this definition, we could say that a semi-autonomous robot used at home is in a way a machine – something that acts independently, but also a tool, since it is controlled at some degree by the user: through a button, or by using an app as a remote controller, or through a remote controller.

In general, humans know where they are, or how to navigate their way where they want to get [47]. One can navigate his or her way based on own knowledge or familiarity with the place, or by using a map. This is done through their own body's locomotion [47]. Wayfinding is different from navigation, by moving from a location to another region (compared to navigation, which is moving from one location to another location) [47, 219-242]. A semi-autonomous robot is moving within a home through both types of motion: first, through wayfinding, by creating a map of the place; and second, through navigation, moving around on the already mapped space. These types of movement can be classified as locomotion, or a global movement, according to [48]. Besides these movements, a robot also has its own motions, such as moving the head of a robot, moving an arm, without changing the robot's location. The authors classify this type of movement as a local movement, or to use the term from robotics, configuration movement [48]. In this paper, the local movement is considered as *still* type of motion. The paper is mainly concerned with the locomotion type of movement. Rather than going into the depths of motion and animation techniques here, we would like instead to focus on exploring further domestic robot's *motion as feedback*: What kind of feedback does the user receive and in, which situations? What are the implications of the motion for the feedback? How is the robot motion perceived by the users in terms of feedback?

We have earlier conceptualized feedback [39] based on Hall et al. (1968) proxemics [49]. We have identified that a semi-autonomous robot includes the same types of feedback as a smartphone app technology, but in addition, it has the motion element [39]. We observed that the motion of the robot could be considered as a type of feedback that it is manifested through *distributed feedback*, via extended proxemics, when the feedback from a robot is given via an app [39]. We noticed that this type of feedback was *distributed* when using an app. To simplify the discussions later, we illustrate (a) getting feedback from a smartphone app technology vs. (b) getting feedback from a robot (Fig. 1). We also noticed that while feedback from a smartphone is direct, feedback from a robot can be both direct, from the robot, or *distributed*, via an appWe build in this paper further on the earlier reported work, the *motion as a form of feedback*, by investigating the *motion* of the robot, and by looking at how it is made sense by the users. We do this by bringing up examples from our empirical data (Section VI). We make sense of *motion as feedback* based on our empirical data, by distinguishing between feedback from a smartphone and a semi-autonomous technology, reshaping and molding the notion, understanding and making sense of the motion as feedback. In this way, can these various types of *motions* be perceived as *feedback* by the participants? How can we classify then these *motions as feedback*? Introducing a common vocabulary may help us to talk about motions of semi-autonomous things in homes in a better way, similarly to perspectives from other fields, such as mathematics, physics, medicine, or biology: anthropomorphizing – moving like a human; zoomorphic – animal movement, robot morphing – moving like a machine. We continue in the next section by laying our theoretical foundation: the *familiarity* concept. The concept will later in the paper help us to unpack and understand the *feedback* notion.

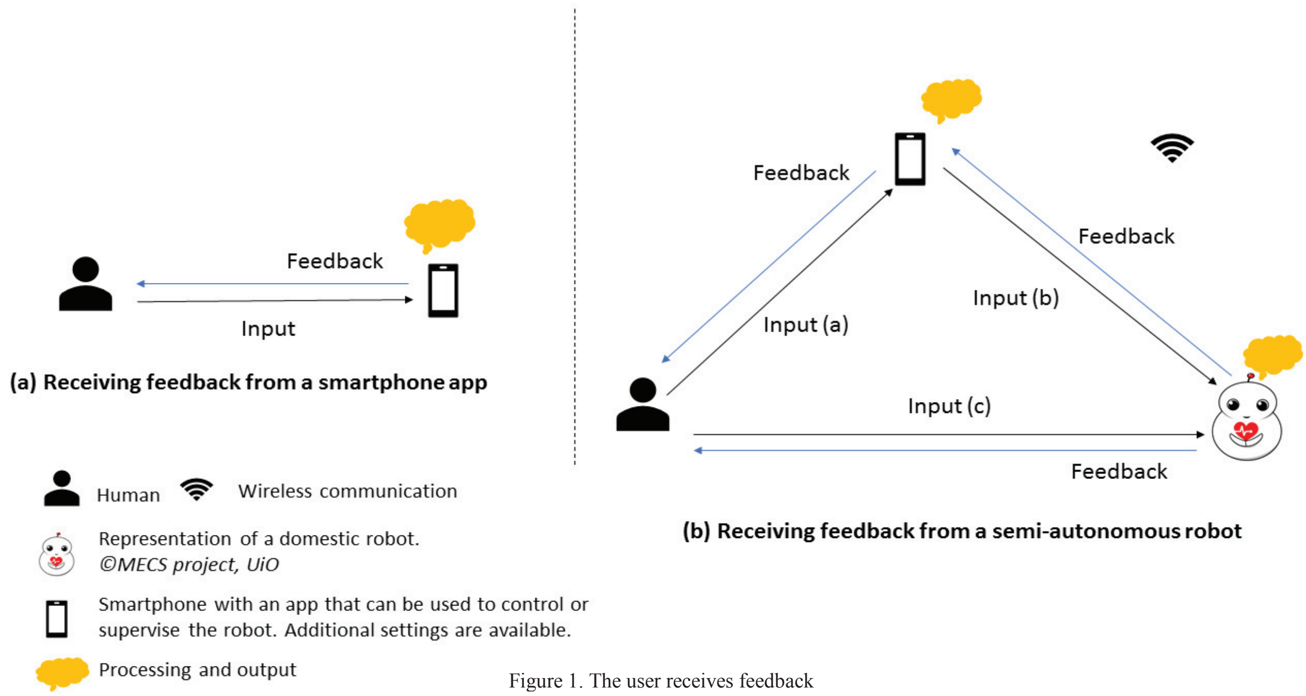

Figure 1. The user receives feedback

IV. THEORETICAL FOUNDATIONS: ON FAMILIARITY

According to [50], theory helps us "to structure knowledge, to evaluate and assess it, to construct it and share it" [50, 126]. Amongst their six models of using theory, there are also: theory as a contextual tool, where the researchers start with a research question and take a position, often referring to theory as concepts, ideas, or perspectives; and theory as an analytical tool, where the researchers use the theory to analyze and interpret the findings in the light of the theory [50]. In this paper, we have used both these types of using theory: for both the former and the latter one, we posit the paper within the frame of the familiarity concept used in HCI.

The concept of *familiarity* is illustrated in Heidegger's Being and Time as "[knowing] its way about" [51]. *Familiarity* can be described as an intimate, close, and friendly state, or interaction [52]. In Dreyfus' view, *familiarity* gives one the tools to respond correspondingly to different situations [53]. In HCI, *familiarity* has been used as a base for the design. For instance, this concept can be used in the skeuomorphic design. Skeuomorphic design refers to when the digital interface adopts some of the physical artifact's properties in order to accommodate better the user by making the digital artifact looking more familiar [54]. Such an example is, for instance, when a digital interface imitates the paper look of an old book. Others have used it within the design of tangible systems [55]. However, it seems the concept is still underexplored within HCI, while it seems to be important in the sense-making of using technology. For instance, [56] found that *familiarity* plays a central role in individuals' relationships with technology [56]. Later, [57] pointed out that *familiarity* concept did not get too much attention in the field of HCI, besides his previous work together with Van de Walle [57].

Inspired by the work of Heidegger, Mereleu-Ponty, and Dreyfus, [58] tried to make sense of everyday's examples of interacting with technology, the readiness of coping with it in everyday life situations. Further, *familiarity* is based on several key points [55]. Among these are: *familiarity* with digital technology depicts a "*know-how*" relationship [58] based on a tacit knowledge; *familiarity* is based on everyday use, on reading about it, and being taught how to use it; *familiarity* with digital technology means knowing how to use it, or using Turner's words, "*to be ready to cope with it*" [55, 25, emphasis added]. *Familiarity* is also a form of *engagement*, of what Heidegger calls involvement [59]. However, *familiarity* with technology is more difficult because involvement with technology can become complex [59]. Involvement represents a form of care, enfoldment, entanglement, according to [55]. *Familiarity* also has *an affective part* that builds upon feelings of closeness, of being at home, feelings of comfort, ownership, and warmness [55]. Inspired perhaps by Heidegger's "being-in-the-world," he calls this relationship of *co-existence* with technology as *being-with* [55]. According to the author, an appropriate way of *becoming familiar* with technology is to integrate it within the participants' everyday life [59]. He sees this type of relationship as a *co-existence relationship* with technology [59]. Turner (2008) also says that *familiarity* can be illustrated as one's perception change rather than knowledge creation [57] .

Finally, [60] also argued for *familiarity* as a basis for universal design. They mean that HCI is based on the distinction between man and machine [60]. Furthermore, [61] described it as an intimate or close relationship, where humans *engage with-* and *try to understand the technology* [61]. The authors propose *a salutogenic approach*, as a way of focusing on the factors that contribute to *well-being* and *health*, rather than treating or fixing a disability, incapability or weakness [61]. In this paper, we try to understand the participants' *engagement with the technology*, by making sense of the *feedback* received from the technology, being it a smartphone app or a semi-autonomous robot.

In the next section, we continue by introducing our methodology and methods used in this study.

V. METHODOLOGY AND METHODS

According to [62], interpretive research is afforded through "language, consciousness, and shared meanings" [62, 2]. Boland (1985) in [62, 2], says that "the philosophical base of interpretive research is hermeneutics and phenomenology." Further, we followed one of Ricoeur's thesis that hermeneutics builds upon phenomenology [63].

In addition to the earlier reported work [1], we have now included both researchers and several elderly people in the study. We describe next our study context, study design, the robots used in this study, selection of robots, participants, data collection, and data analysis, as well as ethical considerations.

A. Study Context

The study was performed in the old district area of Oslo, Norway. The area has approximately 3000 senior citizens, over 67 years old. Some of these elderlies choose to live in accommodation facilities for the elderly. The elderly usually live there independently, or together with their partners. However, the accommodation is provisioned with a 24/7 reception staffed with at least two personnel, available for the elderly, a gym, a restaurant for taking breakfast or lunch, which is also open to the public, a library where meetings or various courses are held, and an open area for coffee breaks and other events. Several studies have been performed in such facilities [64][65][66][67][68], but none of these report data on the use of robots or semi-autonomous robots in the homes of the independent living elderly.

B. Study Design

This study was divided into three stages. The first stage was a pilot phase, with the purpose of learning, and getting a pre-understanding of the context (stage 1). Next, several of the researchers involved in the project tried out the semi-autonomous robots in their homes (stage 2). After some of the researchers have tried out the semi-autonomous robots, we started introducing the first available robot in the homes of the elderly (stage 3). In some cases, the robots were run in parallel in both homes of the elderly, and homes of the researchers.

C. Robots in this Study

In this study, we have used semi-autonomous vacuum-cleaner robots in the homes of our participants. Selecting such a robot was a bi-informed choice. On the one hand, our elderly participants reported earlier *familiarity* with semi-autonomous robots, such as vacuum-cleaners and lawn-mowers that they have seen on TV and were keen to test out. These types of robots are sometimes referred to as *domestic robots* or *domotics*. On the other hand, the study is part of the MECS project, that aims to develop a robot for independent living elderly. This study was made at an incipient phase of the project. The project did not have yet any fully developed robot for the independent living elderly, such as a safety alarm robot, in place at the time. Therefore, we chose to build on our senior participants' familiarity with the robots, e.g., by selecting semi-autonomous vacuum cleaners to be used in their homes.

We have initially investigated several potential robots to acquire for our study. We finally selected three of them for the purpose of our study: iRobot Roomba 980 [69], Neato BotVac, and Samsung PowerBot VR20H. Table I below gives a summary of the technical specifications of the robots.

TABLE I. SUMMARY: TECHNICAL SPECIFICATIONS OF THE SELECTED ROBOTS

Robot / Specifications	iRobot Roomba 980	Neato BotVac	Samsung POWERbot
Dimensions (Depth x Width x Height)	35 x 14 x 9.2 (cm)	33.5 x 32.1 x 10 (cm)	37.8 x 13.5 x 36.2 (cm)
Weight	4 kg	Ca 4.1kg	Cca 4.8 kg
App as a remote controller	YES. iRobot Home App	Yes. Neato Robotics	Yes. Powerbot, smart home app.
Charging	Battery and electricity	Battery and electricity	Battery and electricity

D. Selection of the Robots to be Used in the Elderly's Homes

When the robots were introduced in the homes of the researchers in the first stage of the project, we noticed soon that iRobot Roomba 980 and Neato were the most appropriate for the elderly, due to their reduced sizes, compared to BotVac robot. This led us to make the choice of only using iRobot Roomba 980 and Neato in the elderly's homes.

E. Participants

13 participants took part in this study: seven (7) of the participants were researchers that tested the robots as part of the pilot study, including the authors (SD, HJ), during the period of times ranging from about one week to about one month. At this stage, 2 females and 5 males participated. Six (6) elderly persons used the semi-autonomous vacuum cleaner for about one month: 5 females, and 1 male. Three of the elderly participants were included in the previously reported work [1]. The participants had different backgrounds and presented different levels of interest in modern technologies.

The researchers are represented in this study by both junior and senior researchers. The elderly participants (≥65 years), part of the MECS project, were recruited through MECS' partner organization. Due to the high commitment that the study required, including weekly visits, the use of the robot, photos, participant diary notes as domestic probes, observations, and interviews, only six elderly participants were willing to participate within the timeframe of study data collection. The participants were self-selected and took part in the study based on their free will. Some of the participants took part in the study through the snowball effect by finding out about the study from others.

F. Data Collection

The data was collected from researchers and the elderly. The data collected from researchers was retrieved through diary notes and photos (Table II). The data collected from the elderly participants were retrieved through interviews, elderly's diary notes used as domestic probes, photos, researcher's notes, and headnotes (Table III on the next page). Headnotes are "experiences, impressions, encounters, and evaluations that are continuously present in [the] memory," according to [70] following [71]. Each senior participant received a notebook to be used for their diary notes. We kindly asked the elderly participants to note down in their diaries the situations they encounter. These notes, or posts, as we named them, were written by the elderly, especially when something unusual or unfamiliar occurred.

TABLE II. OVERVIEW OF THE DATA COLLECTED FROM RESEARCHERS

#	Data collection methods - Researchers		
	Timeframe	*Documentation*	*Robot used*
1	One week	Yes. Diary notes, seven posts (one per day), ca 4 and a half A4 pages, analog format, 28 photos	Neato
2	Ca two week	Yes. 3 pages of A4 notes, digital format, 4 photos enclosed	Neato
3	Ca one week	Yes. Short notes on strengths and weaknesses of using such a robot, digital format	iRobot
4	One week	Yes. 1 page of notes, digital format	Samsung PowerBot
5	Ca one week	Yes. Half page was written notes on strengths and weaknesses, digital format	Neato
6	Ca one month	Yes. Four pages of written notes, 22 posts, digital format	Neato
7	Ca one month	Yes. Ca 19 A4 pages of written notes, analog format	Neato

G. Data Analysis

The process of analysis started already while being in the field, as a form of doing some preliminary work [72]. This has been followed by a multiple stage analysis process, where the data went through some analytical filters. Specifically, we have followed thematic analysis from V. Braun & V. Clarke to analyze the data collected in stage 2) and 3) [73]. This was done in 5 steps. We have first started by trying to familiarize ourselves with the data (step 1). We did this by creating a map of data and resources, which later resulted in Table II, respectively Table III. At this stage, we had put aside the initial research question, to be open for novelty, for what may come up and we did not think of, trying to focus on what the participants found interesting. Thereafter, our analysis was done in a bottom up fashion starting from coding each of the resources (step 2). We have then grouped the resources in three categories based on the data sources: researcher's diary, researcher's observation notes during elderly's observation and elderly's own diary notes, and interviews. At this point, the raw data became textual data, in the form of transcribed interviews, notes, or interview summaries. All the interviews with the elderly were transcribed verbatim by author SD. The transcribed interviews alone resulted in around 26000 words exclusive the pilot interview (circa 33500 words together with the pilot interview). At the same time, the author (SD) went through the photos taken (n=147). The coding was done by reading the material "line-by-line to identify and formulate all ideas, themes, or issues they suggest, no matter how varied and disparate" [74, 143]. This resulted in a variety of scattered codes.

Next step was collating the codes further into sub-categories for each of the data sources (step 3). This was done through color coded post-it notes by the author (SD). We cannot claim a full inter-reliability of the study, as the coding was done by one author (SD) [75]. However, following [75], validity, in this case, is not of "a particular concern", as the study focuses on exploring the potential challenges one may encounter when a robot is introduced in the home [75, 212]. Moreover, the findings were discussed at different points during data collection amongst the researchers in the project. In addition, the collated codes were discussed by the authors (SD, HJ) during the data analysis.

As a result, the data collected through researcher's diary, researcher's observation notes and elderly's diary notes, and interviews resulted in [n=51], [n=47], respectively [n=124] collated codes: a total of [n=222] codes. At this stage, we were searching for themes. We observed that some of the collated codes were present across several of the resources: written utterances during our drop-in visits (usually once per week, or on request), and utterances from the interviews. We

TABLE III. OVERVIEW OF THE DATA COLLECTED FROM THE ELDERLY

#	Data collection methods - elderly					
	Gender (Female F, Male M)	***Interview***	***Elderly's Diary notes***	***Researcher's notes***	***Photoswere taken by the researchers***	***Eventual details about the robot used, if any assistive technologies were used, and level of information technology literacy***
1	F	Circa 1 hour, audio-recorded pilot interview, transcribed verbatim (SD) AND Circa 1 hour and 45 minutes of untranscribed audio-recording from the installation of the robot	Yes. Circa 5 A4 pages, analogue format.	Yes. Circa 2 A4 pages.	Yes. 36 photos	iRoomba, 87 years old, walking chair, did not use the app
2	F	Circa 40 minutes, audio-recorded, transcribed verbatim (SD)	Yes. Circa 3 A4 pages notes, analogue format	Yes. Circa 2 A4 pages.	Yes. 4 photos.	iRoomba, walking chair, necklace alarm that she does not wear it, high interest in technology, used the app, has a smartphone,
3	M	Circa 25 minutes, audio-recorded, transcribed verbatim (SD)	Yes. One letter-size page, analog format, short notes.	Yes. Circa 4 letter-sized pages.	Yes. 10 photos.	Neato, wheelchair, not interested in technology, did not used the app, easy to use, has a wearable safety alarm
4	F	Circa 33 minutes audio-recorded, transcribed verbatim (SD)	Yes. One A4 page, analog format	Yes. Circa 2 A4 pages.	Yes. 36 photos	iRomba, wheelchair, interested in technology, did not use the app, easy to use, does not have a smartphone, wearable safety alarm
5	F	Circa 45 minutes audio-recorded, transcribed verbatim (SD)	Yes. One letter size page, analog format.	Not available	Yes. 13 photos	Walker, did not use the app, not interested in technology, does not have a smartphone, wearable safety alarm
6	F	Circa 43 minutes, audio-recorded, (transcribed verbatim) (SD)	Yes. 4 letter-size pages, analog format.	Yes. Circa 1 letter-sized page.	Yes. 16 photos	Interested in technology, no walker, wanted to use the app, but gave up, does not have any wearable alarm

looked for performative utterances [76]. This was carefully paid attention to due to two main reasons: in order to observe whether or not the researchers and elderly encounter the same type of challenges with the robot, and how information technology literacy influenced the attitudes towards the robot.

Finally, the collated codes and findings were discussed between the authors (SD, HJ) at multiple times. At this stage, we reviewed the themes resulted (step 4). The final analysis resulted in three main themes: robot, home space, and human emotions and perspectives on perceived autonomy (step 5).

H. Ethical Considerations

The project is in line with the ethical guidelines from the Norwegian Center for Research Data (NSD) (ref. nr: 50689). The data collected during this study were stored on the Services for Sensitive Data (TSD) facilities, owned by the University of Oslo, Norway, operated and developed by the TSD service group at the University of Oslo, IT-Department (USIT). All the data was anonymized. Prior to starting the study, the participants were given detailed information about the study. The participants could withdraw at any time without giving any explanation and without any consequences for them. The participants willing to participate signed informed consent before taking part in the study.

During the study, we had constant contact with our participants, through regular visits, often each Wednesday, on pre-agreed times, but also on demand, if they needed any support or had questions. Sometimes, we called them on the phone just to check if there was anything they wondered regarding the robot. They also received our contact details and could contact us at any time.

VI. Findings

This section presents the findings from this study. The findings are structured in three categories: the user receives feedback from a smartphone technology (Sub-section A), the user receives distributed feedback via an app (Sub-section B), and robot motion as feedback and its implication for the user (Sub-section C). The findings are supported by empirical examples. A detailed account is given below for each of these.

A. Findings: The User Receives Feedback From A Smartphone Technology

In this section, we present a situation where the user receives feedback from a smartphone app technology. This is illustrated through textual feedback that is either improper or lacking. Fig. 2 illustrates the situation presented here.

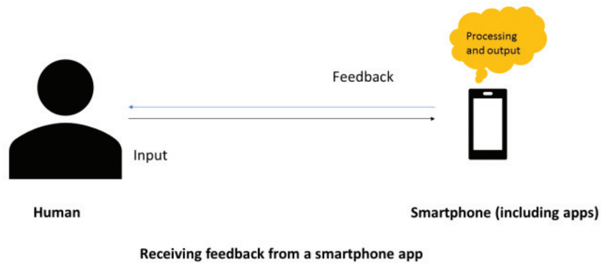

Figure 2. Feedback between smartphone technology and a (human) as user

1) Providing Improper Feedback

The user is provided with improper textual feedback [1]:

a) "SMS shows full. Do I need to buy a new phone?": One of the participants told us about her experience with the mobile phone and the feedback of SMS - full blinking icon. Her concern was that she could not store any longer the photos she received from her family. The participant was concerned that she had to buy a new phone, and that this would lead to losing the existent photos.

b) "Where is the 'No' option when updating software?": Another situation described by one of the participants was related to getting constant updates, where she gets either the option 'Now' or 'Later,' but not a 'No' option. She contacted the company providing the operating system via a handwritten letter and asked about this option. To her surprise, she got called up by the customer service, and got offered help on how to deal with the two options available, 'Now' and 'Later,' but the company had no plan to introduce a No-option. The participant explained that she knew how to deal with the updates, but what she wanted was that the feedback should embed a 'No'-option alternative. Regarding this design issue, this has to do with the continuous update of software and the point of view of the elderly on these always encountering updates. This example illustrates a situation where feedback messages do not provide enough options.

2) Lack of feedback

"You were terribly afraid of doing something wrong": In one of our interview sessions, one participant describes that when she learns using new technologies, she is so afraid of doing something wrong. A concrete example is that the technology, being it smartphone or tablet, does not provide any feedback on how *to get back to basics*: "so you were very afraid that... I did not feel I could come back to the base. But I was afraid to do something wrong."

By this, the participant means that the applications are built in such a way, that one is expected to have that intuitive knowledge, but for new users, it can be difficult to understand how to navigate within an app, and one can easily get stuck.

B. *Findings: The User Receives Distributed Feedback From A Robot via an App*

This sub-section illustrates the situation when a user receives feedback from a semi-autonomous robot technology via a smartphone, through an app. We illustrate first some of the implications that the use of such an app has for the user at the installation time. Thereafter, we illustrate some situations where the users received either improper feedback, or the feedback was lacking. An illustration of the situation is presented in Fig. 3 below.

Some of the participants have chosen to install the app in order to control the robot remotely. Several steps had to be followed in order to install the app. As the diary notes show, for Neato robotics app, for instance, one should create an online account. This, required an email address. This required a Wi-fi connection to the network. One of the issues that occurred during this step at the installation of the robot in one of the participants' homes was that the robot required a 5 GHz Wi-fi, while the participant's router had only 2.4 GHz.

The next step was to choose the right robot amongst several robots listed in the app. The final step was to connect to the robot. Once the app was installed, a map of the local space was created within the app after the robot has moved around. The map provided the approximate area, including obstacles, edges of space, and door limits (Fig. 4).

One of the participants gives a rich description of his experience on installing the app: "Today, it's time to get this thing going. First, I need to connect to the vacuum. This involves enabling Wi-fi on the vacuum, then connect your phone to the vacuum's Wi-fi access point (yes, the vacuum has its own Wi-fi access point). Then you can use

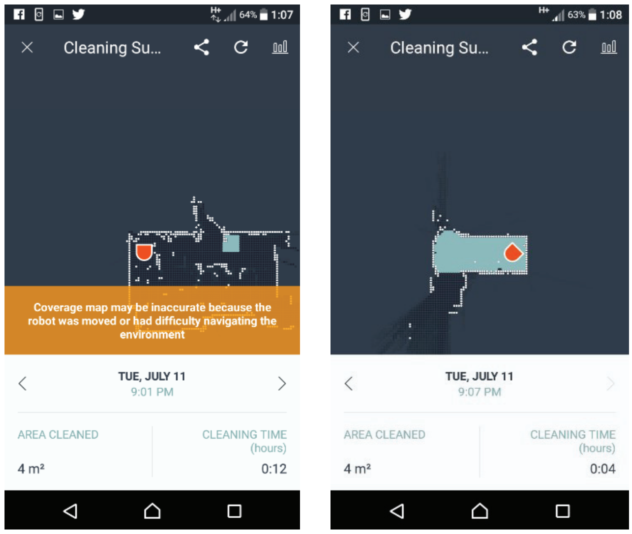

Figure 4. Example on the map is shown in a robot app that was generated by the robot

the Neato app to choose the actual Wi-fi point to connect to. On the one hand, this makes it easier to configure the robot since you connect only to it and you get the richness of a mobile app to input information (including passwords to access point), but it's not without some flaws. First, I assumed it would show the access points right away; it didn't. So, I typed in the access point and the password. I should also point out that I connected it to the "guest" Wi-fi, not our main Wi-fi. It's suddenly at this point that I realize how little I trust this thing belonging to the main network, and I start to think about other ways to partition the network. [...] Regardless, the phone tells me that the process may take up to 3 minutes and that I should watch

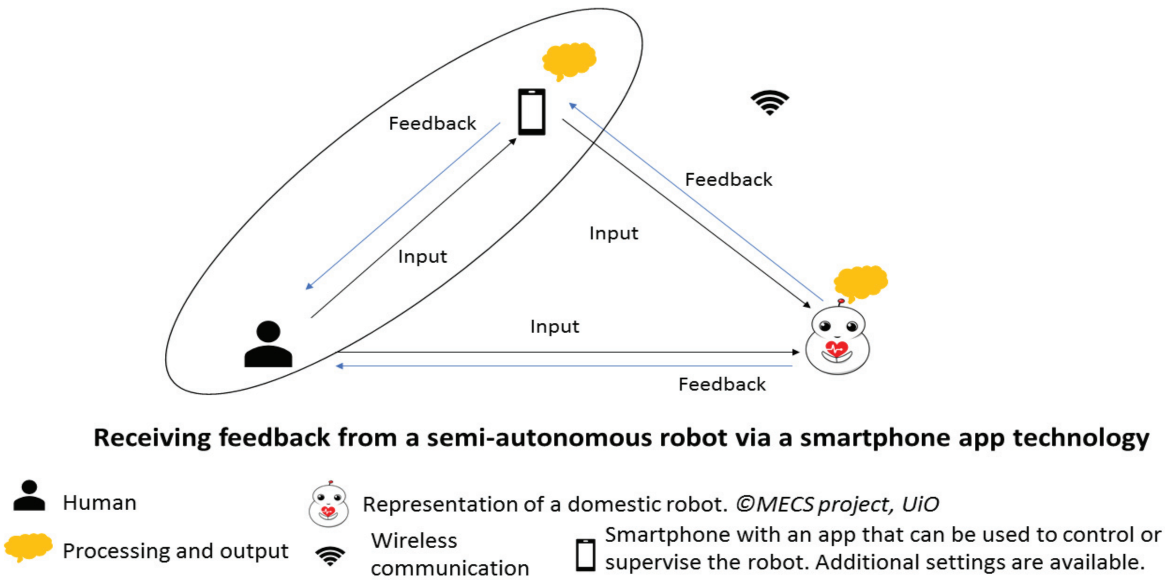

Figure 3. Feedback from a semi-autonomous robot technology to a (human) user mediated via an app

the robot's display screen during this time. I do, but it only shows the current setting of Wi-fi on. When I try to move back, I accidentally turn off Wi-fi, and I put the system in an uncertain state. I try to re-enable the wi-fi, but now the phone and the robot are confused. The phone, after 3 minutes, reports that the wi-fi information was "incorrect" and urges me to try again. But the robot refuses to rebroadcast its Neato access point. […] I switch the vacuum off using its hardware switch and then turn it back on. I go through the process again (with a lighter touch on my fingers). […] Then, I can choose the network and enter the password. This time it connects shortly thereafter. At this point, the robot asks for a name, I just give it Neato, and I set it out for its first vacuum tour" (Diary notes, Researcher).

Further, we found out that many of the in-app instructions and paper instructions that came along with the robot were available only in *English*. Many of the elderly participants pointed out that they do not feel comfortable about using technologies in English, and it would have been better to have it in their mother tongue, Norwegian. Here is an example of what one of the participants say: (Participant): "Yes. So it was another time when it got stuck in the charger, and it blinked. It was something about the light, but I did not understand what it was. I have missed a Norwegian instruction manual. It would have been very nice to have one." (Interviewer): "You are not the first person saying this. […]" (Participant): "Because even if I understand pretty well English, these technical things are a lot worse, because you do not understand them so well: technical language is more difficult!" (Interview, Elder person).

1) Providing Improper Feedback:

Another issue that seems relevant to the use of the app was when a power outage occurred, and the app stopped working, as it required an Internet connection. During a power outage, the app controlling the domestic robot stopped working, according to one of the elderly participants. The participant got a message that the app "cannot connect to the cloud services". The use of technical terms, such as "cloud service" when giving feedback to the user, seems to be inappropriate. She said: "It was just standing still there, or when I pressed on it where it says something about cloud-service. It didn't do anything, but I thought you would come tomorrow" [1]. The technical term "cloud service" confused the elderly user. The user, in this case, relied on the researchers help to come along the next days.

Another participant wrote in his diary notes that the robot urged for attention through a feedback message: *"Please clear my path (2000) and a red cross"* (Diary notes, Researcher), without understanding the meaning of the error 2000. Another participant referred to the message he received from the app as a "cryptic message." One of the participants explained that the app does not give proper feedback regarding the area of the room: *"The area cleaned shown on the map is 4 mp2. But the hall and room 3 are more than 4 mp2."* (Diary notes, Researcher).

2) Lack of Feedback:

It seems that one of the participants has used the app to schedule the robot. However, the participant did not get any notification (e.g., lack of feedback) when the robot once started to run: "Went out to meet some friends, when I got home, I found the robot running. Apparently, I had turned on a schedule when I had last used the app. I'm not sure *how* I did this, but I did it. The Wife was home, so she picked up the rug in the entryway." (Diary notes, Researcher) Another similar situation is illustrated in one of the participant's diary notes: "We went out for a walk, and when we came home the robot was vacuuming, it had sort of cleaned the rug in the entryway, but not really. […] A bit annoyed, I looked at its schedule. It seems it will be going at 9:30 tomorrow evening. We'll be ready for it this time. I enjoy that it has created a staggering vacuuming schedule, but a bit annoyed that it just launches itself out there." (Researcher, Diary notes).

C. Findings: Robot Motion as Feedback and its Implications for the User

In this section, we present situations where the users interact or engage with semi-autonomous robot technology. We make sense of the movements illustrated as *feedback*, as they happened. The situations illustrated that: *the incoherence semi-autonomous robot's motion triggered various feelings*, including stress, anger or other feelings related to robot personification; *the users received indirect feedback to do facilitation work*, such as moving things around in home, lift the robot and move it manually to another place; and *that the robot's motion creates noise*. An illustration of the situations described here is given in Fig. 5.

1) Movement Triggers Feelings

a) Feelings of Incoherence in Robot's Motion: Some participants pointed out incoherence in the robot's movement. The feeling of incoherence was triggered by the non-regular pattern of the movement, the user not being able to predict it. Indirectly, the robot motion gave a feeling of incoherence. Here are some examples: "I think it starts in one room, and then it goes to another, and then it goes again to the first room. I think it is a bit strange that it does not finish in the first room, and it goes perhaps to the kitchen, and then it comes back, and it continues likes this, and then goes out again. I think it was very strange (break), really, very strange." (Interview, Elder participant); "[…] And suddenly it started going by itself one morning. I thought it was very strange." (Interview, Elder participant); "One time when I pressed on HOME, it started going around by itself, so I had to carry it back" [the participant means here that she pressed on the HOME button, but she had to carry manually the robot back to its charging station].

b) Feelings of Anger, Stress, or Annoyance: Some of the participants found it stressful to follow the robots' movement: “There? [it reads out loud from own diary notes]: Puhhh… It was a bit stressful to keep an eye on it. […] Yes, I think it was a bit stressful because it went so many times over the same place. And I think it is a waste, such a waste. It went back and forward, and I wanted then to... I just put my foot in his way, so it couldn’t go another way. You decide very little over it.” (Interview, Elder participant); In another elderly’s participant diary notes was written: “[…] Is this helping, or it will be Stressful [note that the participant writes the word Stressful starting with capital S]” (Diary notes, Elder participant). Another participant points out feelings of anger triggered by the robot motion: “So it was a bit stressful there! I was angry at it.” (Interview, Elder participant). Another participant said: “At the beginning, it was a little odd to have a device moving on its own while we are sitting in the living room or having dinner. Since this was our first experience with this kind of technology, it makes sense to be annoyed or even scared by this robot at the beginning. However, having a remote control to terminate the robot manually or to change the current function overcomes the fear!” (Diary notes, Researcher).

c) Feelings of Personification – Robot as a Companion: However, besides feelings of incoherence in movement, stress, and anger, the robot also awaked feelings of personification – they viewed the robot like a pet, or someone in the home, that they talked to (Interview, Elder participant). Some of the participants personified the robots by giving them names such as King Robot, Frida, or Snilla.

2) Robot Enacts the User to do Facilitation Work

a) The Robot gets Stuck in Obstacles: There were several situations when the robot got stuck, in curtains, under the bed or sofa, in cables, or things around the home. Here are some exemplifications from both elderlies and researchers: “I got my brother fixing the cables under the bed, so they are not in its way. […] If it had gotten stuck there, I wouldn’t have been able to come down there. I was very afraid of this. So no cables were supposed to be there! I felt so much better then!” (Interview, Elder participant); (Interviewer): “Okay… But you also wrote in your diary notes that you had to clean a bit before you could run the robot.”; (Participant): “[…] I have lots of chairs here. I have put those two on top of each other because otherwise, it stops all the time. So I have removed them. And the cables […] Yes, I have cleaned a bit.”; (Interviewer):” Did they get stuck in the cables on the floor?” (Participant): “I have tried to remove those. Yes, because it stopped a bit... or it brought those with it. So I had to clean.” (Interview, Elder participant). Some situations are illustrated below (Fig. 6).

Figure 6. Situations where the robot got stuck and needed facilitation work

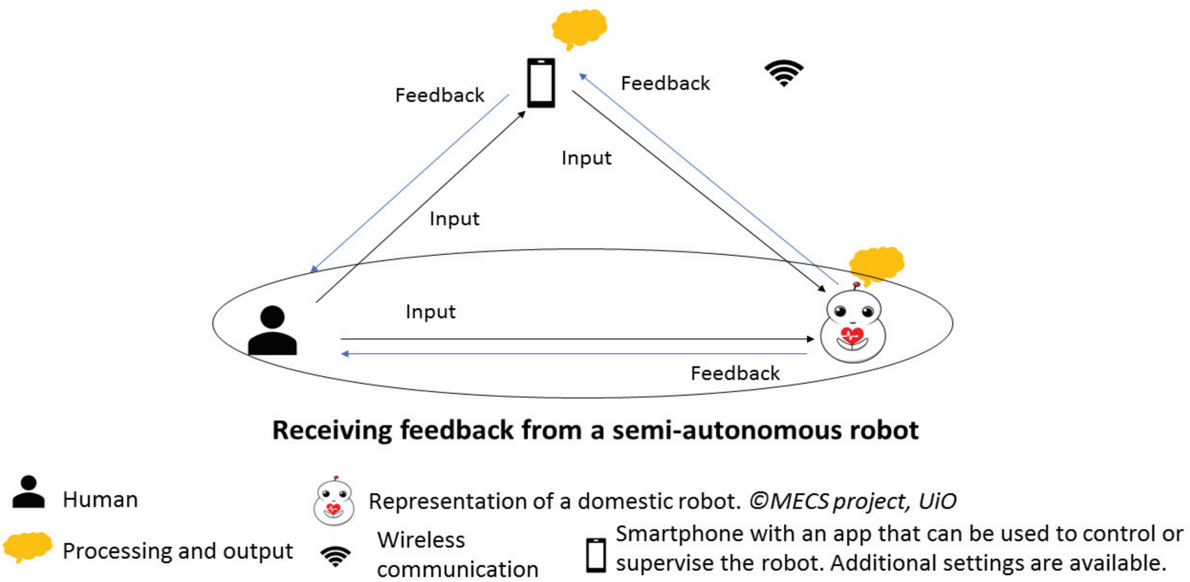

Figure 5. Feedback from a semi-autonomous robot technology directly to the (human) user

A few other examples are: "[…] A chair had to be taken outside of the room, two pillows and a basket were set on a table, two cables had to be taken up. Two doors had to be closed. […]" (Diary notes, Elder participant); "The robot got stuck in the carpet's tassels and stayed still. It took some time to free R from the tassels, so I took away the carpet. […]" (Diary notes, Elder participant); "R got stuck under a little table, I have freed R and lifted the machine to the charging station." (Diary notes, Elder participant); (Interviewer): "Do you see this as a problem?" (Participant): "Well… As I am quite strong, it works. But not everyone can lift and carry it." (Interview, Elder participant); "On a shelf, it was a lamp, but its cable was down on the floor. The robot got stuck, and it dragged the lamp down. As a result, the lamp got disassembled in 2 pieces. Luckily it was a plastic lamp & it didn't break. I could put it together." (Diary notes, Researcher). One of the commented on how a robot generates other types of work – additional and facilitation work is needed to be done. "[…] The *goal* I had was to make the *floor clean*; but to get to this – I needed to install something on the floor… A paradox." (Diary notes, Researcher).

Several participants suggested that one needs to do some facilitation work regarding the surface where the robot should navigate: "It started working, but it got stuck on the TV stand. I got a message about 10 minutes out. I then came back and freed it. It went for a while but got lost under the table. I pulled out the chair, and it seemed to go OK. Afterward, it did OK, though it tried to climb the entrance to the laundry room." (Diary notes, researcher); "I pressed "HOME" button, it started. After a while, it got stuck. I remembered the previous installation at home when the app gave notifications about this – when I was out-of-the-house. This information was disturbing at that time since I did not want to do anything with it. It interrupted a nice train journey I remember now and started off a train of thoughts of where it was stuck, and why (since I had done my best to make a "clean floor" there as well." (Diary notes, Researcher). Another participant pointed out: "Managed to move small, light things like a tiny rug, map tube" (Diary notes, researcher). A few others said: "After getting tired of the robot getting stuck, I put the stripe on the area it always got stuck, and it worked fine. Yay!" (Diary notes, researcher); "I had to move the chairs that were under the table because it was too small. I've noticed that it didn't reach." (Interview, Elder participant); "Yes, it pulled the cables a few times. Especially those behind the sofa, it is a long cable, and it pulled it out. Now I have fastened it, so it doesn't go on it any longer." (Interview, Elder participant); "Isn't it supposed that robots do their job on their own, without needing one's assistance?" (Diary notes, Elder participant); "A few times I had to move because it got stuck a lot. So next time I had to move those things out [talks about furniture] But I think it is a bit confused because it seems to have memory. When I moved the furniture, I think it was a bit confused, I think. But yes, I had to move the furniture." (Paraphrasing from an interview with an elder participant).

b) The Robot Escapes and Indirectly Asks for Facilitation Work: Two of the elderly participants encountered situations when the robot would escape from their apartment. Here are some examples from our data: (Participant): "[reads out loud from his diary notes] Her name is Frida. It behaved well. It got away one of these days. I forgot to lock the entrance door, and it disappeared in the hall."; (Interviewer 1): "[surprised] Okay. So it disappeared??"; (Participant): "Yes, yes. That one is wild. It went fast over the doorstep."; (Interviewer 1): "So you had to go and bring it back."; (Participant): "Yes, yes, yes. Yes, but maybe after it finished, it would have come back by itself. I don't know."; "I also had that door open, and it was out in the hall. But after, I closed the door, and it had to stop there.". Some examples when the robot tries to go over the doorsteps are exemplified in the images below (Fig. 7).

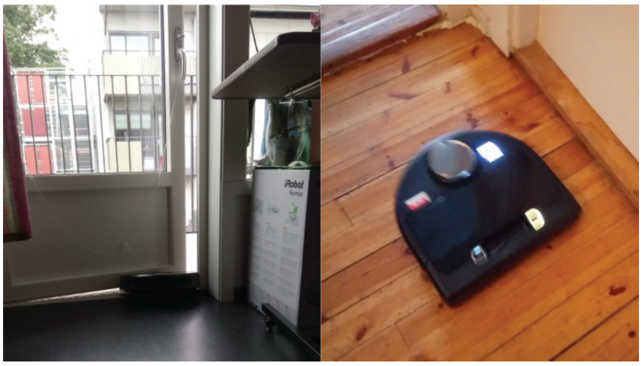

Figure 7. Robot escapes

c) Motion Creates Noise

Several participants, both researchers and elderly, reported that the motion of the robot created noise. Noise, in this case, can be accounted as a form of feedback for the motion, with the meaning of: "the robot is ON, and navigating around." Here are a few excerpts from our data exemplifying this: "R has started just now. The Radio attenuates the sound from R." (Diary notes, Elder participant); "[…] I have pressed on clean, but it was just standing there and making noise. I had to lift it to the charging station, press clean and R continued its tour." (Diary notes, older participant); "Back to the engine sound. I guess this is to be worked with; to make it quieter. Perhaps it could be possible to make user settings; how much power should be used, and this will again regulate the sound/noise. It is hard to think of the sound as nothing but noise… The sound from the movement is very low in comparison to the sound from the vacuum engine. It is also more pleasant to the ear." (Diary notes, researcher participant); "Checked the schedule, and thought nothing was on. So, I went out, but it turned out that it was actually going at 9:30. I wasn't there, but the wife was trying to sleep and complained about all the noise it made. But it got stuck somewhere, constantly asking for attention. When I finally got home, it was waiting at the front door, stuck in the carpet. It complained that it wanted the roller cleaned. I just put it away for tomorrow." (Diary notes, researcher participant); "Noise, can't use together with TV watching" (Diary notes, researcher participant); "Any way to pause cleaning once it starts, e.g., to take a phone call? Via app?" (Diary notes, researcher participant).

Finally, in this section, we have illustrated situations on the motion as feedback and its implications for the user, based on empirical data. In the next Section, we continue with discussing and unpacking further motion as feedback through the lens of familiarity based on the situations presented here, and also coming back to our initial stated research questions.

VII. Discussion

"The designer of any artifact that is a tool *must communicate* the artifact's intended use and, in some cases, the rationale for its behavior, to the user. There is a strong sense, therefore in, which the problem with such a premise, however (as archaeologists well know), is that while the attribution of some design intent is a requirement for an artifact's intelligibility, the artifact's design per se does not unequivocally convey either its actual, or its intended use. While this problem in the interpretation of artifacts can be alleviated, it can never fully be resolved, and it defines the essential problem that the novice user of the artifact confronts. Insofar as the goal of design is that *the artifact should be self-evident*; therefore, *the problem of deciphering an artifact defines the problem of the designer as well*." [44, 14-15, emphasis added].

What kind of *emotions* are triggered by *improper or lack of feedback when engaging* with a smartphone app or semi-autonomous robot technology? How is a *motion* made sense of and understood by the users when *engaging* with a semi-autonomous robot, in their homes? If the *motion* is illustrated as a type of *feedback* – what do we learn from their experiences?

It seems that *emotion* and *motion* are, at least etymologically, interconnected. Etymologically, *emotion* dates back to the 12th century from the old Franch *emovoir,* which means to *stir up,* and from the Latin *emovere,* which means to *move out, remove, agitate* [77]. In the late 17th and 18th century, the term illustrated "a sense of strong feeling," and later was extended to any feeling, according to the Online Etymological Dictionary [77]. The term *motion* dates back to 13th -14th centuries and it means *"the process of moving," movement, change*, coming from the Old French *mocion*, and from the Latin *motionem*, with the meaning of *"a moving, a motion, an emotion"* [78]. The term *locomotion* dates back to the 17th century and is formed from the Latin *locus,* which stands for a *place,* and the term *motion* [79]. Further, findings from our data present issues related to the robot, to the home space, and to human's emotions and perspectives on perceived autonomy. We choose to limit our discussions related to the issues encountered that are related to the robot's movement. The research questions are analyzed and reflected upon, based on the findings presented in Section VI, the Sub-sections A-C. We do this through the lens of the *familiarity* concept by reflecting on the *motion as feedback*.

A. The Role of Familiarity for the Emotions Triggered by the Engagement with Technology

The first question that we address is: *What kind of emotions are triggered in the user by improper or lack of feedback when interacting or engaging with a smartphone app or a semi-autonomous robot technology?*

An intuitive interface is an interface that the user naturally knows how to use it, whereas *a familiar interface* is an interface that the user has been exposed to over time and learned how to use it [80]. Raskin (1994) suggested that we should use the word *familiar* instead of *intuitive* [57][80]. We have earlier noticed that elderly participants *feared* interaction with *unfamiliar* digital technology because they did not master it, they did not feel able to learn it, and it was not in their zone of proximal development. At the same time, we also noticed that *the language* used for giving feedback to the users, in a breakdown situation, was often inappropriate: either by providing improper feedback or through lack of feedback. We talked about improper feedback as textual feedback using technical terms for transmitting a message. This triggered in the elderly feelings of *fear,* including its derivatives: *angst, anxiety, concern, doubt, dread, unease, uneasiness, worry, aversion, fright, phobia,* and *presentiment* [81].

Many of the studies on feedback within HCI are inspired by human-to-human conversational interactions [43][46]. However, specifically, [44] noticed earlier that human-machine communication was using English as the "natural language" for communicating between humans and machines [44, p. 28]. This choice was anchored in Austin's (1962) "*How to do things with words*," that language through its utterances can be a form of action, but this requires an appropriate interpretation of its interlocutor [76]. We noticed in our study that the interlocutor could not always interpret the use of technical terms. This is an issue of *mutual intelligibility*, as [44] would call it. Therefore, designers should consider avoiding the use of those in textual feedback. Similar findings to ours were presented in the study of eco-feedback from [82], that pointed out that householders participants did not understand the language used in the textual feedback. In addition, the Macintosh User Interface Guidelines, dating back to 1992, pointed out that feedback should be proper, and inform the user as much as possible, instead of providing the user with a technical language such as: "The computer unexpectedly crashed. ID = 13" [41, 9]. We encountered a similar situation in our findings when one of the participants received the error message: "*Please clear my path (2000) and a red cross*". This type of error message is improper because it did not make sense for the participant. Feedback should be *appropriate* and *timely* [41]. In addition, another study showed that seniors that are not *familiar* with particular technical terminology do not use these words [60]. In our findings, a similar situation occurred when one of the participants pointed out the use of *technical language* in the feedback they received via an app: "it cannot connect to the *cloud services.*" [1, 176]. These are, however, examples from the everyday' participants' interaction with the robot but are nevertheless important to be accounted to make sense of them. [58] explained that making sense of everyday examples of interacting with technology, of coping with it in everyday life situations is an indication of our *familiarity* with the technology. This relies upon the *know-how*, following Dreyfus in [59].

Feedback, however, has cognitive attributes that can be interpreted by the users. For instance, [42] talks about the *mind* and the *text*, and how the information transmitted can change the state of someone's mind and/or affect, depending on the conceptualization and interpretation of the information. We have seen concrete examples in this study of how someone's interpretation of robot motion changed his/her state of mind to stress, anger, or feelings of personification. However, apart from the *emotions* triggered by smartphone app technologies, moving further to the emotions triggered by the semi-autonomous robot, we noticed the following: the incoherence in motion triggered various feelings, including stress, anger or other feelings related to robot personification. When a technology triggers *emotions* within a user, being positive or negative, it means that the user *engages* with it, rather than *interacts* with it [83]. Interaction is a form of "'dialogue' with the technology" [83, 62]. *Engaging* with the technology also has an *affective* part, in comparison to interaction [83]. We have also observed that amongst different mechanisms *to engage with technology*, to be able to *maintain a dialogue* with it, *to cope, to co-exist with it*, one is *feedback*. If, for instance, *motion feedback* supports this *engagement* with the technology in itself, rather than just the interaction with it, we become more *familiar* with it. The repertoire of *emotions* awaken by the participants' experience of the robot is the result of their interaction, *engagement*, or even *familiarity* with it. The *emotions* triggered in both elderly and researcher participants were often of stress, anger, annoyance. However, we observed that, in general, elderly often felt as non-experts when using the robot and did not have the same deep tacit knowledge as the researchers in this study, that seemed to be more *familiar* with using the same technologies, or similar ones. We also observed that both the independent living elderly and the researchers in this study were challenged in many ways by interacting with a semi-autonomous robot technology: perhaps more than with a smartphone app technology. Many of these challenges arose due to additional interaction elements: the (sometimes incoherent) motion of the robot and the use of the app. The participants often had to learn the *know-how, to co-exist with* the robot, and *to accommodate it*: not the opposite – the robot did not necessary accommodated them, although it was its purpose. On the other hand, [84] talk about *unfamiliarity* of the users with a new technological machine makes it *more difficult to cope with it* – this does not mean that the machine lacks technological advancement, but perhaps *it is not designed in a familiar way for the users*.

Finally, we have noticed that the robot, through its motion, did not only trigger negative feelings but also feelings of personification: the participants associated the *motion feedback* of the robot with *aliveness*. The movement of the robot put the robot somewhere in between a static object, and a fully autonomous object: it was something that could move by itself, be self-propelled, i.e., it could change its location without a necessary and continuous intervention of a human or another object. Nevertheless, this idea of *aliveness* as a *familiar characteristic* has been earlier noticed, based on "autonomous motion, or reactivity" [44]. These feelings of personification can be translated as awaking *positive emotions* in the elderly. However, making sense of the *motion* itself as *feedback,* and how it can be understood through the lens of familiarity remains to be discussed. We explore this next.

B. Making Sense of the Motion as Feedback

The second set of questions addressed in this paper is: *How is a motion made sense of and understood by the users when interacting or engaging with a semi-autonomous robot, in their homes? If the motion is illustrated as a type of feedback – what did we learn from their experiences?*

Humans are usually *familiar* with their own *movement,* with seeing things that move around outdoors: bicycles, cars, trains, ships, airplanes. However, one is not yet familiar with semi-autonomous *things* that move within a home. This phenomenon has been discussed within Robotics and Human-Robot Interaction (HRI), but it still remains to be explored within HCI. A *home* is not a static linear environment, but rather things happen in a dynamic and non-linear fashion: people in the home move objects around: a chair is moved to another place, a bag is placed on the floor, a sock is forgotten on the floor and so on. A robot, whose main surface of navigation is *the floor,* may encounter these objects and treat them as *obstacles*: both in its wayfinding and in its navigation. Familiarity is also a form of engagement, or what Heidegger calls *involvement* [83]. One becomes familiar with the technology through repeated, everyday exposure to it [59][60]. But a semi-autonomous robot that moves within the home seems to be still unfamiliar so far: perhaps because we are not yet exposed in our daily lives to robots that move semi-autonomously in our homes. Turner (2011) talks about the inclusiveness of technology, that it must fit users' everyday lives [58]. *Did the robot fit the participants' everyday lives?* The elderly in this study were willing to adopt a robot in their homes, out of curiosity, willing to learn more about such semi-autonomous robot technologies, to become familiar with it, but also perhaps they sought out some sort of practical coping, that ameliorate some of the direct consequences of aging, such as bending while doing cleaning work. Housekeeping, for instance, seems to be considered not only a physical task, but also a goal-oriented task that requires some degree of cognitive functioning [3].

However, the authors refer to information retrieval only as a *text regarding* these types of feedback, not as a *motion* [42][46]. The human is considered here as an interpreter of the *motion as feedback*. *Motion feedback*, similarly to visual feedback, can also be translated into *positive, negative, homeostatic feedback*, or *archival feedbac*k. Based on our study, we have observed that the *motion as feedback* can be mapped out to four situations: (1) when the robot is still, (2) when the robot goes from a still state to motion, (3) when the robot goes from a motion state to a still state, and finally, (4) when the robot is in motion. We ground our mapping on empirical examples from our data to illustrate motion as feedback, but we do not argue that other ways of are not possible. Besides *polarity feedback, homeostatic feedback,* and *archival feedback*, we introduce the notion of *transition feedback*. *Transition feedback* emerged during our mapping of *motion as feedback.* Transition feedback refers to *motion as feedback* when the robot changes its state from *still to motion* (2), or from *motion to a still state* (3). Next, we map *polarity feedback, homeostatic feedback, and archival feedback* to *motion as feedback*.

1) When the Robot is Still

When the robot stands still, the *motion as feedbac*k can be translated into homeostatic feedback: the robot does not perform any change in its motion state. The homeostatic feedback can be either positive or negative, depending on if the user has previously pressed the button to start it, or not. For instance, if the user presses the CLEAN button, which means that the change of the robot should be changed from still to motion, but the robot remains still, the feedback is negative.

2) When the Robot Goes from a Still to a Motion State

The transition between the still state to a motion state of a robot can be translated as positive or negative feedback, depending on the correspondence between the user's input and expectations. Positive feedback is given when the user presses the CLEAN button, and the robot moves around cleaning. This is also transitioning state feedback, as the robot changes its state. An example of negative feedback for this situation is when the robot starts moving around by itself, without being enacted by the user.

3) When the Robot Goes from a Motion State to a Still State

The robot turns back to its charging station when the user presses the HOME button can be translated into positive feedback, as the robot responds to the user's input. At the same time, this can also be translated into transitioning feedback since the robot changes its state, from motion to a still state. A second situation is when the robot turns back to its charging station when it is almost out of battery. This motion feedback can be translated as positive archival feedback since the robot acts accordingly to its resources, e.g., needs to be charged. However, from the point of view of the user, this can be translated as negative feedback, since the robot does not meet the expectation of the user: to be in motion once that the user has pressed CLEAN. It can also be translated into *transition motion feedback* since it is changing its state. A third situation is when the robot remembers the path and turns back to its charging station after finishing cleaning. This can be translated as positive archival feedback because it remembers its way back, based on a logged history or a previously created map. A fourth situation is when the robot gets stuck and enacts the users through indirect or invisible feedback to do facilitation work. In other words, the robot gives a negative *transition motion feedback* to the user by changing its state, from motion to a still state.

4) When the Robot is in Motion

We could see in our findings that when the user presses the HOME button, but the robot does not go back to its home station, and yet here the *archival feedback* was missing. This can be translated as negative homeostatic motion feedback. We can say that when the user presses the HOME button and the robot returns to the home station, the user understands the robots' navigation to the base station as immediate positive feedback: it responded to the user's action. Another situation is illustrated when the motion of the robot is incoherent: it only cleans a small surface, without navigating the whole area. This can be translated as negative homeostatic motion feedback. When the robot is in motion, and the motion feedback is manifested through the noise, it can be translated into positive homeostatic feedback. However, in the view of the user, this is translated as negative feedback since the noise itself creates feelings of annoyance, disturbing the user.

When the robot remembers the map of the rooms when is not running for the first time in the area (coherent navigation), the motion of the robot can be translated into positive archival homeostatic motion feedback, since the robot remembers the map of the room and can navigate accordingly. Opposite to this situation is when the robot escapes a room previously navigated, i.e., the navigation path of the robot does not respect the boundaries. This can be translated as negative motion feedback.

We illustrate some examples of positive, negative, homeostatic and archival motion feedback in Table IV.

C. Familiarity with the Motion as Feedback

Based on this study, we have observed that the *familiarity*, or for that matter *unfamiliarity,* of the *motion as feedback* can be based on already established notions of the polarity of feedback, homeostatic feedback, and archival feedback. However, these notions were used so far in relation to textual or visual feedback [55][60]. We have classified motion as feedback, based on the motion state of the robot and empirical examples from our data: 1) motion as feedback when the robot is still, 2) motion as feedback when the robot is transitioning from a still state to a motion state, 3) motion as feedback when the robot is transitioning from a motion state to a still state, and 4) motion as feedback when the robot is in motion. To the already existent types of feedback, we have observed that for semi-autonomous robots, transitioning feedback for situation 2) and 3) is a new type of feedback. We have mapped and illustrated the four situations based on the robot's states and their corresponding feedback (Fig. 8 on the next page).

Further, [85] compared and synthesized the design principles from Schneider (1999) [37][38], from Constantine & Lockwood (1999) [86], and from Nielsen (2005) [87]. The author found out that the principles related to error handling and error recovery, based on the three named guidelines are necessary for any type of interactive system [85, 45]. Specifically, the author means that errors should be avoided [85, 45]. If we translate this to the familiarity of *motion as feedback,* it implies that any feedback that can be translated as a form of *negative feedback* illustrates some sort of *unfamiliarity*: either of the robot as a response to a user action, or of the *emotions* triggered in the user. The authors say: "in other words, the environment would behave in a manner familiar to the user as if they were not actually using a computer system." [85, 45]. We can observe that negative feedback occurred in all types of situations. This means that the semi-autonomous robot did not respond or act in a *familiar* way. Further, according to the authors the concept of UNDO, of *archival feedback,* which we translated as a way for the robot for going to a previous state, is "unnatural" and conflicts "with the principle of familiarity" [85, 45]. We observed this type of *archival feedback* in situation 3) when the robot transitioned from a motion state to a still state, and in 4) when the robot maintained its motion state. For *motion as feedback*, this idea that the archival feedback is unnatural and conflicts with the *familiarity* concepts seems to do not always hold. We argue rather that there are situations when the robot acts in a familiar way for the user. Here are our arguments: the robot turns back to its charging station when the user presses HOME button – this is in line with the user's expectations; the robot turns back to its charging station when it is almost out of battery – the robot is at least in line with the needs of its system for more resources; the robot remembers the path and turns back to its charging

TABLE IV. MAKING SENSE OF MOTION AS FEEDBACK

Robot state	**Example of situation**	**Motion as negative feedback**	**Motion as positive feedback**	**Motion as homeostatic feedback**	**Motion as archival feedback**
1) The robot is *still*	The robot stands still.			X	
	The user presses the button, but nothing happens.	X		X	
2) The robot is transitioning *from a still state to a motion state* (transition feedback)	The user presses the CLEAN button and the robot moves around cleaning.		X	X	
	The robot starts moving around by itself without being enacted by the user.	X		X	
3) The robot is going *from a motion state to a still state* (transition feedback)	The robot turns back to its charging station when the user presses HOME button.		X		X
	The robot turns back to its charging station when it is almost out of battery.	X	X		X
	The robot remembers the path and turns back to its charging station after finishing cleaning.		X		X
	The robot gets stuck and enacts the users through indirect or invisible feedback to do facilitation work.	X		X	
4) The robot is *in motion*	Motion feedback manifested through noise.	X	X	X	
	The robot remembers the map of the rooms when is not running for the first time in the area (coherent navigation).		X	X	X
	The motion of the robot is incoherent (it only cleans a small surface, without navigating the whole area).	X		X	
	The robot escapes (e.g., the navigation path of the robot does not respect the boundaries).	X		X	

station after finishing cleaning – the robot is acting in a familiar way to user's expectations, it acts accordingly after finishing its job.

Further, in this section, we have followed Turner (2011), of making sense everyday examples of interacting with technology, the readiness of coping with it in everyday life situations [58]. This sense-making lead us to a mapping between polarity feedback (positive or negative), homeostatic feedback, and archival feedback to motion as feedback. In addition, we observed that doing this mapping by using the states of a robot, still and in motion, and their corresponding transitions, we could define the *transition feedback type*. We have also observed that different feedback for different states can trigger *emotions* (positive or negative) in the user. If we follow the idea that the interaction is a form of dialogue' with the technology, we are still concerned that current design remains *unfamiliar* to the user in specific situations, regardless if the user is experienced or not. To come back to Suchman's (1986) idea that a "*tool must communicate*", and that "*the artifact should be self-evident*" [44, 14-15], it seems that our *artifact, tool,* and *machine,* the robot, was not able to communicate in a number of situations that we illustrated based on our empirical data. This problem of *unfamiliarity,* as opposed to *familiarity,* reveals a deeper underlying problem: "*the problem of deciphering an artifact defines the problem of the designer as well*." [44, 14-15].

If the robot does not follow a *familiar* way of navigating a space, responding to the user's expectations, this may lead, in the case of the elderly and their use of a safety alarm robot, to additional falls for them. A concrete example is when the robot *transitions* from a still state to a motion state, without giving any *feedback* to the user, besides the feedback in the form of *transition motion feedback*, and noise as homeostatic feedback. Falls amongst elderly is a well-known problem [88]. The situation presented above may lead the user to additional falls if the user is not aware of the *transition and homeostatic feedback*. Introducing a robot that does not respond accordingly, by giving negative feedback, being it homeostatic or archival, may have negative consequences on the user. Further, the report about falls amongst the elderly shows that fall may lead to fear of falling, and other negative physical and mental health consequences [88]. The literature also shows that falls amongst elderly people (≥65 years old) are very common, and hospitalized due to fall injuries seem to occur five times more than due to other causes [89]. Another problem with the *motion as feedback* is when the robot escapes. In the situation of the use of a robot in the home, e.g. a safety alarm robot for the elderly, such a type of negative and homeostatic feedback may lead to a non-detected fall. The situation of the robot getting stuck, as negative and homeostatic motion feedback, may also lead in a real situation to a non-detected fall, and in other implications for the user: bending over to move the robot.

Lastly, we can say that looking at the *motion as feedback* with the help of *familiarity concept* contributed to understand the potential challenges and implications when introducing a robot in the homes of the independent living elderly. Moreover, it also contributed to map and discusses *motion as a positive, negative, homeostatic, archival,* and *transition motion feedback*.

VIII. Conclusion and Future Work

In this paper, we have presented *motion as feedback* through empirical data from an explorative study of semi-autonomous robots used in domestic settings. We started the

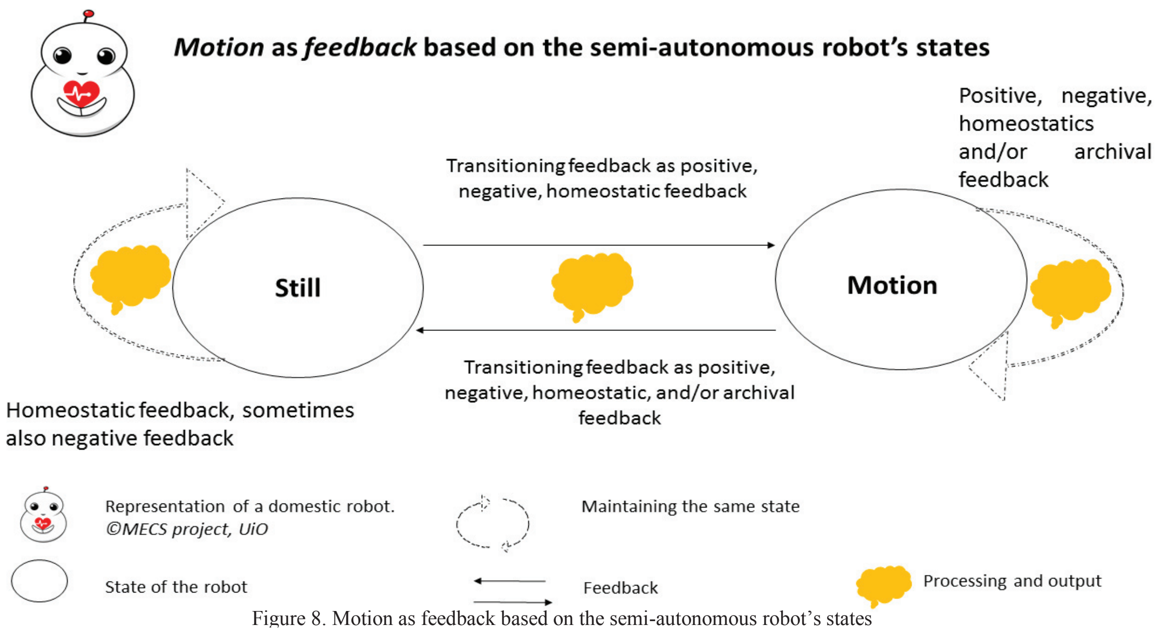

Figure 8. Motion as feedback based on the semi-autonomous robot's states

paper by stating our research questions, introducing some terminology and the background for this study. In Section II, we gave an account on the state-of-the-art. Section III introduced the reader to the concept of feedback within HCI, where it often is understood and designed as visual, auditory, haptic, or textual. We drew attention upon the significance of the use of natural language when interacting with computers, or designing feedback, dating back to the work of Suchman (1985) [41][44]. We elaborated on *polarity-, homeostatic,* and *archival feedback* based on the existent literature. We briefly described *motion as feedback* based on robot navigation. We have framed *feedback* from a smartphone app and semi-autonomous robot technology, to be able to discuss robot's *motion as feedback*, and differentiate it from *feedback* received from stationary technology, we have framed feedback from smartphone app and semi-autonomous robot technology.

Further, in Section IV, we have elaborated on our theoretical foundations, explaining the *familiarity* concept. Section V illustrated in detail the methodology and methods for this study, including the ethical aspects. In Section VI, we have presented our findings structured in: the user receives feedback from a smartphone technology; the user receives distributed feedback from a robot - mediated via an app; and motion as feedback and its implications for the user. Finally, in Section VII, we discussed the *motion as feedback*: the role of *familiarity* for the *emotions* triggered by the *engagement* with the technology, discussing how *feedback* can support *familiarity* with technology; and making sense of the motion as feedback, based on polarity-, homeostatic-, and archival feedback. The *transitioning feedback* emerged here. We continued by discussing *familiarity with the motion as feedback.* We argue that having *familiarity* in mind when designing new technologies, can make it easier for the user to *know-how* to use the technology.

Our conclusion is that a semi-autonomous robot technology can become more *familiar* to the user if it triggers (more often) positive feelings in the user (than negative feelings). Finally, from a System Engineering perspective, following HCI requirements derive from the findings: if its motion is coherent, if its navigation is appropriate to the situation (e.g., going back to the charging station when it is out of battery, not getting stuck, remembering the map of the rooms to be navigated, without "escaping"), and if its motion is not disturbing or interrupting the user (e.g., when taking a phone call, or when eating). Taking a *being-with* approach to *familiarity* for semi-autonomous robot technology to make sense of the robot's motion helped us in being able to distinguish amongst *motion as positive, negative, homeostatic, archival,* and *transitioning feedback*. This approach changed how we view that the participants *engaged with* the technology: it changed their routines at home through the enactment of facilitation work, their schedule, their relationship with the technology itself and with others that live or visit the same home – once part of the home or one's daily's live, it became a subject for discussion suddenly. It was part of their everyday lives. However, we can conclude that through *making sense of motion as the feedback,* we may observe that the semi-autonomous robot was *part of,* but *not* yet *integrated* within their homes and their daily lives. The robot did not accommodate the participants, but rather, the participants had to accommodate the robot. *Familiarity* was defined as an intimate, close, and friendly state, or interaction [81]. However, we showed through this study that while using *familiarity* as a lens *to analyze* the participants' experiences with the semi-autonomous robot technology, the relationship between the participants and the robot remains *unfamiliar* in many situations. The robot still remains in many situations un-familiar to the participants, the *know-how* relationship is not fully developed, and the participants do not always have tacit knowledge on how to interact with it. Finally, the *co-existence* with such robots in domestic settings is not fully developed yet. We can conclude that familiarity *per se* plays a central role in individuals' relationships with technology [56].

Coming back to the State of the Art described in Section II, this study supports the findings from the ACCOMPANY project and Care-O-Bot robot [13][14][15][16]: many of the elderly need support with the ADL. Specifically, the need for support with the housekeeping related needs was nevertheless present also in this study, along with the findings from [19]. However, some of the studies made with the robots used in Robot-Era Project [3], ACCOMPANY [13][14], MARIO, EURON RoboEthics Roadman, EP6, ETHICBOTS, BREATHE, or ICT & Ageing Project [18] were centering their focus around the functionalities of the robot, and the user acceptance of the robots. These robots were also specifically designed for home care of the elderly. The studies made on the companion robots: PARO [21][22][23], AIBO, Furby, NeCoRo [21][22], Pepper and NAO [25], or Giraff [26] focused nevertheless on how a robot may impact the elderly's behavior across time. Many of the studies used quantitative statistical data for the evaluation of the robots. While this is nevertheless important, our study provides an example on how existent robots on the market can be used instrumentally in explorative interpretative qualitative studies for understanding more about the participants' everyday experiences, and how their daily activities may change when introducing such robot in their homes. The study is primarily about the lived experiences of the participants. These experiences are instrumentally used as a foundation for understanding more about design, design of robots for their use at home, design implications of feedback, and motion as feedback distributed or not via an app.

We suggest as future work to elaborate further on the relationship between motion*, transitioning motion feedback,* and the role of *familiar feedback* in *engaging* with technology, rather than *interacting* with it. Further, one could explore more the affordances of motion as feedback, following the definition of affordances as given by [90], or as seen in HCI. Introducing moving technologies in the home lays the foundation for further explorations. One way to build further on this study is by conducting a quantitative statistical study on the acceptance of the robots in the home, on the movement types of robot, or by using the concept of animacy as shown in [48]. Exploring the abstract concept of *feedback* as a coordination mechanism and/or as a boundary object is also of high interest and relevance for those interested in theoretical anchored explorations. Another way for continuing this study is by conducting a qualitative interpretative study by analyzing the division of work tasks and types of work performed by the human and the robot. Here we encourage the analysis of work tasks and types of works to be done by borrowing established concepts used outside of HCI field, such as Computer Supported Cooperative Work. Nevertheless, studying the boundaries between when the interaction between the human and a robot becomes a cooperation between the human and the robot is of high relevance, especially now with faceless interaction devices: conversational based devices on face- or faceless interactions based mainly on speech, such as, e.g., Sophia the Robot, or with Google Home Mini.

Finally, this study was conducted to understand the potential challenges (e.g., robot motion as feedback is not understood by the participants, the robot motion enacts the participants to do facilitation work, the robot escapes, etc.) that may occur when introducing a robot in the homes of the independent living elderly. Introducing modern technologies in the homes of the elderly, such domestic robots requires scrutiny of the design of current and eventual future technologies that will be used by them. Understanding which challenges the elderly encounter *when* they interact with a semi-autonomous robot, in their everyday lives in domestic settings, contributes to our understanding on potential challenges on the future home care robots for the independent living elderly.

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REFERENCES

[1] D. Saplacan and J. Herstad, "Fear, Feedback, Familiarity... How are These Connected? - Can familiarity as a design concept applied to digital feedback reduce fear?," *Proceedings of The Eleventh International Conference on Advances in Computer-Human Interactions (ACHI)*. Mar-2018.

[2] Dictionary.com, "Thesaurus.com | Meanings and Definitions of Words at Thesaurus.com," *Thesaurus.com*, 2016. [Online]. Available: http://www.thesaurus.com/, http://www.thesaurus.com/. [Accessed: 26-Jul-2017].

[3] L. D. Riek, "Healthcare Robotics," *ACM Communications*, vol. 60. pp. 68–78, Nov-2017.

[4] S. Thrun, "Toward a Framework for Human-robot Interaction," *Hum-Comput Interact*, vol. 19, no. 1, pp. 9–24, Jun. 2004.

[5] R. Soma, V. Dønnem Søyseth, M. Søyland, and T. Schulz, "Facilitating Robots at Home: A Framework for Understanding Robot Facilitation," presented at the ACHI 2018, The Eleventh International Conference on Advances in Computer-Human Interactions, 2018, pp. 1–6.

[6] J. S. Oskarsen, "Human-supported robot work," Master Thesis, University of Oslo, Department of Informatics, Faculty of mathematics and natural sciences, Oslo, Norway, 2018.

[7] S. Bødker, "Third-Wave HCI, 10 Years Later—Participation and Sharing," *interactions*, vol. 22. ACM New York, NY, USA, pp. 24–31, 2015.

[8] "MECS," *Multimodal Elderly Care Systems (MECS), About the project*, 17-Oct-2016. [Online]. Available: http://www.mn.uio.no/ifi/english/research/groups/robin/research-projects/mecs/. [Accessed: 17-Oct-2016].

[9] P. B. Baltes and J. Smith, "New frontiers in the future of aging: from successful aging of the young old to the dilemmas of the fourth age," *Gerontology*, vol. 49, no. 2, pp. 123–135, Apr. 2003.

[10] D. Field and M. Minkler, "Continuity and change in social support between young-old and old-old or very-old age," *J. Gerontol.*, vol. 43, no. 4, pp. P100-106, Jul. 1988.

[11] T. T. Hewett *et al.*, "ACM SIGCHI Curricula for Human-Computer Interaction : 2. Definition and Overview of Human-Computer Interaction." ACM SIGCHI, 1996-1992.

[12] S. Bedaf, G. J. Gelderblom, and L. De Witte, "Overview and Categorization of Robots Supporting Independent Living of Elderly People: What Activities Do They Support and How Far Have They Developed," *Assist. Technol. Off. J. RESNA*, vol. 27, no. 2, pp. 88–100, 2015.

[13] S. Bedaf, H. Draper, G.-J. Gelderblom, T. Sorell, and L. de Witte, "Can a Service Robot Which Supports Independent Living of Older People Disobey a Command? The Views of Older People, Informal Carers and Professional Caregivers on the Acceptability of Robots," *Int. J. Soc. Robot.*, vol. 8, no. 3, pp. 409–420, Jun. 2016.

[14] F. Amirabdollahian *et al.*, "Accompany: Acceptable roboticS COMPanions for AgeiNG Years — Multidimensional aspects of human-system interactions," in *2013 6th International Conference on Human System Interactions (HSI)*, 2013, pp. 570–577.

[15] B. Graf, M. Hans, and R. D. Schraft, "Care-O-bot II—Development of a Next Generation Robotic Home Assistant," *Auton. Robots*, vol. 16, no. 2, pp. 193–205, Mar. 2004.

[16] M. Hans and W. Baum, "Concept of a hybrid architecture for Care-O-bot," in *Proceedings 10th IEEE International Workshop on Robot and Human Interactive Communication. ROMAN 2001 (Cat. No.01TH8591)*, 2001, pp. 407–411.

[17] B. Graf, "Reactive navigation of an intelligent robotic walking aid," in *Proceedings 10th IEEE International Workshop on Robot and Human Interactive*

Communication. ROMAN 2001 (Cat. No.01TH8591), 2001, pp. 353–358.

[18] H. Felzmann, K. Murphy, D. Casey, and O. Beyan, "Robot-assisted care for elderly with dementia: is there a potential for genuine end-user empowerment?," in *The Emerging Policy and Ethics of Human Robot Interaction*, Portland, Oregon, USA, 2015.

[19] L. Pigini, D. Facal, L. Blasi, and R. Andrich, "Service robots in elderly care at home: Users' needs and perceptions as a basis for concept development," *Technol. Disabil.*, vol. 24, no. 4, pp. 303–311, 2012.

[20] J. Forlizzi and C. DiSalvo, "Service Robots in the Domestic Environment: A Study of the Roomba Vacuum in the Home," in *Proceedings of the 1st ACM SIGCHI/SIGART Conference on Human-robot Interaction*, New York, NY, USA, 2006, pp. 258–265.

[21] S. A. McGlynn, S. Kemple, T. L. Mitzner, C.-H. A. King, and W. A. Rogers, "Understanding the potential of PARO for healthy older adults," *Int. J. Hum.-Comput. Stud.*, vol. 100, pp. 33–47, Apr. 2017.

[22] K. Wada, Y. Takasawa, and T. Shibata, "Robot therapy at facilities for the elderly in Kanagawa prefecture - a report on the experimental result of the first month," in *The 23rd IEEE International Symposium on Robot and Human Interactive Communication*, 2014, pp. 193–198.

[23] L. Giusti and P. Marti, "Interpretative Dynamics in Human Robot Interaction," in *ROMAN 2006 - The 15th IEEE International Symposium on Robot and Human Interactive Communication*, 2006, pp. 111–116.

[24] K. Wada and T. Shibata, "Robot Therapy in a Care House - Change of Relationship among the Residents and Seal Robot during a 2-month Long Study," in *RO-MAN 2007 - The 16th IEEE International Symposium on Robot and Human Interactive Communication*, 2007, pp. 107–112.

[25] J. Hoefinghoff, A. R. der Pütten, J. Pauli, and N. Krämer, "'Yes Dear, that Belongs into the Shelf!' - Exploratory Studies with Elderly People Who Learn to Train an Adaptive Robot Companion," in *Social Robotics*, 2015, pp. 235–244.

[26] J. González-Jiménez, C. Galindo, and J. R. Ruiz-Sarmiento, "Technical improvements of the Giraff telepresence robot based on users' evaluation," in *2012 IEEE RO-MAN: The 21st IEEE International Symposium on Robot and Human Interactive Communication*, 2012, pp. 827–832.

[27] A. Cesta, G. Cortellessa, A. Orlandini, and L. Tiberio, "Long-Term Evaluation of a Telepresence Robot for the Elderly: Methodology and Ecological Case Study," *Int. J. Soc. Robot.*, vol. 8, no. 3, pp. 421–441, Jan. 2016.

[28] eurostat, "Population structure and ageing - Statistics Explained," *Population structure and ageing*, 20-Jul-2017. [Online]. Available: http://ec.europa.eu/eurostat/statistics-explained/index.php/Population_structure_and_ageing. [Accessed: 20-Jul-2017].

[29] ssb, "Next million reached set to be the fastest," *ssb.no*, 2017. [Online]. Available: http://www.ssb.no/en/befolkning/statistikker/folkfram/aar/2016-06-21. [Accessed: 20-Jul-2017].

[30] M. Forzati and C. Mattson, "Effekter av digitala tjänster för äldrevård - ekonomisk studie," ssnf.org, acr057005, Jan. 2014.

[31] J. Ramm, "Health and care. Use of services among the elderly," *ssb.no*, 2013. [Online]. Available: http://www.ssb.no/en/helse/artikler-og-publikasjoner/eldres-bruk-av-helse-og-omsorgstjenester. [Accessed: 20-Jul-2017].

[32] European Commision, "eHealth Action Plan 2012-2020: Innovative healthcare for the 21st century," *Digital Single Market*, 07-Dec-2012. [Online]. Available: https://ec.europa.eu/digital-single-market/en/news/ehealth-action-plan-2012-2020-innovative-healthcare-21st-century. [Accessed: 20-Jul-2017].

[33] J. A. Delello and R. R. McWhorter, "Reducing the Digital Divide: Connecting Older Adults to iPad Technology," *J. Appl. Gerontol.*, vol. 36, no. 1, pp. 3–28, Jan. 2017.

[34] Y.-H. Wu, S. Damnée, H. Kerhervé, C. Ware, and A.-S. Rigaud, "Bridging the digital divide in older adults: a study from an initiative to inform older adults about new technologies," *Clin. Interv. Aging*, vol. 10, pp. 193–201, Jan. 2015.

[35] T. Halbach and T. Schulz, "MobileSage - A Prototype Based Case Study for Delivering Context-Aware, Personalized, On-Demand Help Content," presented at the CENTRIC 2013, The Sixth International Conference on Advances in Human oriented and Personalized Mechanisms, Technologies, and Services, 2014, vol. International Journal on Advances in Intelligent Systems, 7, nos. 1–2, pp. 267–278.

[36] M. Anerson and A. Perrin, "1. Technology use among seniors," *Pew Research Center: Internet, Science & Tech*, 17-May-2017. .

[37] B. Shneiderman, *Designing the User Interface: Strategies for Effective Human-computer Interaction*. Boston, MA, USA: Addison-Wesley Longman Publishing Co., Inc., 1986.

[38] E. Wong, "Shneiderman's Eight Golden Rules Will Help You Design Better Interfaces," *The Interaction Design Foundation*, 2019. [Online]. Available: https://www.interaction-design.org/literature/article/shneiderman-s-eight-golden-rules-will-help-you-design-better-interfaces. [Accessed: 07-Feb-2019].

[39] D. Saplacan and J. Herstad, "A Quadratic Anthropocentric Perspective on Feedback - Using Proxemics as a Framework," *Conference Proceedings of BritishHCI 2017*. Sunderland, U.K., 03-Jul-2017.

[40] D. A. Norman, *The design of everyday things*, Revised and expanded edition. New York, New York: Basic Books, 2013.

[41] I. Apple Computer, *Macintosh Human Interface Guidelines*. USA: Addison-Wesley Publishing Company, 1992.

[42] A. Spink and T. Saracevic, "Human-computer interaction in information retrieval: nature and manifestations of feedback," *Interact. Comput.*, vol. 10, no. 3, pp. 249–267, Jun. 1998.

[43] M. A. Pérez-Quiñones and J. L. Sibert, "A Collaborative Model of Feedback in Human-computer Interaction," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, New York, NY, USA, 1996, pp. 316–323.

[44] L. Suchman, *Plans and situated actions: The problem of human-machine communication*. Palo Alto, California 94304: Xerox Corporation Palo Alto Research Centers, 1985.

[45] P. Dourish, "What we talk about when we talk about context," *Pers. Ubiquitous Comput.*, vol. 8, no. 1, pp. 19–30, Feb. 2004.
[46] K. Renaud and R. Cooper, "Feedback in human-computer interaction - characteristics and recommendations," *South Afr. Comput. J.*, vol. 2000, no. 26, pp. 105–114, Nov. 2000.
[47] T. Ingold, *The perception of the environment: essays on livelihood, dwelling and skill*. London ; New York: Routledge, Taylor & Francis Group, 2011.
[48] T. Schulz, J. Torresen, and J. Herstad, "Animation Techniques in Human-Robot Interaction User Studies: a Systematic Literature Review," *ArXiv181206784 Cs*, Dec. 2018.
[49] E. T. Hall, *The hidden dimension*. New York: Anchor Books, 1990.
[50] J. Beck and E. Stolterman, "Examining Practical, Everyday Theory Use in Design Research," *She Ji J. Des. Econ. Innov.*, vol. 2, no. 2, pp. 125–140, Jun. 2016.
[51] M. Heidegger, *Being and time*. Oxford, U.K.: Blackwell Publishers Ltd, 1967.
[52] "familiarity, n.," *OED Online*. Oxford University Press.
[53] H. Dreyfus, *Being-in-the-world: A Commentary on Heidegger's Being and Time, Division I*. Massachusetts Institute of Technology, 1991.
[54] N. Backhaus, A. K. Trapp, and M. Thüring, "Skeuomorph Versus Flat Design: User Experience and Age-Related Preferences," in *Design, User Experience, and Usability: Designing Interactions*, 2018, pp. 527–542.
[55] P. Turner, *How We Cope with Digital Technology*. San Rafael: Morgan & Claypool Publishers, 2013.
[56] G. Van de Walle, P. Turner, and E. Davenport, "A study of familiarity," in *Human-Computer Interaction-INTERACT*, 2003, vol. 3, pp. 463–70.
[57] P. Turner, "Towards an account of intuitiveness," *Behav. Inf. Technol.*, vol. 27, no. 6, pp. 475–482, Nov. 2008.
[58] P. Turner, "Everyday Coping: The Appropriation of Technology," in *Proceedings of the 29th Annual European Conference on Cognitive Ergonomics*, New York, NY, USA, 2011, pp. 127–133.
[59] P. Turner, "Being-with: A study of familiarity," *Interact. Comput.*, vol. 20, no. 4, pp. 447–454, Sep. 2008.
[60] P. Turner and G. van de Walle, "Familiarity as a basis for universal design," *Gerontechnology*, vol. 5, no. 3, pp. 150–159, Jan. 2006.
[61] J. Herstad and H. Holone, "Making Sense of Co-creative Tangibles Through the Concept of Familiarity," in *NORDICHI'12, Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design*, New York, NY, USA, 2012, pp. 89–98.
[62] M. Myers D., "Qualitative Research in Information Systems," *MISQ Discovery*, 1997.
[63] P. Ricoeur, "Phenomenology and Hermeneutics," *Noûs*, vol. 9, no. 1, pp. 85–102, 1975.
[64] S. G. Joshi, "Designing for Experienced Simplicity. Why Analytic and Imagined Simplicity Fail in Design of Assistive Technology," *Int. J. Adv. Intell. Syst.*, vol. 8, no. 3 and 4, pp. 324–338, Dec. 2015.
[65] S. G. Joshi, "Designing for Capabilities: A Phenomenological Approach to the Design of Enabling Technologies for Older Adults," 2017.
[66] R. B. Rosseland, "Exploring Movement-Based Rhythmic Interaction with Senior Citizens," University of Oslo, Department of Informatics, Faculty of mathematics and natural sciences, Oslo, Norway, 2018.
[67] A. Woll, "use of Welfare Technology in Elderly Care," University of Oslo, Oslo, Norway, 2017.
[68] S. G. Joshi and T. Bratteteig, "Assembling Fragments into Continuous Design: On Participatory Design with Old People," in *Nordic Contributions in IS Research*, 2015, pp. 13–29.
[69] iRobot Corporation, "Roomba Robot Vacuum | iRobot." [Online]. Available: http://www.irobot.com/For-the-Home/Vacuuming/Roomba.aspx. [Accessed: 22-Mar-2017].
[70] G. Verne, "'The winners are those who have used the old paper form'. On citizens and automated public services," University of Oslo, Oslo, Norway, 2015.
[71] S. Ottenberg, "Thirty Years of Fieldnotes: Changing Relationships to the text," in *The Making of Anthropology, R. Sanjek*, Cornell University Press, 1990, pp. 139–160.
[72] M. Crang and I. Cook, *Doing Ethnographies*. SAGE Publications, Inc., 2007.
[73] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qual. Res. Psychol.*, vol. 3, no. 2, pp. 77–101, Jan. 2006.
[74] R. M. Emerson, R. I. Fretz, and L. L. Shaw, "Processing Fieldnotes: Coding and Memoing (Chapter 6)," in *Writing Etnographic Fieldnotes*, Chigago and London: University of Chicago Press, 1995, pp. 142–168.
[75] J. Lazar, J. H. Feng, and H. Hochheiser, *Research Methods In Human-Computer Interaction*. West Sussex, United Kingdom: Jon Wiley & Sons Ltd, 2010.
[76] W. J. Austin, *How to do things with words*. Great Britain, Guernesey, Channel Islands: Oxford University Press, 1962.
[77] Online Etymology Dictionary, "emotion," 15-Feb-2019. [Online]. Available: https://www.etymonline.com/word/emotion. [Accessed: 15-Feb-2019].
[78] Online Etymology Dictionary, "motion | Search Online Etymology Dictionary," 15-Feb-2019. [Online]. Available: https://www.etymonline.com/search?q=motion. [Accessed: 15-Feb-2019].
[79] Online Etymology Dictionary, "locomotion," 15-Feb-2019. [Online]. Available: https://www.etymonline.com/word/locomotion. [Accessed: 15-Feb-2019].
[80] J. Raskin, "Viewpoint: Intuitive Equals Familiar," *Commun ACM*, vol. 37, no. 9, pp. 17–18, Sep. 1994.
[81] OED, "fear, n.1," *Oxford Engglish Dictionary Online*. Oxford University Press, 2017.
[82] Y. A. A. Strengers, "Designing Eco-feedback Systems for Everyday Life," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, New York, NY, USA, 2011, pp. 2135–2144.
[83] P. Turner, "The Anatomy of Engagement," in *Proceedings of the 28th Annual European Conference on Cognitive Ergonomics*, New York, NY, USA, 2010, pp. 59–66.
[84] L. Suchman, J. Blomberg, J. E. Orr, and R. Trigg, "Reconstructing Technologies as Social Practice," *Am. Behav. Sci.*, vol. 43, no. 3, pp. 392–408, Nov. 1999.
[85] R. Picking, V. Grout, J. McGinn, J. Crisp, and H. Grout, "Simplicity, Consistency, Universality, Flexibility and Familiarity: The SCUFF Principles for Developing User Interfaces for Ambient Computer Systems," *Int. J. Ambient Comput. Intell. IJACI*, vol. 2, no. 3, pp. 40–49, 2010.

[86] L. L. Constantine and L. A. D. Lockwood, *Software for Use: A Practical Guide to the Models and Methods of Usage-Centered Design*, 1 edition. Boston, Mass.: Addison-Wesley Professional, 1999.

[87] J. Nielsen, “10 Usability heuristics.” Nielsen, Jakob, 2005.

[88] “Seniors’ falls in Canada - protecting Canadians from Illness,” Ministery of Health, Canada, Second Edition, 2014.

[89] A. Danielsen, H. Olofsen, and B. A. Bremdal, “Increasing fall risk awareness using wearables: A fall risk awareness protocol,” *J. Biomed. Inform.*, vol. 63, pp. 184–194, Oct. 2016.

[90] J. J. Gibson, *The ecological approach to visual perception*. New York, London: Psychology Press, 2015.

PAPER III

Multimodal Technologies and Interaction

Article

A Framework on Division of Work Tasks between Humans and Robots in the Home

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Abstract: This paper analyzes work activity in the home, e.g., cleaning, performed by two actors, a human and a robot. Nowadays, there are attempts to automate this activity through the use of robots. However, the activity of cleaning, in and of itself, is not important; it is used instrumentally to understand if and how robots can be integrated within current and future homes. The theoretical framework of the paper is based on empirical work collected as part of the Multimodal Elderly Care Systems (MECS) project. The study proposes a framework for the division of work tasks between humans and robots. The framework is anchored within existing research and our empirical findings. Swim-lane diagrams are used to visualize the tasks performed (WHAT), by each of the two actors, to ascertain the tasks' temporality (WHEN), and their distribution and transitioning from one actor to the other (WHERE). The study presents the framework of various dimensions of work tasks, such as the types of work tasks, but also the temporality and spatiality of tasks, illustrating linear, parallel, sequential, and distributed tasks in a shared or non-shared space. The study's contribution lies in its foundation for analyzing work tasks that robots integrated into or used in the home may generate for humans, along with their multimodal interactions. Finally, the framework can be used to visualize, plan, and design work tasks for the human and for the robot, respectively, and their work division.

Keywords: framework; human; robot; division of work; work task; human work; robot work; joint activity; human-robot interaction (HRI); human-robot cooperation; computer-supported cooperative work (CSCW)

1. Introduction

This study is an empirical study, which is part of the Multimodal Elderly Care Systems (MECS) project. This project aims to develop a robot to be used in home-care services for the elderly. Within the framework of the MECS project, this paper aims to investigate semi-autonomous robots, as moving entities in the home that change the tasks and routines of the people living there. To illustrate this, we have studied the current literature on what types of robots are employed in the home of the independent living elderlies [1,2] and non-elderlies. Thus, we found that several previous studies have shown that instrumental use of vacuum cleaner robots is useful to understand the design implications of introducing robots in the homes (see [3–5]). It seems that many of the elderly consider cleaning their homes as a work activity that requires a significant amount of physical effort and concentration. The literature shows that they often need support with this type of work activity. Similarly, the majority of the elderly in the MECS project, during an initial phase of the study, talked about robots and how they often wished for personal domestic service robots that could help them with work tasks in the home [6,7]. Moreover, the activity of cleaning was demonstrated to be of high importance for the elderly. Furthermore, many of them usually received help with home cleaning every other week. In this way, the researchers in the project decided to offer some personal service robots, such as semi-autonomous vacuum-cleaner robots, e.g., iRobot Roomba and Neato BotVac, to mutually help each other: we were interested in what kind of work tasks are generated with the introduction of a moving object—a semi-autonomous robot—in the home, while the elderly were interested in receiving help with the cleaning task. In this way, we could instrumentally use the data gathered to explore the work tasks that come along with the introduction of a robot in a home setting.

Thus, this paper investigates and abstracts the types of work tasks generated by introducing a semi-autonomous robot in the home. The research question addressed in this paper is: what are the types of work tasks that are generated by a robot, a semi-autonomous moving entity, in the home? To answer this question, we introduced a robot vacuum cleaner to the homes of several participants. Furthermore, to answer our research question, we based our theoretical framework on a model developed by Verne [7] and Verne and Bratteteig [8]. We use swim-lane diagrams to visualize the tasks performed by each of the two actors (WHAT), e.g., the human and the robot, to ascertain the tasks' temporality (WHEN), and their spatial distribution and transitioning from one actor to the other (WHERE). In this way, the paper adds new dimensions to the existing theoretical framework, about the temporality and spatiality of tasks, illustrating linear, parallel, sequential, and distributed tasks. The contribution of this paper is the further development of the theoretical framework developed by Verne [7] and Verne and Bratteteig [8], by adding new dimensions to it. The framework lays the foundation for analyzing work tasks that robots integrated into or used in home settings may generate for humans. This is useful for the MECS project and outside of it, when analyzing the new, redundant, temporally, or spatially distributed work tasks. However, the framework can also be used in other settings, as we later show in the paper. Specifically, the framework helps us in identifying, understanding, visualizing, planning, and designing automated work tasks carried out by the robot, and by the human, when introducing a robot in a home setting—a cluttered and dynamic environment.

This paper continues in Section 2 by defining concepts such as work and tasks, as defined in the computer-supported cooperative work (CSCW) literature. Section 3, Literature Review, gives an overview of similar studies that have been undertaken and which are relevant to this work. In this section, we also present how this study is different and why it is important. In Section 4, Theoretical Framework, the theoretical model from Verne [7] and Verne and Bratteteig [8] are described. Section 5, Methodology and Methods, is then presented in detail. Section 6 thereafter presents empirical data, visualizes different types of tasks, their dimensions, and finally presents the resulted framework. Finally, Section 7, Discussion, reflects on the method and setting of the study and discusses the proposed framework. A Summary and Conclusion section, followed by Future Work, follows thereafter.

2. Definitions of Concepts

2.1. Division of Work

Strauss [9] wrote first about work and the division of labor, to understand work in complex projects. He referred to all tasks that make up the work as 'the arc of work' (p. 2). The arc of work 'for any given trajectory' is defined as: 'consist[ing] of the totality of tasks arrayed both sequentially and simultaneously along the course of the trajectory or of the project'. According to the author, some of the tasks are foreseen; however, some are unplanned and may occur unexpectedly during the trajectory. An arc of work may include arc phases, types of work, clusters of tasks, and articulation of tasks. Sometimes the division of work that makes up the arc of work is based on the particular skills of the actors. To understand the tasks as part of the work activity is to understand the division of work.

2.2. Actors' Part in the Division of Work

Within coordinative work, several objects of coordination are identified as being part of the division of work, such as actors, roles, responsibilities and obligations, tasks with an operational intention, activities, conceptual structures, and other types of resources [10]. According to the Oxford English Dictionary, an actor is a participant who takes part in a process or action [11]. The two actors considered in this study were involved in the work activity of cleaning: the human and the robot. Discussing if and how the robot is both an actor and the main tool of the work activity is outside the scope of this paper.

2.3. Framing the Concept of Work Tasks

Work tasks are related to questions such as: 'what, where, when, how, for how long, how complex, how well defined are their boundaries, how attainable are they under current working conditions, how precisely are they defined [. . .], and what is the expected level of the performance' [9]. According to Gasser [12], a work situation is translated into a work task and its context (p. 211). In this study, the work tasks were related to performing all the necessary steps involved in the work activity of cleaning. The context was that of cleaning, a shared activity between the actors: the human and the robot. According to the author, a work task involves an agenda, a place where and an interval when it is executed; it requires several resources, and has to be carried out by one or several people. However, in this study, a robot was considered to be a type of actor, as previously mentioned. Each task is part of a division of labor, a system of tasks, referred to in this study as the work activity, and it is related to other tasks [12]. A task chain is made up of two or several work tasks that come one after another, sequentially. In complex structures, where the division of labor involves many tasks that may intersect with each other, the tasks form the production lattice. The work tasks in the production lattice need to be aligned according to the resources available—both material and human.

2.4. Why We Need to Understand the Division of Work between the Actors and Their Tasks

Each of the actors performs certain tasks that contribute to the actor operation, whether the human operation or the robot operation. The system of all the tasks that are included in the operations performed by each of the actors forms the work activity. In this case, the joint work activity is cleaning. To understand the tasks performed by the human and the robot, respectively, we need to understand the concept of work tasks first, and how they are part of the division of work. Moreover, using certain concepts to understand the division of work helps us to understand the accountability for work: who does what, what resources are allocated to whom (the human or the robot) and when, and what situations are encountered while the work is performed.

3. Literature Review

In general, the literature shows that studies on robots used within the home environment are sometimes conducted in virtual mock-home environments or living labs. These studies often fail to reproduce the complexity of a real home as an environment to navigate for a robot [13]. In this section, we present a literature review on some of the existing studies investigating the use of robots in the home. Moreover, we also present some of the existing frameworks investigating robots in the home or the work that comes along with automation.

3.1. Robots in the Home

One study by Sung et al. [14] looked into understanding domestic robot owners, through an examination of the Roomba vacuum cleaner robot. The study was based on an online Internet survey. While the study lacked data collected directly from the natural setting where the events occur, the study still confirmed the changes performed by the robots' owners in the home, to facilitate the robots' navigation of the rooms, a phenomenon referred to as 'roombarization' [14]. Moreover, based on the survey's respondents' answers, the study illustrated that the users were engaging in tasks such as: watching the robot, ascribing gender to the robot, naming the robot, talking to the robot, hacking its system, or playing and experimenting with the robot [14].

We know, however, from earlier research that several studies have been conducted investigating the use of robots in a natural setting, such as the home. For instance, Forlizzi and DiSalvo [3] explained how studies about domestic robots are mostly carried out in experimental settings in the lab, and they argued for more studies 'in the wild'. As such, they conducted a study on service robots in the domestic environment, using the Roomba vacuum cleaner. According to the authors, the practice of cleaning also reflects the structure of the home. Amongst their findings, they explained that the participants expected the robot to develop its knowledge over time; that the floors needed to be clutter-free; that many participants had to do workarounds to facilitate the robot's movement; that the robot often bumped into things; that the participants developed social relationships with the product; and that the robot became a value-laden symbol.

Along the same lines, other studies confirmed the need for more studies on robot use in the home environment. For instance, some studies have investigated the home organization to inform domestic robot behavior [13,15]. A study on kitchen organization explained how the home, a personal space, gives access to information that otherwise is hard to extract from photos, videos, or other sensor data [13]. The study argued that while there is an increasing interest in domestic robots, there is a lack of knowledge to illustrate the complexity of the home [13]. Moreover, the study also supported the idea that it is necessary to understand the users' needs and demands [13]. However, assigning tasks to robots implies not only technical challenges but also the calibration of the users' expectations of the robots' capabilities [15].

Furthermore, Forlizzi [16] conducted a study focusing on how robotic vacuum cleaning products become social products in the home. She explained in the study how the home is an interesting place to study new social robotic products since many human needs reside in a home environment. Her ethnographic study was conducted in the home of the elderly and non-elderly. Her findings illustrated that robotic products in the home triggered changes in household activities and tasks undertaken by the household members, and the nature of their work, i.e., 'who cleaned and how they cleaned', the frequency of their cleaning activities, and giving more autonomy to the robot [16], p. 133.

Forlizzi [4] developed the product ecology framework by studying the long-term use of robotic vacuum cleaners, such as the Roomba Discovery and the Hoover Flair, in the homes of the elderly and non-elderly. She developed this framework to understand social relationships and users' experiences as developed when using such intelligent robotic products [4]. As she said, the 'performance levels [of the elderly] decline more when they are coping with environments built for younger people' [4] (p. 10). Moreover, she showed in her study that many elderly people had reduced mobility, cognitive impairments, and encountered challenges in performing household activities. According to her, the inability to cope with home maintenance created fear and anxiety amongst elderly people. This sometimes led the users to downsize their home, giving up personal items, and even moving into a care facility—thus, leading them to a 'reconstruction of the self' [4]. At the same time, she also explained that, in general, robotic products are not built with any consideration for the aesthetics and social, and emotional relations that the elderly people build with the product [4]. Moreover, according to her, the structure of most homes is not currently designed to facilitate such moving objects. She argued that homes of the future should be able to accommodate ubiquitous services and automated service robots, along with allowing elderly people to retain their integrity, dignity, and independence. In addition, Sung et al. [17] recognized that robots shape relationships in the home. The authors conducted long-term studies in 30 households, where Roomba vacuum cleaners were deployed and observed. As a result of the study, the Domestic Robot Ecology (DRE) was framed. The study identified that the robots were considered to fulfill varying roles as a tool, an agent, a mediating factor for change, or a mediator for modifying relationships amongst the household members. However, while the authors mentioned that the robot triggered new types of domestic tasks, these were neither identified nor explored in-depth.

3.2. Available Frameworks

Some theoretical frameworks studying the use of robots in the home or the work that comes with automation were presented by Soma et al. [18], You and Robert [19], Ijtsma et al. [20], Lee and Paine [21], and Ajoudani et al. [22].

For instance, Soma et al. [18] presented the robot facilitation framework. The framework talks about different types of facilitation that the human needs to do when a robot is introduced in a hospital setting or a home. The types of facilitation described are pre-, peri- and post-facilitation. This framework seems interesting. However, the framework limits itself to different types of work carried out only by the human, not also by the robot. Moreover, the framework only addresses the temporal perspective of the work carried out by the human before, during, and after the work activity.

Furthermore, You and Robert [19] talked about the human-robot teams framed in the Inputs-Mediators-Outputs-Inputs (IMOI) framework. According to the authors, robots become more and more part of the teams and thus participate in teamwork. However, they also pointed out that frameworks for understanding the human-robot teams and their work, which enable or hinder them, are still lacking. They also emphasized that the existing frameworks often focus either on situational awareness or on their workload. The authors also argued that none of the existing frameworks focus specifically on human-robot teamwork as dynamic and adaptive teams where the actors need to adjust their actions throughout the life cycle. Thus, the authors proposed the IMOI framework that includes inputs, mediators, and outputs. They argued that these are some of the parts of the key elements of the teams' and the actors' life cycles. This can be an interesting framework; however, it is limited to theory, lacking empirical evidence that illustrates and exemplifies the proposed framework.

Along the same lines, Ijtsma et al. [20] talked about simulating human-robot teamwork dynamics for improving the work strategies in human-robot teams. They proposed the visualization of work between different actors, or agents, as they called them, through graph network visualization. In other words, they illustrated different strategies adopted by the team members, to identify eventual dependencies or constraints between the actors, and whether or not the work to be carried out by different actors is feasible at given times. Specifically, the study simulated the work dynamics in a human-robot team for space operations. The simulated team was structured from two astronauts and a rover. While this work provided significant insights for human-robot teamwork, the work was limited from two perspectives: (1) it was limited to a simulated environment, and (2) it did not simulate a home setting—a complex, dynamic and cluttered place.

Further, Lee and Paine [21] talked about the Model for Coordinated Action (MoCA). They described it as the actions taken by the actors involved in a work activity with a shared goal through one or several "overlapping fields of actions" (p. 6). The authors described seven dimensions of the MoCA. (1) The first one is the synchronicity of work amongst the actors. (2) The second dimension is the physical distribution of the actors' actions. (3) The third one is the scale representing the number of actors involved in a shared work activity. (4) The fourth one is the number of communities of practice involved in the work activity. (5) The fifth one is the nascence, referring to new and old coordinated actors' actions. (6) The sixth one refers to the planned permanence of the collaborative arrangement, where the coordinated action can be temporary or permanent. (7) Finally, the last dimension is turnover. The turnover refers to how stable the actors participating in shared work activity are. According to the authors, some of these dimensions, such as (8) nascence and (9) planned permanence, are less explored in the CSCW. This is also one of the reasons why we wish in this paper to address these dimensions through our proposed framework.

Finally, Ajoudani et al. [22] presented the state-of-the-art on human-robot collaboration. The authors emphasized that for a successful human-robot collaboration, a shared authority framework needs to be established between the two actors. The authors argued that while the hardware components are crucial in such a collaboration, there are also other factors, such as the intermediate interfaces between the human and the robot and the control or interaction modalities. According to the authors, multimodal interaction modalities, through feed-forward and feedback communication channels, can address even complex interaction scenarios. Their review paper, which was rich in examples, still lacked the application of the framework to specific use-cases.

We continue in the next section with a theoretical framework that is more appropriate for our area of interest, which we later will develop further, by adding new dimensions to it.

4. Theoretical Framework: The Model from Verne (2015) and Verne and Bratteteig (2016)

As we have shown in our literature review, many studies have investigated the use of robots in the home or have talked about robot frameworks. Although these studies informed our research, they neither focused on the types of tasks shared between humans and the robot nor on which types of tasks become automated and which do not. However, we identified one study that is relevant for our work, namely the study from Verne [23]. Verne's [23] study on the lawnmower robot used the theoretical framework on tasks developed in her Ph.D. thesis [7], and in her co-authored paper (see [8]). Since the author(s) focused on the tasks that arise as a consequence of the automation of work, we found this theoretical framework relevant and useful for this study. This framework indirectly fulfills dimension (5) on the nascence of work, and (6) on planned permanence, as explained in Lee and Paine's study [21]. The types of tasks that arise as a result of the automation of work are summarized in Table 1 below. However, these definitions only illustrate the tasks that come along with the automation of work for desktop interface systems, not robots.

Table 1. Types of tasks (based on Verne, 2015 [7]; Verne and Bratteteig, 2016 [8]).

Types of Task	Task Description
New tasks	Tasks that arise as a result of automation cannot be performed by the users themselves. These tasks usually occur when errors or inconsistencies are encountered.
Residual tasks	Tasks that still need to be performed outside the automation, usually manual tasks.
Automated tasks	Tasks that are automated.
Redundant tasks	Tasks that can be done both through automation and manually.
Tasks inside the automation	Tasks generated with the automation that is inside the automation.
Tasks outside the automation	Tasks generated by automation, but which are outside it.

The same author used the framework in a study with robots, where she showcased human adaptation to a robot lawnmower [23]. In an auto-ethnographic study, the author presented a robot mower automating certain human work tasks but also introduced new tasks to be performed by the human. While the expectation of the author, and also the user, was to acquire the robot lawnmower to automate maintenance work in the garden, she and her husband soon observed that both old tasks and new tasks in mowing the lawn were introduced. The work tasks in ensuring that the robot could carry out its work included old, new, and genuinely new tasks. The old tasks included: manual mowing of the lawn in areas which the robot did not reach and removing things from the lawn before mowing. The new tasks included: technical tasks to install the robot and its base station; removing obstacles from the lawn to avoid receiving error messages from the robot, i.e., one such task was to regularly pick up apples from the ground so the robot could run freely without cutting the apples; another involved hiring someone with a stump grubber to remove a tree stump from the garden, to offer a better navigation environment for the lawnmower robot; others involved manual work to remove the wood chippings, sowing new grass and repairing a patch and regularly checking if the robot was stuck, which interrupted other activities. Other new tasks that the users adopted to make the robot was working were: changing their habits in terms of watering the garden, as the robot did not function well when the lawn was wet; doing workarounds to protect the robot from the rain, as its electronics could be damaged irreparably; changing the layout of the garden and re-installation of the robot to optimize its performance.

However, the study from Verne [23] focused on a lawnmower and its work performed in the garden, not in the home. The garden is an outdoor place and is inherently different from the inside of a home. To inform the future development of robots used indoors, research into domestic robots is necessary to understand the work task division between humans and robots, new tasks that need to be undertaken, old tasks that are replaced, and redundant tasks. Therefore, this study is both interesting and relevant in answering our research question: what are the types of tasks and work that are generated by a robot, a semi-autonomous moving entity, in the home?

5. Methodology and Methods

The study followed an interpretative, analytical-qualitative approach. This section gives an overview of the participants, data collection, data analysis, and ethical considerations.

5.1. Participants

The participants in this study were elderly and non-elderly people. The study was based on data collected from 13 participants and ten other known household members. One of the households had a pet. The elderly participants were recruited through personal visits at the MECS partner accommodation facility for the elderly and snowball sampling (e.g., the elderly people passed information about the study on through word-of-mouth to other elderly people they knew). The non-elderly were recruited through personal contact. We chose these two groups due to three main reasons. First, we wished to see which robot suits the elderly best—i.e., being less technically difficult to use—therefore, we wished to test several robot types with the non-elderly participants. For instance, after a short use of Samsung PowerBot, we soon observed that the robot was not appropriate for the elderly's use: partially because they required a robot that is small in size, and easy to interact with. Second, we wish to see if both groups experience the same kind of situations when having a semi-autonomous robot in their homes. Finally, we wished to see the technical level of difficulty encountered by both groups. However, our intention was never to compare the experiences from each of the participants, but to look at the situations experienced by them and investigate potential challenges that a robot may bring along when introduced in the home. Details about the participants are given in Tables 2 and 3.

Table 2. Overview of the data collected from non-elders [5].

Data Collection Methods—Non-Elders			
#	**Timeframe**	**Documentation**	**Robot Used**
1	One week	Yes. Diary notes, seven posts (one per day), ca. 4 and a half A4 pages, analog format, 28 photos	Neato
2	Ca. two week	Yes. Three pages of A4 notes, digital format, 4 photos enclosed	Neato
3	Ca. one week	Yes. Short notes on strengths and weaknesses of using such a robot, digital format	iRobot Roomba
4	One week	Yes. one page of notes, digital format	Samsung PowerBot
5	Ca. one week	Yes. Half-page was written notes on strengths and weaknesses, digital format	Neato
6	Ca. one month	Yes. Four pages of written notes, 22 posts, digital format	Neato
7	Ca. one month	Yes. Ca. 19 A4 pages of written notes, analog format	Neato

Table 3. Overview of the data collected from the elders [5].

#	Data Collection Methods—Elderly					
	Gender (Female F, Male M)	**Interview**	**Elderly's Diary Notes**	**Author's Notes (SD)**	**Photos Were Taken by the Researchers**	**Eventual Details about the Robot Used, If Any Assistive Technologies Were Used, and Level of Information Technology Literacy**
1	F	Ca. 1 h, audio-recorded pilot interview transcribed verbatim (SD) AND Ca. 1 h and 45 min of untranscribed audio-recording from the installation of the robot	Yes. Ca. 5 A4 pages, analog format.	Yes. Ca. 2 A4 pages.	Yes, 36 photos	iRoomba, 87 years old, walking chair, did not use the app
2	F	Ca. 40 min, audio-recorded, transcribed verbatim (SD)	Yes. Ca. 3 A4 pages notes, analog format	Yes. Ca. 2 A4 pages.	Yes, 4 photos.	iRoomba, walking chair, a necklace alarm that she does not wear it, high interest in technology, used the app, has a smartphone.
3	M	Ca. 25 min, audio-recorded, transcribed verbatim (SD)	Yes. One letter-size page, analog format, short notes.	Yes. Ca. 4 letter-sized pages.	Yes, 10 photos.	Neato, wheelchair, not interested in technology, did not use the app, has a wearable safety alarm
4	F	Ca. 33 min audio-recorded, transcribed verbatim (SD)	Yes. One A4 page, analog format	Yes. Ca. 2 A4 pages.	Yes, 36 photos	iRoomba, wheelchair, interested in technology, did not use the app, does not have a smartphone, has a wearable safety alarm
5	F	Ca. 45 min audio-recorded, transcribed verbatim (SD)	Yes. One letter-size page, analog format.	Not available	Yes, 13 photos	Walker did not use the app, not interested in technology, does not have a smartphone, has a wearable safety alarm
6	F	Ca. 43 min, audio-recorded, (transcribed verbatim) (SD)	Yes. 4 letter-size pages, analog format.	Yes. Ca. 1 letter-sized page.	Yes, 16 photos	Interested in technology, no walker, wanted to use the app, but gave up, does not have any safety wearable alarm

5.2. Data Collection

The elderly participants had the robots in their homes for about one month each, whereas the non-elderly people used the robots in their homes for about one week and one month. While the elderly participants lived alone, the non-elderly participants lived with other household members.

The experiences of the elderly participants were documented through the author's notes and observations, the participants' diary notes, 115 photos taken by the first author during visits to the elderly peoples' homes, and several hours of audio-recorded semi-structured interviews that took place at the end of the study. The experiences of the non-elderly participants were documented through their diary notes and 32 photos. An overview of the data collected is given in Tables 2 and 3.

5.3. Data Analysis

The interviews were fully transcribed verbatim by the first author (SD) and analyzed following Braun and Clarke's [24] thematic analysis method. The steps followed were: (1) familiarization with the data, (2) coding each of the data collection resources (n = 222 codes), (3) collating the codes present across different data collection resources into initial themes, (4) reviewing the initial themes, (5) defining and naming the themes.

In the first step (step 1), we have familiarized ourselves with the data by creating a map of the data and data resources (Tables 2 and 3). The research question was put aside to be open for eventual novelties that might emerge from the data. At this stage, we focused on what was interesting for the participants. During the next step (step 2), we coded the resources and grouped them in categories based on the data sources: interviews, first author's diary notes, and observation notes, and the elderly's diary notes. The data were coded line-by-line. The next step (step 3) was to collate the codes into sub-categories for each of the data sources. This was carried out by the first author (SD) and documented through color-coded post-it notes, as shown in Figure 1. The collated codes resulted in $n = 222$ codes that were then organized into themes. Some of the identified themes were repeated across the data coming from different sources. We paid careful attention to see if the elders and non-elders encountered the same type of issues with having a semi-autonomous in the home, and how they dealt with the challenges that arose. Finally, after the authors (SD and HJ) discussed the collated codes at multiple times, we have reviewed the themes (step 4). The final resulting themes (step 5) were: issues related to the robot deployment in the home (blue), issues related to the home space (red), and issues related to the human aspects, such as emotions and perceived autonomy (green). An overview of the final themes emerged can be found in Figure 2. In our earlier work, reported in [5], we focused on interpreting the experiences of the participants with the robot (blue and green themes). The focus of this study is understanding the types of tasks and work generated by a semi-autonomous robot introduced in the home (blue and red themes).

5.4. Ethical Considerations

The project is in line with the ethical guidelines from the Norwegian Center for Research Data (NSD), project number 58689. The data were encrypted and stored on the Service for Sensitive Data at the University of Oslo, Norway. The participants were informed beforehand about the study and could withdraw from the study at any point without any consequences for them. The participants signed informed consent.

Figure 1. Photo from the data analysis—collating codes into sub-categories.

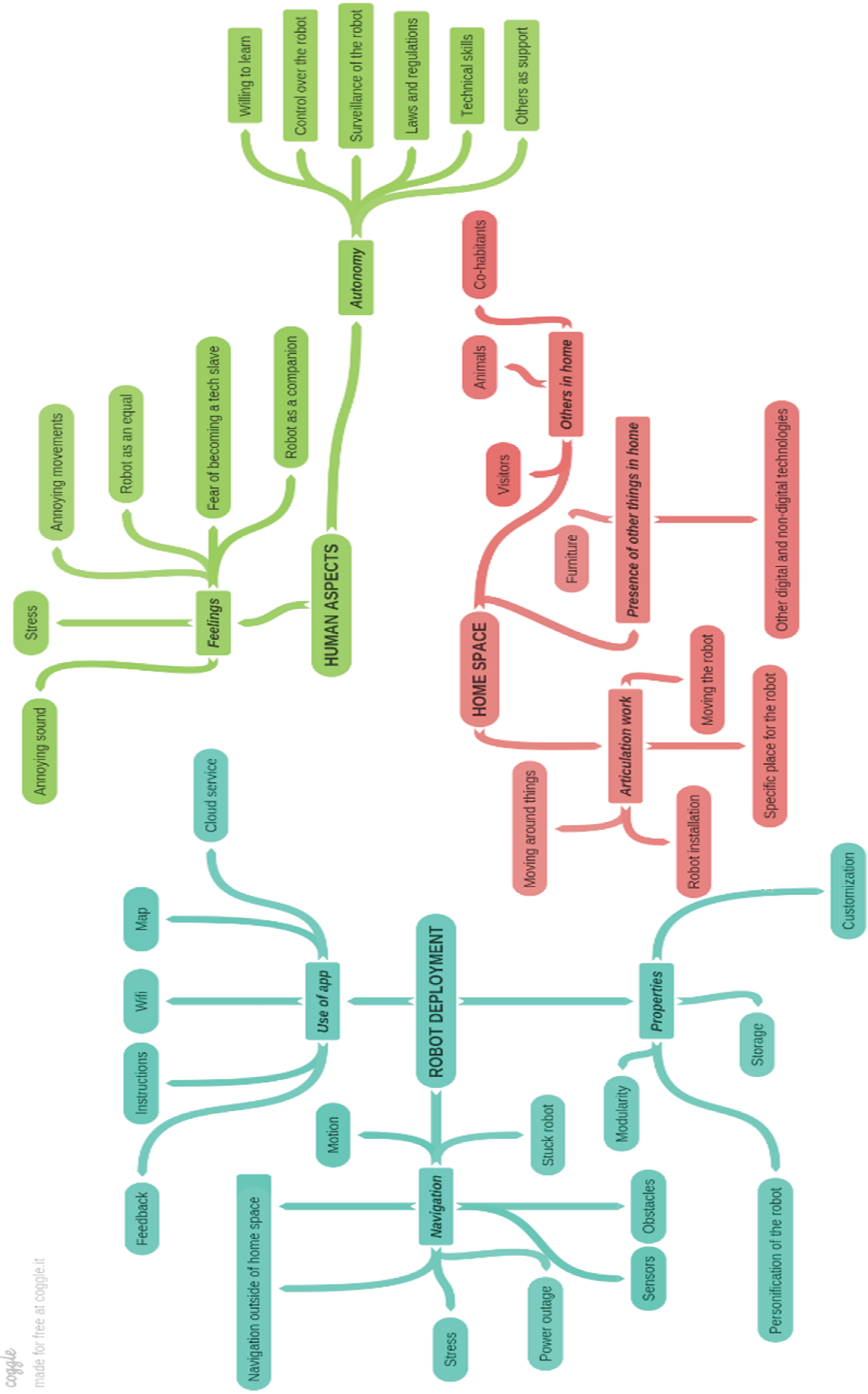

Figure 2. Final themes emerged from the data analysis.

6. Findings

We illustrate in our findings two use-case scenarios represented as two situations: (1) the human work tasks when using an ordinary device; (2) division of work tasks in joint human-robot work activity in the home. We chose to visualize these two situations since Situation 1 does not include automation of work, while Situation 2 does. This approach better emphasizes the tasks that come with automation, in comparison to not illustrating Situation 1. To make this comparison, we defragmented the work performed by the human, in Situation 1, and by the human and robot, in Situation 2, into tasks. The illustration for Situation 1 is based on general experience with an ordinary device, while Situation 2 is anchored within our data collection and analysis. This helps us to better understand the different types of tasks that come along with the automation of work, in a human-robot joint activity, in the home.

6.1. Use-Case Scenario 1: Human Work Tasks When Using an Ordinary Device (Situation 1)

Situation 1 is illustrated by the human (user) using an ordinary device. The navigation area for the ordinary vacuum cleaner is usually decided upon and controlled manually by the user, i.e., the user decides where the vacuum cleaner should clean, and if there are any obstacles in the way, the user will pick those up. In this case, a device is a tool rather than a (semi-)independent actor. Figure 3 illustrates a typical user journey in the vacuum cleaning operation when using an ordinary vacuum cleaner, whose navigation path is decided by the user. As previously mentioned, the visualization is based on general experience with an ordinary device.

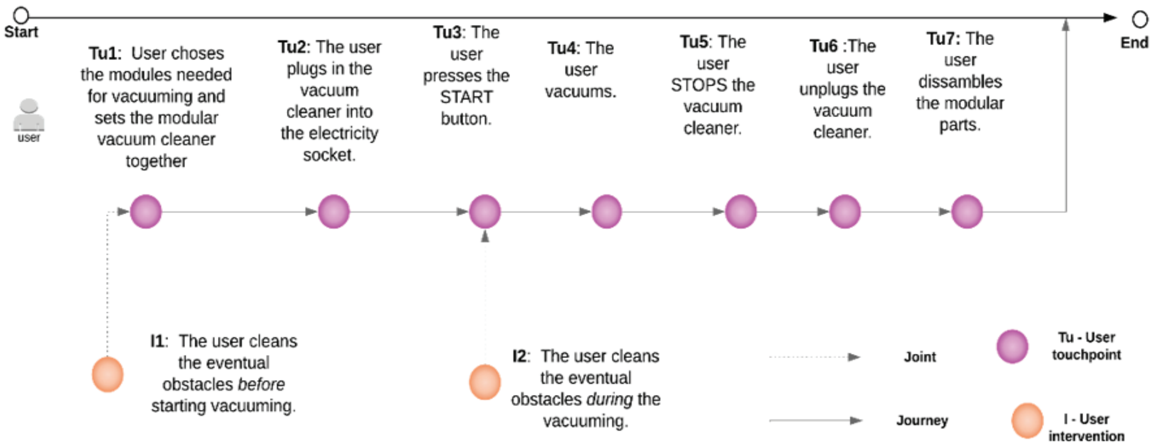

Figure 3. User journey when using an ordinary device (Situation 1).

6.2. Use-Case Scenario 2: Division of Work Tasks in Joint Human-Robot Work Activity in the Home Situation 2

We divided the work and tasks carried out by each of the actors, e.g., the human and the robot respectively, after analyzing the data through thematic analysis [24]. Moreover, we also classified the tasks carried out in the form of joint action between the human and the robot, through or without using the app to control the robot. We illustrate in this sub-section these different work tasks by supporting them with some examples from our data.

6.2.1. Work Performed by the Human Actor

Based on our data, the human, in each case, seems to need to carry out certain preparatory work to enable the robot to work. Some examples include the fact that the human needs to remove obstacles, to press the robot start button, and stop the robot by pressing the button or through the app. Some examples of removing obstacles from our participants include:

(Participant): I got my brother fixing the cables under the bed, so they are not in its way. [. . .] If it had gotten stuck there, I would not have been able to come down there. I was very afraid of this. So no cables were supposed to be there! I felt then so much better! (Interview, elderly participant).

(Interviewer): Okay ... However, you also wrote in your diary notes that you had to clean a bit before you could run the robot.

(Participant): I had to do that more than with an ordinary vacuum cleaner, isn't it? I have lots of chairs here. I have put those two on top of each other because otherwise, it stops all the time. So I have removed them. Moreover, the cables ... I have tried to remove those. Yes, I have cleaned a bit. (Interview, elderly participant).

Another example from one of our participants is from the diary notes written by one of the non-elderly participants, in which the participant explains how he had to remove obstacles, an operation that took up to two hours, before being able to run the robot:

(Participant): Having experienced a couple of weeks with a robot vacuum cleaner at home, I learned that for the vacuum cleaner to do the job without interruptions, the floor needs to 'be clean'—understood as tidy. Therefore, I set out to unclutter the floor today. I spent about two hours with moving things from the floor and putting the chair upon the table before setting up the Botvac. There is a reason why things end up on the floor—if there is too much stuff about storage capacities on shelves. While putting down the charging station, finding a 220 V outlet, I thought about means and end. The 'goal' I had was to make 'clean floor'; but to get to this—I needed to install something on the floor ... A paradox. (Diary notes, non-elderly participant).

Another situation is illustrated when one human chose to use the app to control the robot. When the robot is controlled through an app, and the robot gets stuck, the users have to go to the same place as the robot is, and 'help' the robot to do its work:

(Participant): I pressed the 'home' button, it started. After a while, it got stuck. I remembered the previous installation at home when the app gave notifications about this—when I was out of the house. This information was disturbing at that time since I did not want to do anything with it. It interrupted a nice train journey I remember now, and started a train of thoughts of where it was stuck, and why (since I had done my best to make a 'clean floor' there well. (Diary notes, non-elderly participant)

Other types of tasks are tasks that are usually carried out once, such as installing the robot before running it for the first time, administering its settings, or installing the robot app on the smartphone, if the human had such a mobile phone.

6.2.2. Work Carried out by the Human in Breakdown Situations

The work carried out by the human in breakdown situations points out situations where the human needs to interfere in the robot's work, to ensure the robot can work. For instance, the participants described situations when the robot started randomly by itself and started cleaning. In such situations, the human often needs to carry the robot back to its base station. Another situation encountered by the participants was when the robot started cleaning by itself during dinnertime. In this situation, the human had to stop the robot and again carry it to its base station. Other situations when the human had to interfere with the robot to work properly included when the robot got stuck, or when the robot 'escaped' the boundaries of the home. In these situations, the robot often needed the support of the human to get 'unstuck', or to be carried back within the boundaries of the home. Here are some examples from the participants:

(Participant): One time when I pressed on Home, it started going around by itself, so I had to carry it back [meaning back to the charging station]. (Interview)

(Participant): The robot got stuck in the carpet's tassels and stayed still. It took some time to free R from the tassels, so I took away the carpet. [. . .] Is R made for rooms without carpets and some furniture? (Diary notes, elderly participant)

(Participant): I had to take away the cables a couple of times, and it was trying to take down the lamps. However, I felt that I had to « save » the cables . . . I had to! I should say. (Diary notes, elderly participant)

6.2.3. Work Performed by the Robot Actor

Our data show that the robots seemed to navigate the environments inconsistently. For instance, the robots followed an incoherent path, going from one room to another, and then coming back to the first room. Moreover, the data also show that the robots seemed to clean the same place over and over again. Furthermore, the robots frequently seemed to get stuck on obstacles, such as cables, including laptop cables, the carpet, and under small tables. Here are some examples from our participants:

(Participant): I think it starts in one room, and then it goes to another, and then it goes again to the first room. I think it is a bit strange that it does not finish in the first room, and it goes perhaps to the kitchen, and then it comes back, and it continues likes this and then goes out again. I think it was very strange (break), really, very strange. (Interview, elderly participant)

(Participant): [. . .] And suddenly it started going by itself one morning, though it was very strange. (Interview, elderly participant).

6.2.4. Division of Work Tasks between the Human and the Robot

Based on the examples that emerged from our data, we compressed the findings into an illustration. Thus, we illustrate in the next diagram (Figure 4) the division of work tasks between the human and the robot. Thus, Situation 2 illustrates the division of work of these two actors. Specifically, Situation 2 is defragmented through applying the customer journey analysis (CJA) and customer journey framework (CJF). For this purpose, we employed visualizations from service design, following [25]. We separated the trajectory of the human and the robot, respectively, and their touchpoints, by using a swim-lane diagram, to offer a clear illustration of the division of work task. As we can observe, in addition to the types of tasks illustrated in Situation 1, it is also possible to notice some deviations on the robot's side. For instance, some of the examples are the robot starts by itself (D1), the robot cleans the same place over and over again (D2), the robot escapes the room (D3), the robot gets stuck (D4), or the robot does not return by itself to the base station (D5). Each of these robot deviations creates new interventions for the human: stopping the robot, removing obstacles while the robot runs, moving the robot from one place to another (I4), or bringing the robot back to its base station (I5).

6.3. The Proposed Framework on Division of Work Tasks between Humans and Robots

Our findings show that when a robot is introduced into a home, the robot's trajectory becomes one of its own, and the human actor's journey changes. In complex structures, the division of labor involves many tasks that may intersect with each other, and form the production lattice [12], p. 210. The tasks are also more intertwined. For instance, if a robot is integrated into the home as part of a larger system, where several actors are part of the same system, the actors' trajectories would be even more complex than the one we illustrated in Situation 2. However, we argue that our findings, shown through the simple example of using a semi-autonomous vacuum cleaner robot, can easily be understood, even by non-roboticists. Our paper illustrates an example similar to Suchman's copy-machine [26] and her situated actions. Although at first sight a trivial example, it illustrates well the complexity of the design and how a semi-autonomous robot introduced in the home can change the routines of the people living there. However, our empirical example is slightly different, considering that the robot actor has some autonomy itself, as it can move around, compared to Suchman's copy-machine, which was a static device. The semi-autonomous vacuum cleaner is also characterized by a multimodal interaction, including movement, feedback as motion [5,27,28], or visual and audio feedback.

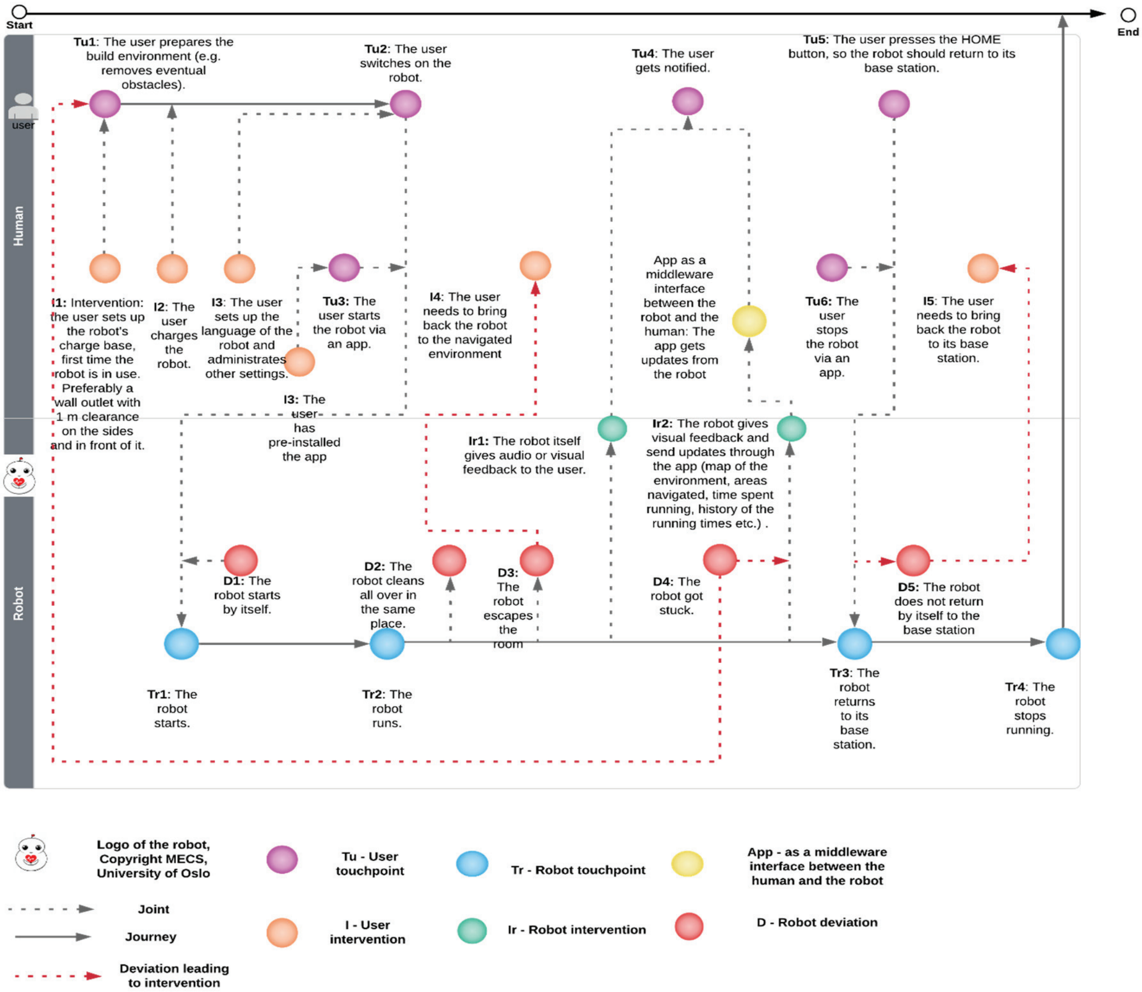

Figure 4. Division of work between human and robot in a vacuum cleaning work activity (Situation 2).

Thus, we portray two situations through Figures 3 and 4: (1) human work tasks when using an ordinary vacuum cleaner, and (2) division of work tasks between humans and the robot. The purpose of visualizing the actors' trajectories was to facilitate unpacking the types of work tasks generated by the introduction or use of a robot in the home.

6.3.1. New Dimensions of Tasks: Temporal and Spatial Distribution

The theoretical framework in this work was initially based on the model presented by Verne [4] and Verne and Bratteteig [5]. The tasks represented by the authors seem to refer to the character of the tasks themselves, about how the work should be carried out, either manually or through automation. The characteristics of these tasks were categorized by the authors as new tasks, residual tasks, automated tasks, redundant tasks, tasks inside the automation, and tasks outside the automation. Moreover, a well-known assumption in CSCW is that 'work is socially organized and cooperative' and it requires tacit knowledge about the context and its specific work practice [29]. Much of the cooperative work is about coordinating and negotiating physically and temporally distributed work amongst the actors. Besides the character of the tasks given by the indicated model from the theoretical framework, we also identified other dimensions of tasks. The visualizations from Figures 3 and 4 indicate two new dimensions: temporality and spatial distribution, which we explain next. The new dimensions are then illustrated in Table 4.

Table 4. Exemplified framework on the division of work tasks between humans and robots: including the spatial and temporal dimensions.

Tasks Dimensions	Type of Task	When the Human Actor Is Using a Non-Moving Actor (N/A = Not Available)	When a Robot Is Introduced in a Physical Environment
Tasks that come with automation (based on Verne, 2015, and Verne and Bratteteig, 2016)	Residual tasks	Yes. Humans need to do some manual work tasks	Yes. The human needs to clean some of the areas that the robot did not reach.
	Redundant tasks	N/A	Yes. The human needs to start the robot through direct (e.g., by pushing the button) or remote (e.g., through the app) interaction.
	Tasks within the automation	N/A	Yes. The robot gives audio or visual feedback to the human.
	Tasks outside the automation and new tasks	Yes.	Yes. The human chooses to move the robot, or to remove obstacles without the robot indicating it.
	Tasks generated with the automation and new tasks	N/A	Yes. The human needs to charge the robot, to lift the robot from one place to another, when it gets stuck, to bring it back when it "escapes".
Temporality of tasks	Sequential	Yes.	Yes, partially. Some sequential tasks, for each of the actors, are available. When the tasks for one actor is interrupted or paused, usually the other actor takes on the tasks.
	Parallel	No. The device itself cannot perform tasks on its own. However, the human can perform several tasks at the same time.	Yes. The human and the robot can perform tasks in parallel.
	Linear	Yes. The device is controlled by humans.	Yes. Both the human and the robot can perform linear tasks. However, linear tasks are often interrupted.
Spatiality of tasks	Spatial tasks in shared spatiality	Yes. The human and the device share the space.	Yes. Both of the actors can share space and perform different tasks at the same time.
	Spatial tasks in distributed spatiality	No. The human and the device cannot be in two different places and work on a joint task	Yes. The robot can perform tasks remotely, while the human can control or give autonomy to the robot through an app, that can be used remotely.

- Temporality of Tasks

For instance, we identified linear tasks, parallel tasks, and sequential tasks. The linear tasks refer to tasks that are done either by the human, or by the robot, and the order in which these tasks are performed. The linear tasks are performed in the same line of work. These tasks are usually performed by either the human or the robot. Examples of this for humans are when the user prepares the built environment before starting the robot (Tu1) when the human starts the robot (Tu2), and when the human presses the stop button, so the robot returns to its base station (Tu5). Other examples of such linear tasks are performed by the robot, such as when the robot starts (Tr1), when the robot runs (Tr2), when the robot returns to its base station (Tr3) and when the robot stops (Tr4). The linear tasks are the desired type of tasks for a smooth flow of the work operations for each of the actors.

Parallel tasks refer to tasks that are carried out by the human and by the robot actors, in parallel, at the same time. One example is when the human needs to undertake work to articulate something, such as removing cables or furniture, while the robot is running.

Sequential tasks refer to tasks that are carried out immediately after one another. However, these tasks can either belong or not to the same line of work. Such examples of sequential human tasks include when: the user prepares the built environment (Tu1), the user needs to charge the robot before being able to run it (I2), the user switches on the robot (Tu2), and when the user presses the home button to stop the robot and return it to its base station (Tu5).

- Spatial Distribution of Tasks

The spatial distribution of tasks in a shared physical environment is specific and unique for contexts where a robot or a semi-autonomous device is introduced in the home, compared to tasks that are distributed in a virtual environment, like the tasks discussed in the Norwegian automation of the tax system presented in Verne [7,8]. However, as is shown in this study, the robot may exceed the close boundaries of the navigated physical environment. Similar situations were presented in the work from Verne [23] where she illustrated the adaptation of the human to the use of a lawnmower robot.

At the same time, we can also talk about the distribution of tasks that challenges and crosses a geographical space, i.e., a distributed spatiality of tasks. As we have seen in the earlier example, participants are informed about the deviations of the robot (e.g., the robot being stuck) through an app. The physical and geographical location of the human may, in any case, be remote, as shown in the example given in our findings, where a participant chose to run the robot while he was not at home. When the human is required to act upon a request from the robot that was sent via an app (the yellow touchpoint in Figure 4), the human may not be able to act immediately, so we cannot talk about immediacy of an action upon the task.

6.3.2. The Framework

Based on the empirical findings and having our departure point in the theoretical framework from Verne [7] and Verne and Bratteteig [8] applied to the case presented in this paper, we developed the framework further. The new framework addresses semi-autonomous robots, that can move autonomously in space, compared to static interfaces as addressed in Verne [7] and Verne and Bratteteig [8]. To their types of tasks, we have added the temporal and spatial dimensions. Based on the earlier presented examples, we can talk about the relationship between the temporality and spatial distribution of tasks: when the human actor is remote, i.e., does not share the same space with the robot actor, the human cannot interfere and facilitate the robot's work to ensure its efficacy. Finally, we have represented the framework in Figure 5 below.

To understand the illustration of the framework, we have exemplified it with some mapped examples from our empirical work to the framework (Table 4). However, the framework above can be applied to other types of settings, and other types of robots.

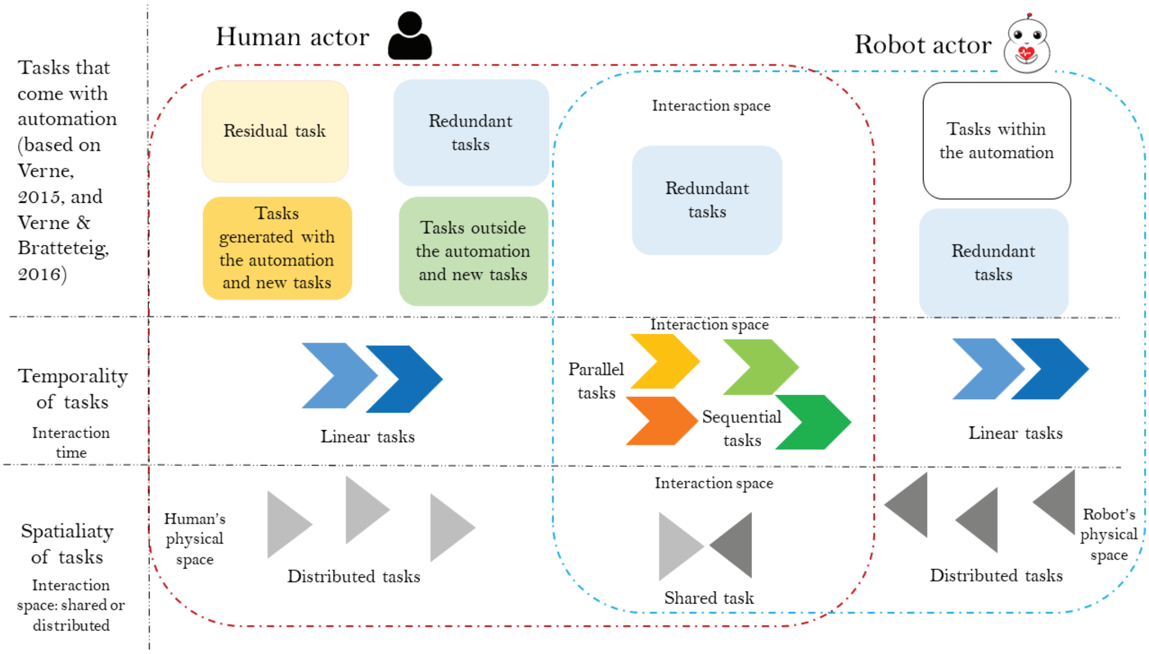

Figure 5. Framework: division of work tasks between humans and robots.

7. Discussion

This section presents first some reflections on the method and the setting of the study and thereafter discusses the proposed framework concerning the division of work between humans and robots and human-robot cooperation.

7.1. Reflections on the Method and Setting

This study adopted a qualitative interpretive approach carried out in a domestic setting. The data collected in this study are from natural environments, e.g., the real homes of our participants. It seems that the home, as a shared physical space and a dynamic environment, creates unpredictable conditions, unforeseen contingencies, and makes room for fluid situations that may occur unexpectedly in a human-robot joint work activity. This paper has investigated the work tasks generated by introducing a semi-autonomous robot in the home and the division of work between the human and the robot actors. The robot employed in this study was a semi-autonomous vacuum cleaner. The purpose of employing such a robot was instrumental, similar to other studies (see [3–5,16]). However, many of the previous studies conducted with robots are either carried out in simulation environments [20] or mock-labs. In addition, several studies have argued for more studies of robots 'in the wild' [30,31]. Some other studies based their data only on an online survey on the use of robots in the home [14]. While other have studies offered a nice overview of the types of robotic devices used in the home, and the 'roombarization' process, these did not allow the researcher to become immersed in the participants' homes and their complex environments [14]. Compared to previous studies, our naturalistic approach allowed us to immerse ourselves in the homes of the participants, and to be able to illustrate the complexity of a real home, factors that are otherwise hard to extract from a virtual or mock environment [13]. Similar to the findings from the previous studies carried out with robots in the home [4], this study confirms that the current built home environment is not adequate for a moving robot. Finally, the qualitative approach adopted in this study revealed the complexity of a home and many of the human actors' work tasks that might otherwise be invisible to stakeholders.

7.2. Reflections on the Proposed Framework for Division of Work between Humans and Robots

This paper addresses the following research question: *what are the types of work tasks that are generated by a robot, a semi-autonomous moving entity, in the home?* This research question was answered by carrying out qualitative research that informed us about different work tasks carried out by the human and by the robot actor. This was exemplified through concrete situations experienced by our participants in their interaction with the robot. This led us to the proposed framework on the division of work between humans and robots (Figure 5). The framework was anchored in the theoretical model proposed by Verne [7] and Verne and Bratteteig [8], and our empirical data. The framework illustrates new dimensions of tasks, such as temporality and spatiality of work tasks. But when is it useful, and what are its design implications for human-robot cooperation? We cover both these aspects next.

7.2.1. When Is the Framework Useful and Relevant?

The framework proposed can be used to analyze the division of work and types of work tasks between a human and a robot. Outside of home settings, it can be applied to, for instance, hospital settings or in studying the Mixed Reality settings for designing robot work tasks. We illustrate these two examples below.

1. Hospital setting scenario: Using the framework to plan the division of work between human and robot.

The study by Oskarsen [32] described automated guided vehicles (AGVs)—robots used in hospital settings for transporting goods and medicines, navigating along specific dedicated magnetic paths. The robots were considered actors in the hospital cooperative ensemble, to automate some of the hospital work. Amongst the key findings from the studies were that pre-, peri- and post-facilitation from the human side should be undertaken to accommodate the robot before, during, and after its navigation. Based on the pre-, peri-, and post-facilitation framework from Soma et al. [18], the study limited itself to the temporal dimension of the work tasks carried out by the human, without discussing in detail the different types of work tasks that the human and the robot have to carry out. For instance, amongst the study's findings were that the human had to accommodate the robot by performing changes in the navigation environments, but also its organization of the work tasks. Another key finding was that the robots were not designed with cooperative work in mind for a dynamic workplace environment. Moreover, the hospital employed three full-time workers to support the robots' work and two AGV technicians had to test the robots regularly and check them for technical errors.

Thus, the proposed framework in this study could be applied to this scenario. The benefits of applying the framework would be that the work tasks can be easier identified and classified, based on their type and spatiality, not only temporality in the form of pre-, peri-, and post-facilitation. Once the types of work tasks and their belonging to the human or the robot actor are identified and classified, we can easier try to see which of the human work tasks can be moved to the robot. This implies that the design of the robot should be improved. Slowly, some of the human tasks can eventually be removed.

2. Mixed Reality remote-controlled robot scenario: Using the framework to plan the division of work between human and robot.

Eve robot is a research robot platform [33] that can potentially be remote-controlled, while it is in the home of the elderly as part of their home-care services, or in a hospital setting. A potential future scenario is that the robot can be remote-controlled through Mixed Reality. Still, in a research phase, the robot can currently be used in Virtual Reality simulation environments to plan and design its work tasks.

Considering the scenario of the use of Eve in the homecare services or a hospital setting, several actors are involved: the care-recipient, formal and informal care-givers, technical staff, and the robot itself. The proposed framework in this paper can support the researchers using Eve as a research platform to plan and design how the work should be automated: which work tasks should be carried out by whom, e.g., the care-recipient, the formal or informal caregiver, the technical staff, or the robot, when, and where.

7.2.2. Design Implications: From Interaction to Cooperation with a Robot

Some human-robot interaction (HRI) researchers have investigated the collaboration between humans and robots (see the work from Hoffman [34]). Collaboration with robots in HRI is seen as performing perhaps what we consider to be small tasks in CSCW, e.g., when a robot brings a cup or transports things from A to B, aiming for joint fluid activity [34].

HRI is currently locked into human-robot interaction studies, whereas CSCW is currently limited to studying cooperative work arrangements between humans while using things. Cooperation per se is understood as a form of co-operating, a joint operation where the entities (individuals or objects) work together towards the same goal, purpose, or effect. In the field of CSCW, we talk mostly about cooperative work via computers, independently of the current or future technology [35], p. 10. Schmidt and Bannon [35] tried, through their work, to set out a framework for the field, which, according to them, 'should be concerned with the support requirements of cooperative work arrangements' (p. 7). However, in the early 1990s, when the study [35] was published, technologies, e.g., computers and robots, were considered artifacts that did not have autonomy. At the same time, there are situations where robots can directly or indirectly delegate work tasks to humans, machines can reconfigure themselves, or (chat) bots can delegate tasks to humans when the tasks become too complex to be solved only by the machines, see, for instance, the work presented at CHI'19 by Grudin and Jackques [36]. Grudin [37] also drew attention to this vital debate.

We are, in the end, interested in how to improve the human-robot cooperation to be smoother, without generating residual, redundant, or tasks outside of the automation, or completely new work tasks for the human. The idea of designing robots to be used within our homes, or for that matter, outside of it, is to automate the human work. Inevitably, some of the new tasks will be generated, some of them being carried out by the human, while others are carried out by the robot. However, the purpose of having a robot doing human work is to decrease the amount of work earlier carried out by the human and to free up time for the human to carry out other tasks of his or her choice while the robot is carrying out its work. However, this is not the case, as this study also proved: the human often needs to carry out residual, redundant, or tasks outside the automation, and even new tasks to make the robot's work possible. While Ajoudani et al. [22] argued that the robot's hardware components often limit the types of interaction and the level of intelligence of a robot, they also argued that the intermediate interfaces between the human and the robot and the control or interaction modalities also play a role. The authors argue feed-forward and feedback communication can address well even complex interaction scenarios. However, neither the robot's feedback in the form of audio, visual, or motion feedback nor the robot's feed-forward was successfully designed, as the journeys of both of the actors were often interrupted by the robot's deviations. This leads us back to a discussion around the design of robots. As Suchman [26] pointed out, "the goal of the design is that the artifact should be self-evident; therefore the problem of deciphering an artifact defines the problem of the designer as well" (pp. 14–15). How can we design, then, for cooperation with a robot?

While some attempts to describe human-supported robot work and robot-supported cooperative work are discussed in several studies [32,38,39], this question remains unanswered. Although this will be the case for a while from now on, we have proposed the framework on the division of work tasks between humans and robots. We hope that this can bring us a step further in our design of robot work tasks, and as we proved through the illustrated examples and this empirical study, the framework can be useful and relevant for the planned work tasks and design of robots.

8. Summary and Conclusions

In this paper, we have analyzed the division of work of a home work task, e.g., cleaning carried out by two actors: a human and a semi-autonomous robot. However, our main concern was to consider if and how robots can be integrated within the home, and which work tasks accompany the automation of work. The paper was grounded in the concept of tasks as defined in the existing CSCW existing literature and in the model presented by Verne [4] and Verne and Bratteteig [5], covering: residual tasks, redundant tasks, tasks within the automation, tasks outside the automation, tasks generated by the automation, and new tasks. Analyzing the concept of work tasks and work division between humans and robots through the lens of CSCW helped us to better understand the potential challenges that may arise with the introduction of a robot in the home. The research question that guided the paper was: what are the types of work tasks that are generated by a robot, a semi-autonomous moving entity, in the home? We analyzed the types of tasks carried out by the human and the robot, respectively. As a result of this work, we proposed a framework on the division of work between humans and robots. The framework resulted from the current literature, from an existing theoretical model, and our empirical findings. The framework includes new dimensions of work tasks, such as temporal and spatial dimensions. These two dimensions exceed the boundaries of a desktop system and are relevant and useful when talking about interaction and cooperation with a robot, in a shared or distributed physical space. Specifically, the framework is relevant for identifying, understanding, planning, visualizing, and designing work tasks in a human-robot division of work setting.

9. Future Work

Finally, for future work, two interesting areas are relevant: focusing on the invisible work of the human and on different degrees of automation. First, it would be interesting to focus solely on the work performed by the human and explore it through the analytical CSCW concept of invisible work, including routine and non-routine work. Second, it would also be interesting to explore Cummings' [40] 10 levels of automation, and more recent work on this topic, concerning new forms of human-robot automation. For instance, level (1) can be described as the computer not offering any assistance, and the human needing to take all the decisions, whereas, at level (5), the computers act only if the human approves. The highest level, level (10), is described as the computer making its own decisions and acting autonomously, ignoring the human. One could also explore different degrees of these levels of automation. For instance, new machines can intelligently reconfigure themselves with the help of AI algorithms, such as a robot or (chat) bots that can delegate tasks to humans [36]. We may consider the latter as being on a higher level than level (10) of automation, while we can reasonably categorize the robot vacuum cleaner at a lower level than level (10) of automation. While these degrees of the level of automation are not discussed in the existing research, placing different machines on such a continuum of automation levels, describing different degrees of it, might be helpful to also be able to talk about degrees of cooperation with these machines. This could be a potential area of interest for future work.

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References

1. Baltes, P.B.; Smith, J. New frontiers in the future of aging: From successful aging of the young old to the dilemmas of the fourth age. *Gerontology* **2003**, *49*, 123–135. [CrossRef] [PubMed]
2. Field, D.; Minkler, M. Continuity and change in social support between young-old and old-old or very-old age. *J. Gerontol.* **1988**, *43*, 100–106. [CrossRef] [PubMed]
3. Forlizzi, J.; DiSalvo, C. Service Robots in the Domestic Environment: A Study of the Roomba Vacuum in the Home. In Proceedings of the 1st ACM SIGCHI/SIGART Conference on Human-Robot Interaction, New York, NY, USA, 2–4 March 2006; pp. 258–265. [CrossRef]
4. Forlizzi, J. Product Ecologies: Understanding the Context of Use Surrounding Products. Ph.D. Thesis, School of Computer Science, Carnegie Mellon University, Pittsburgh, PA, USA, 2007.
5. Saplacan, D.; Herstad, J. An Explorative Study on Motion as Feedback: Using Semi-Autonomous Robots in Domestic Settings. *Int. J. Adv. Softw.* **2019**, *12*, 23.
6. Saplacan, D.; Herstad, J.; Pajalic, Z. An analysis of independent living elderly's views on robots-A descriptive study from the Norwegian context. In Proceedings of the International Conference on Advances in Computer-Human Interactions (ACHI), IARIA Conferences, Valencia, Spain, 21–25 November 2020.
7. Verne, G. *"The Winners Are Those Who Have Used the Old Paper Form". On Citizens and Automated Public Services*; University of Oslo: Oslo, Norway, 2015.
8. Verne, G.; Bratteteig, T. Do-it-yourself services and work-like chores: On civic duties and digital public services. *Pers. Ubiquitous Comput.* **2016**, *20*, 517–532. [CrossRef]
9. Strauss, A. Work and the Division of Labor. *Sociol. Q.* **1985**, *26*, 1–19. [CrossRef]
10. Carstensen, P.H.; Sørensen, C. From the social to the systematic. *Comput. Support. Coop. Work CSCW* **1996**, *5*, 387–413. [CrossRef]
11. Oxford English Dictionary, actor, n. *OED Online*; Oxford University Press: Oxford, UK, 2019.
12. Gasser, L. The Integration of Computing and Routine Work. *ACM Trans. Inf. Syst.* **1986**, *4*, 205–225. [CrossRef]
13. Cha, E.; Forlizzi, J.; Srinivasa, S.S. Robots in the Home: Qualitative and Quantitative Insights into Kitchen Organization. In Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction, New York, NY, USA, 2–5 March 2015; pp. 319–326. [CrossRef]
14. Sung, J.-Y.; Grinter, R.E.; Christensen, H.I.; Guo, L. Housewives or technophiles? Understanding domestic robot owners. In Proceedings of the 3rd ACM/IEEE International Conference on Human-Robot Interaction, Amsterdam, The Netherlands, 12–15 March 2008; pp. 129–136. [CrossRef]
15. Pantofaru, C.; Takayama, L.; Foote, T.; Soto, B. Exploring the Role of Robots in Home Organization. In Proceedings of the Seventh Annual ACM/IEEE International Conference on Human-Robot Interaction, New York, NY, USA, 5–8 March 2012; pp. 327–334. [CrossRef]
16. Forlizzi, J. How Robotic Products Become Social Products: An Ethnographic Study of Cleaning in the Home. In Proceedings of the ACM/IEEE International Conference on Human-Robot Interaction, New York, NY, USA, 8–11 March 2007; pp. 129–136. [CrossRef]
17. Sung, J.; Grinter, R.E.; Christensen, H.I. Domestic Robot Ecology. *Int. J. Soc. Robot.* **2010**, *2*, 417–429. [CrossRef]
18. Soma, R.; Søyseth, V.D.; Søyland, M.; Schulz, T.W. Facilitating Robots at Home: A Framework for Understanding Robot Facilitation. In Proceedings of the ACHI 2018: The Eleventh International Conference on Advances in Computer-Human Interactions, Rome, Italy, 25–29 March 2018; pp. 1–6. Available online: https://www.thinkmind.org/index.php?view=article&articleid=achi_2018_1_10_20085 (accessed on 6 March 2019).
19. Teaming Up with Robots: An IMOI (Inputs-Mediators-Outputs-Inputs) Framework of Human-Robot Teamwork. Available online: https://deepblue.lib.umich.edu/handle/2027.42/138192 (accessed on 1 July 2020).
20. Ijtsma, M.; Ye, S.; Feigh, K.; Pritchett, A. Simulating Human-Robot Teamwork Dynamics for Evaluation of Work Strategies in Human-Robot Teams. In Proceedings of the 20th International Symposium on Aviation Psychology, Dayton, OH, USA, 7–10 May 2019; pp. 103–108.
21. Lee, C.P.; Paine, D. From The Matrix to a Model of Coordinated Action (MoCA): A Conceptual Framework of and for CSCW. In Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing, Vancouver, BC, Canada, 14–18 March 2015; pp. 179–194. [CrossRef]

22. Ajoudani, A.; Zanchettin, A.M.; Ivaldi, S.; Albu-Schäffer, A.; Kosuge, K.; Khatib, O. Progress and prospects of the human–robot collaboration. *Auton. Robot.* **2018**, *42*, 957–975. [CrossRef]
23. Verne, G.B. Adapting to a Robot: Adapting Gardening and the Garden to fit a Robot Lawn Mower. In Proceedings of the Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction, Cambridge, UK, 23–26 March 2020; pp. 34–42. [CrossRef]
24. Braun, V.; Clarke, V. Using thematic analysis in psychology. *Qual. Res. Psychol.* **2006**, *3*, 77–101. [CrossRef]
25. Halvorsrud, R.; Kvale, K.; Følstad, A. Improving service quality through customer journey analysis. *J. Serv. Theory Pract.* **2016**, *26*, 840–867. [CrossRef]
26. Suchman, L. *Plans and Situated Actions: The Problem of Human-Machine Communication*; Cambridge University Press: Cambridge, UK, 1987.
27. Saplacan, D.; Herstad, J. A Quadratic Anthropocentric Perspective on Feedback-Using Proxemics as a Framework. In Proceedings of the British HCI 2017, Sunderland, UK, 3 July 2017. Available online: http://hci2017.bcs.org/wp-content/uploads/46.pdf (accessed on 19 July 2017).
28. Saplacan, D.; Herstad, J. Understanding robot motion in domestic settings. In Proceedings of the 9th Joint IEEE International Conference on Development and Learning and on Epigenetic Robotics, IEEE XPlore, Oslo, Norway, 19–22 August 2019. [CrossRef]
29. Halverson, C.A.; Ellis, J.B.; Danis, C.; Kellogg, W.A. Designing Task Visualizations to Support the Coordination of Work in Software Development. In Proceedings of the 2006 20th Anniversary Conference on Computer Supported Cooperative Work, New York, NY, USA, 4–8 November 2006; pp. 39–48. [CrossRef]
30. Jung, M.; Hinds, P. Robots in the Wild: A Time for More Robust Theories of Human-Robot Interaction. *ACM Trans. Hum. Robot Interact.* **2018**, *7*, 2:1–2:5. [CrossRef]
31. Sung, J.-Y.; Christensen, H.I.; Grinter, R. Robots in the wild: Understanding long-term use. In Proceedings of the 4th ACM/IEEE International Conference on Human-Robot Interaction, San Diego, CA, USA, 11–13 March 2009; pp. 45–52. [CrossRef]
32. Oskarsen, J.S. Human-Supported Robot Work. Master's Thesis, Department of Informatics, Faculty of Mathematics and Natural Sciences, University of Oslo, Oslo, Norway, 2018.
33. Halodi Robotics. Available online: https://www.halodi.com (accessed on 12 July 2020).
34. Hoffman, G. Designing Fluent Human-Robot Collaboration. In Proceedings of the 3rd International Conference on Human-Agent Interaction, Daegu, Korea, 21–24 October 2015; p. 1. [CrossRef]
35. Schmidt, K.; Bannon, L. Taking CSCW seriously. *Comput. Support. Coop. Work CSCW* **1992**, *1*, 7–40. [CrossRef]
36. Grudin, J.; Jacques, R. Chatbots, Humbots, and the Quest for Artificial General Intelligence. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, Glasgow, UK, 4–9 May 2019; pp. 209:1–209:11. [CrossRef]
37. Grudin, J. From Tool to Partner: The Evolution of Human-Computer Interaction. In Proceedings of the Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems, Montreal, QC, Canada, 21–26 April 2018; pp. C15:1–C15:3. [CrossRef]
38. Kaindl, H.; Popp, R.; Raneburger, D.; Ertl, D.; Falb, J.; Szép, A.; Bogdan, C. Robot-Supported Cooperative Work: A Shared-Shopping Scenario. In Proceedings of the 2011 44th Hawaii International Conference on System Sciences, 4–7 January 2011; pp. 1–10. [CrossRef]
39. Yamazaki, K.; Kawashima, M.; Kuno, Y.; Akiya, N.; Burdelski, M.; Yamazaki, A.; Kuzuoka, H. *Prior-To-Request and Request Behaviors within Elderly Day Care: Implications for Developing Service Robots for Use in Multiparty Settings*; Springer: London, UK, 2007.
40. Cummings, M. Automation Bias in Intelligent Time Critical Decision Support Systems. In Proceedings of the AIAA 1st Intelligent Systems Technical Conference, American Institute of Aeronautics and Astronautics, Chicago, IL, USA, 20–22 September 2004. [CrossRef]

PAPER V

Cross-Use of Digital Learning Environments in Higher Education: A Conceptual Analysis Grounded in Common Information Spaces

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***Abstract*—This paper addresses the cross-use of different Digital Learning Environments (DLE) in Higher Education (HE). The paper aims to analyze DLEs and their use in a HE organizational entity through the lens of Common Information Spaces (CIS), a concept grounded in Computer Supported Cooperative Work (CSCW). In general, CSCW literature focuses on individual systems regarded as CIS. Moreover, the research shows that DLEs are often analyzed from an educational perspective, and less from a *cooperative work* perspective. However, a teaching/learning context can be viewed as a co-dependent cooperative work arrangement, where the exchange of information and knowledge is performed *through*- and *with* the help of DLEs. In this way, DLEs should be rather viewed as being part of a complex cooperative ensemble rather than analyzed as individual CIS. This paper sheds light on such complex information spaces, where the information spaces are formed through clusters of DLEs, rather than individual DLE units. Finally, the contribution of the paper consists of addressing the cross-use of DLEs from a CIS perspective, moving beyond looking at DLEs just through an educational perspective.**

Keywords-Digital Learning Environments (DLE); Higher Education (HE); Computer-Supported Cooperative Work (CSCW); Common Information Spaces (CIS); information spaces.

I. Introduction

This paper presents the cross-use of different Digital Learning Environments (DLE) in a Higher Education (HE) organizational entity. DLEs are defined here as digital platforms, websites or specific webpages used by course instructors and students in a course for exchanging information or knowledge, relevant for their learning, respectively teaching, within the frame of the course. In a course, a course instructor can use one or more such DLEs: for instance, the course instructor can use both a dedicated Learning Management System (LMS), the email system, the HE website, and a social media platform or channel dedicated to the course. Each of these is considered individually as a DLE when they are used for the purpose of teaching/learning. We will call in this paper the individual DLE as a DLE unit. Therefore the terminology used here is not LMS but rather DLEs. They all together form a Common Information Space (CIS) in that specific course, for the course attendees, and the course instructor. However, the complexity of understanding these information spaces increase when each of the course instructors start using several DLEs in their courses, some of them being officially the HE institutions' DLEs, whereas some of them are not.

Nevertheless, students may attend several such courses, where each of the course instructors may have their own set of dedicated DLEs. The students usually have very little power regarding the decision on what DLEs to use. At the same time, there are cases when the course attendees themselves suggest to the course instructors to use some *new* web platforms or the *latest* social media platform, in the course. Through this paper, we wish to understand the complexities that come along with this dynamic use of DLEs. Specifically, we want to understand: *what challenges do they set for the students, respectively for the course instructors; h*ow *do DLE translate as CIS: what type of CIS are they, how are those represented, and used in a HE setting?* Specifically, the paper discusses and analyzes DLEs through the lenses of Common Information Spaces (CIS) (*compare to* Communication Spaces [1]).

The rest of this paper is organized as follows. We continue with the background of this study in Section II. Section III posits this paper on a theoretical level, elaborating on the concept of Common Information Spaces (CIS), giving a detailed account of the existent literature discussing CIS, including relevant definitions, examples, and characteristics. We continue then by introducing the methods in Section IV. Section V summarizes the findings, whereas Section VI discusses them through the lens of CIS. Finally, Section VII concludes the paper and gives directions for further work. The acknowledgments close the article.

II. Background

DLEs are often analyzed from an educational perspective, and less from a cooperative or collaborative perspective. Analyzing DLE in a HE organizational entity through the concept of CIS is interesting because it challenges the traditional view on DLE as educational platforms and less as cooperative or collaborative platforms. This perspective is grounded on several arguments.

First, we argue that DLE should be seen as cooperative platforms and as CIS since multiple stakeholders usually use them: Course Instructors (CI), Students (S), administrative staff (ADM), junior and senior researchers, and nevertheless by the IT department (IT) for maintaining, securing or updating them. There are many cases when one individual in an organization takes multiple roles: CI are asked to take

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courses at the same HE institution, students work part-time as teaching or research- assistants, or senior CI are both researchers using various research platforms and at the same time teaching personnel.

Second, a HE organization usually has its own official DLEs that were either bought through a formal agreement or built in-house for many years. These can cover a range from LMS to web publishing systems, to examination systems, or submission systems. Some of these DLEs official systems to the HE organization might also be official at a national level, not only at a local level. The official DLE's are required by the Norwegian law to be universally designed [2][3]. However, although there are official DLEs that are usually used by multiple internal stakeholders (CI, S, ADM, IT), there are also non-official DLEs, i.e., DLEs that are not quality ensured, secured, maintained, or tracked by the organization itself, but by external stakeholders, such as privately-owned companies, perhaps located in another country. One such example is social media platforms owned by private companies. In this case, the platforms are not primarily LMSs. However, these can be used by a HE organizational entity as DLEs to support communication, exchange files, knowledge, and information.

Third, etymologically, teaching can be defined as showing something to someone by informing or instructing, directing, guiding, sharing, delivering, or making someone aware of some specific knowledge, communicating or informing someone about something [4], while learning refers to acquiring knowledge or skill(s) through teaching, an exchange of experiences, or as a result of studying [5]. Learning is strongly connected to teaching and the individual's experience.

Fourth, although much focus is on teaching and learning in HE institutions, these entities are after all public organizations with their own procedures, rules, regulations, dedicated laws, own organizational structures, and employees. They are workplaces similar to other public institutions: The Tax Office, Public Hospitals, or National Employment Agency. In the Nordic countries, many of these institutions' procedures and ways of interaction with their "clients" are very much automated, digitalized, or in the process of automation and digitalization. Along the same lines, HE processes and ways of interaction between different stakeholders are aimed to be automated and digitalized. For instance, in Sweden, the application process to universities is done through an online website [6], where the prospective students can apply online to educational programs or extra curriculum courses, at least twice a year, with some standards deadlines (April, 15th and October, 15th). The website functions as a national database where any citizen can apply to any university programs or courses, as long as they fulfill the requirements. The whole process is smooth. In Norway, an almost similar digital platform exists [7].

Nevertheless, once accepted to a program or a course, being it campus-, distance-, or Internet-based, the students will be asked to use new digital platforms. Moreover, in Sweden and Norway, much of the teaching, even the campus-based one, make use of various DLEs. Nevertheless, employees at these institutions will use additional human resources platforms, the type of Enterprise Resource Planning (ERP) systems to plan their resources (teaching staff, courses, budget), such as SAP [8], Microsoft Sharepoint [9] or Box [10]; time schedule systems that have to be synchronized with teaching staff, courses, class-, laboratory- or group rooms; or in some cases digital examination platforms, that have to be secured, and limit the individuals taking the exam to navigate the web or reach to other external resources during the examination time. Moreover, email is usually extensively used for communication within and outside of these organizational entities.

As such, HE institutions are more than educational entities that *produce* or prepare individuals for taking part in the workforce, but as complex and dynamic cooperative assemblages, where interactions, different negotiations amongst various stakeholders, communication, and cooperative work arrangements take place. Computer Supported Cooperative Work (CSCW) emerged from the need to study group work and office automation [11]. As indicated by Schmidt and Bannon [12], CSCW is conceived as "*an endeavor to understand the nature and requirements of cooperative work to design computer based technologies for cooperative work arrangements*" (emphasis in original). A subfield of CSCW is Computer-Supported Collaborative Learning (CSCL). As shown in a CSCL study, information technology, such as DLEs, can support collaborative learning; however, the users need to overcome some challenges that come along with the use of these technologies [13].

Nevertheless, these information technologies also change the behaviors and practices of learners and teachers [13]. However, CSCL focuses in general on mediated communication technology between teachers and students, and not on seeing DLEs as part of large organizations, where DLEs can be seen as information spaces. Moreover, seeing learning/teaching as a form of *cooperative work* is interesting because, according to Schmidt [14], cooperative work refers to co-dependent work that has to be done by an ensemble of people together, (either for achieving a product or a service), which otherwise would not be able to be achieved by individual persons. *Cooperative work,* (comp. to *collaborative work* which is positively laden [12]), refers to the interdependent relations that develop due to the manifested practices that take place, which very often require some form of *coordination* as well, e.g., so-called *coordinative practices* [15]. At the same time, a learning/teaching relation in a HE context is usually a co-dependent one: the teacher's responsibility is to provide relevant knowledge in a course that the students can learn; at the same time, the students need to deliver assignments, take exams or in some form show that they have achieved the learning outcomes. In this way, such a setting can be regarded as a cooperative setting.

Finally, the paper emphasizes the use of multiple systems and how these are viewed as clusters of CIS, rather than individual systems. All in all, HE organizational entities viewed through the lens of cooperative work helps us in seeing beyond educational setting and reflecting on the complexity of the use of multiple virtual information spaces used in HE organizational entities, and on the need of coordinative practices for enabling a successful cooperative work, i.e., a successful exchange of knowledge in teaching/learning context.

III. Literature Review: On CIS

This section gives an extensive overview of CIS, by defining the concept, grounding it in examples, illustrating the specific characteristics, and explaining how the concept will be later used in the paper.

A. Defining CIS

The concept of CIS was first used in Schmidt, and Bannon's [12] work on "Taking CSCW seriously." The authors used the terminology along with the definition of articulation work, saying that CIS is one of the aspects supporting articulation work, together with workflow [12]. According to them, a CIS is necessary for distributed cooperative work, to maintain some form of 'shared' and locally and temporarily created understanding about the objects in the CIS. Usually, such a CIS is actively created, accessed, maintained, manipulated, and shared at various degrees, amongst multiple actors or stakeholders.

A CIS has the aim to allow the members of a cooperative ensemble to cooperate and interact without formal constraints, such as procedures or conventions [12]. A CIS also aims to bring "people and information together, through artifacts (…) and interpersonal communication, and they help ensure uniformity of information" [16].

TABLE I. Seven CIS Parameters From Bossen [17]

#	CIS Parameter	Explanation
1	degree of distribution	physical distribution of the cooperative work;
2	the multiplicity of the web of significance	several webs of significance are included in CIS;
3	degree of the needed articulation work	articulation work may vary depending on the character of the cooperative work;
4	multiplicity and intensity of means of communication	face to face communication, but also other communication means available and/or necessary during the cooperative work;
5	web of artifacts	all the artifacts included in the cooperative work;
6	immaterial means of interaction	habits, procedures, the structure of the organization, division of labor, etc. that decrease the need for coordination;
7	need for precision and promptness of interpretation, in the cooperative work.	the need for precision for the available information; this parameter is especially important in time- or safe-critical situations;

Moreover, CIS "indicate spaces that support distributed cooperative work as an alternative to procedural or workflow type arrangements" [18]. A CIS goes beyond a personal information space, where the individual producer of an object is also the 'consumer' of an object, i.e., the meaning that an individual attributed to an object is interpreted by the *same* individual [12].

A CIS also includes a common developed vocabulary [12]. CIS are containers and carriers of information [19]. Finally, Bossen [17] developed and formulated seven parameters of CIS. He argued that CIS is too loosely defined and that the proposed parameters can be used as an analytical framework for CIS [17]. These are represented in Table I.

B. Examples of CIS

A shared database is not necessarily a CIS, following [12]. The objects represented in a database are "*carriers* of representations," and not objects *per se* [12] if the actors do not have direct access to the material objects as artifacts. For instance, if the actors have access to a product X, or to a file Y, both outside of the database system, then they can build a common and shared understanding of how these objects should be represented in a database system. In other words, the actors can give a *common* interpretation of the material objects. Hence, a CIS embeds a coherent and interpretative aspect of the material objects represented in a database, compared to database objects that are rather "*carriers* of representations" [12].

A clear example of a CIS given by the authors is a whiteboard, where several members of the cooperative ensemble jointly scribble, modify, draw, or erase things written on the whiteboard [12]. Each member of the cooperative ensemble interprets the objects on the whiteboard individually. However, the scope is to achieve a common and shared meaning.

An excellent example of a CIS is when a department develops its own "set of meanings for key terms" (Savage, 1987, p. 6) in [12]. For instance, in a HE institution, the meaning of a *seminar* or *laboratory assignment* may be different based on different educational departments or courses. A laboratory assignment in a programming course means perhaps the development of a program by coding in an ordinary classroom environment, while laboratory assignment in biology or chemistry can possibly mean a form of experimenting in a specially dedicated lab, where specific tools and instruments are available. In this sense, CIS has a physical character.

Other examples of CIS are documents and artifacts used in an organization, supporting the cooperation between the cooperative ensemble members [12].

However, we have seen that lately, with the advanced web or software solutions available, these documents or artifacts can be represented virtually: virtual post-its or virtual dash-boards shared between members of an organization. Trello, Microsoft Team, Slack, or Google Drive are a few examples of CIS where objects of a CIS are co-created by several members of the cooperative ensemble. Such a system should: "in addition to services facilitating the creation, modification, transmission, etc. of messages, provide services supporting the cross-referencing, cataloging and indexing of the accumulating stock of messages", but they should also support the inclusion of external items [12].

A more extreme example of CIS is the web (www), where some pages are produced by several entities that do not necessarily are tangential to each other, however, a heterogeneous group of consumers of the CIS access information produced by several of them [19]. According to the study, this is a paradox example of CIS, which is both *internally closed* to the producers, however *open and accessible* for many.

C. *Characteristics of CIS*

Besides the seven parameters of CIS identified by Bossen [17], the literature has identified a couple of other parameters of characteristics specific to CIS. We briefly illustrate each of those, as follows.

1) *Dialectic Nature of CIS*

Bannon and Bødker [19] argue that putting information in common and interpreting it was not sufficiently discussed [19]. Their paper argues for a dialectical nature of CIS: CIS is both *open* and *closed,* and they are often both *portable* and *immutable*, containing *malleable information items* while *supporting the cooperative work*".

2) *Hybrid Information Spaces: In-between Private and Common*

CISs are also characterized by some sort of malleability: "open for some yet closure for others" [19]. Such an example of *hybrid* information spaces is illustrated in [18]. These are framed as information spaces that are in-between private and common [18]. Such an example is the Personal Health Records (PHR) studied in MyBook and MyHealth Norwegian projects [18]. PHR are considered to be *hybrid information spaces,* partially because the patients have to input and track their personal health data, but some of this data is also shared with medical staff [18]. Hence, they can be shared across roles and boundaries [18]. This can trigger dilemmas along how and with whom the information is shared, who owns it, in which ways it is accessible and for whom, and how these are regulated amongst the patient and the medical staff [18]. The authors recommend the regionalization of hybrid information spaces, such that the systems are designed in such a way that they can both be private and preserve the user's autonomy and control, but also shared (hybrid), with the aim of cooperative work [18].

Nevertheless, CIS should be mediated by human mediators, that support both those members of the cooperative ensemble who create, modify, or develop (*producers*) the common information, and those that use this information (*consumers*) [19].

3) *Scalability and Multiplicity of CIS*

One study added to Bossen's CIS parameters, the following ones: collaboration's scalability and information spaces' multiplicity [17]. Collaboration scalability includes the number of participants involved, and the phases necessary for achieving the collaborative work [17]. The information spaces' multiplicity refers to the number of entities and artifacts that intersect in the collaborative work and form the CIS [17].

4) *Multiple Centers, Peripheries and Overlapping Areas*

Information always belongs to a place, although the place does not necessarily need to be geographically fixed [20]. Following [20], CIS is described as having both *multiple centers* and *peripheries* but also *overlapping areas*.

5) *CIS Objects Re-producing Fragmentation*

Rolland et al. conceptualizing CIS across heterogeneous contexts [21]. They presented the idea of CIS as malleable and open objects, which are achieved in practice [21]. They also emphasized the idea of large scale CIS reproducing fragmentation [21]. One of the earlier studies [22] *(forthcoming*) also proves this fragmentation.

6) *Temporality of CIS*

CIS distributed across time and space is characterized by physical separation of cooperative members, limited access and control over the shared material, and more strict division of tasks [19].

A study investigated CIS across distributed medical teams in *emergency, time-critical, episodic, and heterogeneous cooperative situations* [23]. Having a shared understanding of these emergency cooperative settings is necessary. Munkvold and Ellingsen [24] talk about CIS use in a hospital ward while they introduce the temporal dimension of CIS, when several users are involved with their own trajectories, and intersected trajectories. Moreover, Bertelsen and Bødker [20] problematized cooperation and CIS in *massively distributed information spaces*, a case on a wastewater plant. The authors challenge the idea of CIS that provides access to *everything everywhere* [20].

7) *Physical Aspects*

The study from [16] investigated the physical aspects of objects part of a physical CIS in emergencies. The CIS part of the emergency rooms is artifacts, including electronic records, equipment, or whiteboards, supporting the staff work [16]. However, the study stresses that the information available on these CIS's is determined not only on the quality of the information, or how timely it is disposed of but also how easy it is for the staff to interact with it [16]. For instance, the study illustrated that the height and the place where the displays in the hospital are placed determines the coordination work the staff, and how much they engage with each other. Bossen [17] presented a similar case from a hospital ward. Another study that explored distributed information spaces in a hospital setting from Mexico city is the study presented in [25]. Specifically, the authors explore the physical mobility, moving beyond the desktop metaphor [26].

CIS in a shared workspace is characterized by the physical co-location of the cooperative ensemble' members, real-time sharing of resources, and sometimes ad-hoc co-handling tasks [19]. However, cooperative work does not always take place in the same shared location: the *cooperative work might exceed the temporal and local boundaries* [19]. This also puts additional requirements and changes in the design of a CIS. The information shared in a distributed CIS has to be packaged and belong to a context [19].

8) Communication Means in CIS

Hjelle [27] illustrates an example of information spaces used in an oil and gas company. He analyzes the case through Bossen's seven parameters of CIS [17]. The author points out that the best interaction is done through face to face communication [27]. The study concludes that not all of the seven parameters [17] are equally significant. However, many tools seem to be used to facilitate the cooperation, although they are not always cooperation tools, communication tools used to facilitate the cooperation when face to face meetings are not possible [27].

Sometimes, information technologies used in organizational settings are discussed as *communication spaces* instead. However, CIS and communication spaces are different, although they might have some similarities in common [1][28]. While communication spaces focus very much on the communication takes place across distributed or non-distributed spaces, CIS focus instead on how information is created, shared, maintained, and achieved. At the same time, CIS may include various communication spaces.

D. CIS in This Study

The CIS literature covers, in general, a few studies from hospital wards (see [14][17][21][22]), and in organizations, such as oil and gas companies [27], or wastewater plants [20]. However, many of these studies focused very much on the physical CIS, except for the study from [18], who focused on the hybrid and mobile information spaces. To our knowledge, it seems that CIS was not so far studied in HE institutions and that DLEs were much more often regarded from an educational perspective rather than a CSCW perspective. This study aims to bring new insights on both DLEs seen through the lens of CIS and CSCW literature, but also to the CSCW community on how DLEs can be regarded as CIS and the complexity of analyzing those as such. We continue in the next section with the method, and after that, we present the findings before we discuss those.

IV. METHOD

A. Participants and Setting

We have interviewed several experts, with an area of expertise in pedagogics and universal design. We define experts as senior researchers, with an area of knowledge in either pedagogics or universal design and a subdomain of informatics, such as human-computer interaction, interaction design, computer-supported cooperative work, or computer-supported collaborative learning. All of the participants had several years of experience of being course instructors. We will use, therefore, interchangeably the notions of experts, course instructors, or teachers, referring to the same participants.

The interviews were performed in several stages of the study. In this paper, we illustrate some findings from the interviews conducted with the interviewees having their background in pedagogics (n=3). However, similar findings are also presented in the rest of the interviews (see [22], [29]).

Finally, the interviewees were recruited through personal contact. The author had no relation to the participants since before.

B. Data Collection and Analysis

The interviews lasted about one hour- one hour and fifteen minutes each. These were transcribed verbatim by the author (SD). The data were analyzed in several steps, as recommended by [30]. Some photos were also taken during the interviews, on artifacts shown by the participants. These did not contain any personal or sensitive data.

The analysis was done through systematic text condensation [30]. 12 Excel spreadsheets were used for documenting all the steps throughout the process. The analysis was done in four steps: (step 1) the data was fully read to get a sense of what the data was talking about (themes: n_1=6, prioritized themes n_1=4); (step 2) identifying and categorizing meaning units (codes n_1=130 for the first theme, n_2=124 for the second theme, n_3=125 for the third theme, and n_4=39 for the fourth theme); (step 3) condensing the codes into meanings (n_1=23, n_2=13, n_3=25, and n_4=9); these subcategories were then organized in categories (n_1=7); (step 4) finally, during the last step, the author has synthesized the condensates into concepts (n_1=3). The resulted concepts were: cross-platform use of DLE, user diversity in Higher Education, universal design, and organizational tensions. This paper focuses solely on the cross-platform use of DLEs. However, the theme of user diversity and universal design were covered in [29].

C. Ethical Considerations

All the participants were given detailed information about the study, the possibility to ask questions prior- and during the study, and they could withdraw at any time without providing any explanation and without any consequences for them. The participation was based on free will. All the participants were willing to participate in the study signed informed consent before taking part in the study. The study follows the ethical guidelines from the Norwegian Center for Research Data (NSD) ref. Nr: 55087). This work was performed on the Tjenster for Sensitive Data (TSD) facilities, owned by the University of Oslo, Norway, operated and developed by the TSD service group at the University of Oslo, IT-Department (USIT) (project number: p400).

V. Findings

The participants mentioned 23 DLEs. The minimum number of DLEs used by the participants was 5, whereas the maximum was 16 out of 23. It seems that the youngest of the interviewee was more prone to use digital technology in class, together with her students. The same interviewee used social media platforms and considering using instant messenger in her communication with students, arguing that these were the preferred communication channels by the students.

The official publishing system was used by two out of three participants. However, one of the interviewees used it only for information related to her area of work, research, and publications, but not in a teaching/learning context. The interviewee considered the HE's official web publishing system more as an administrative tool rather than being a dedicated tool for teaching/learning.

Moreover, only two participants used the official examination system, whereas the third participant was aware of it, but did not find it appropriate to use it together with its course-takers. However, email and the new official DLEs introduced at the HE institution were used by all interviewees.

Further, one of the interviewees used three simulation environments, as the leading DLE platforms, in his teaching, although another DLE was the official institutional platform. These simulation environments were mandatory to be used by the students during the course. While some of the students were against using these external simulation tools, some felt motivated in using real-world scenarios in simulated environments. Teaching specific and generic skills by using these external simulations environments and DLEs was the main argument for using those. However, the students were required to make their submissions in the official DLEs, across the semester. But a final official examination at the end of the semester was required to be done in a third system, i.e., in the official examination system.

Two of the interviewees were using two other digital systems each in their teaching. Only one participant used cloud-based storage. The same participant also used additional plug-ins in the official DLEs.

Further, one of the participants expressed the need for a participatory tool and keeping track of things in a DLE. Therefore, she chose a publicly available database system-like online tool for recording each years' course participants' entries.

Table II gives an overview of the systems in use, as described by the participants. Another inventory of DLEs used by other participants taking part in the same study was done in our earlier published work (see more in [22], *forthcoming*).

TABLE II. Overview Over The Digital Learning Environments And Tools

#	Participant (CI) / Systems used in a HE Organizational Entity	#1	#2	#3
1	Publishing system		X	X
2	Internally and externally used submission and assessment system	X		X
3	External quiz and input system 1			X
4	External quiz and input system 2			X
5	External quiz and input system 3			X
6	Email	X	X	X
7	New DLE system	X	X	X
8	Third-party application			X
9	Social media platform 1			X
10	Web service for forum discussions and wikis		X	
11	MOOC or MOOC like platform		X	
12	Examination platform	X		X
13	Virtual game environment 1	X		
14	Virtual game environment 2	X		
15	Virtual game environment 3	X		
16	Learning Analytics	X		X
17	Specialized analysis software 1	X		
18	Specialized analysis software 2	X		
19	Specialized video analysis software 1			X
20	Specialized video analysis software 2			X
21	Cloud-based storage			X
22	Different variants of messenger applications			X
23	The third-party plugin used in the official DLE system			X

The official DLE was described by one of the participants as being an administrative tool rather than supporting learning. The system was also described as not being user-friendly and being cumbersome; however, it was also described as being easy to access and manipulate if one is familiar with such tools. At the same time, it seems to be a complex system to navigate, and that many of the student users complained about navigation issues. She also mentioned that non-regular students, i.e., older employees at the HE who are asked to use the official DLE, have a hard time using it. She described how the systems are nowadays designed as dashboards. According to the participant, these are often seen by international students that lack digital skills as a "dump place," where the course instructor "dumps" course material and information rather than as a DLE that provides opportunities for learning.

"(...) for some of the students, they were not used to it, and they were not introduced to it in the way I would like to do it, it was just like a.., sort of a repository, like a "dump place," where all this information about the course, slides, whatever the material teachers wanted to use, it was kind of thrown into that, in an organized way - which is good. For them, this was not a discussion platform; it was not a place where they could express their views or interact with the materials where they would say: okay, I would want it in

this way, or I would post my idea or view in an idea or knowledge in a discussion. They did not perceive technology as something that offers them the possibility to express, learn, engage, and be an active participant in this case in a learning activity. And I think it is an important function of the technology, to provide a platform, for those that either does not have a possibility or the attitude to do this face-to-face in plenary, for various reasons, or for those that are at a distance. So this is an opportunity. I think it is a missed opportunity if we do not present it and use it as teachers, or those who introduce it in the right way." (Participant, Interview)

Finally, one participant was pledging for digital natives being prone to like dynamic DLE than others, and therefore they might find the official web publishing system as being *out of date*. However, she was complaining that there are (perhaps too) many functionalities available in the official DLE, that there are anomalies in these functionalities, i.e., a chat functionality available in the system for all class, but not inside the groups, that the system is characterized of high complexity, that it can be perceived as overwhelming at times, that it is rich in functionalities, and has a U.S. based design geared towards assessment. She mentioned that the system requires to have a pedagogical rationale when planning a course to be able to make the most use of it.

"It's often that the students, like the natives, they come to the University, first-year students and they know they will be using learning platform, digital learning platforms, because most of them have used it in high school, or even in lower grades, while students coming from other parts of the world, don't have this ingrained experience, or simply experience of using the technology in this way. And I think there is always a gap there that often creates difficulties for the other group, not because they are not good performers, or good learners, or interest or motivated, because they simply need, a different encounter- start encounter with technology." (Participant, Interview)

VI. DISCUSSION

This section presents a regionalization of DLEs units in categories and clusters of information spaces. Based on our findings, shown earlier in Table II, DLEs are re-grouped in this section into official systems, third-party applications, and specialized software applications, quiz input systems, virtual games environments, and social media platforms. The classification is made based on each DLE unit's own primary purpose. The reason for regionalizing DLEs in these categories is to illustrate that the majority of the DLEs in use are non-official systems, but also to showcase their distribution across different domains requiring a different set of skills for using those. After that, a discussion on DLEs as information spaces follows.

A. Regionalization of the DLEs Units in Categories and Clusters of Information Spaces

Information always belongs to a *place*, or for that matter, to *space,* as it was also proved in the illustrated examples [20]. In line with [20], this study also proves that information can belong to some *overlapped areas* and *multiple centers*, i.e., see for instance the information distributed or shared through the official systems; or to *peripheries,* such as the information belonging to the quiz input systems, social media, virtual game environments, or specific specialized software systems that are used solely in particular courses. Such regionalization is needed to show the high use of non-official systems and the cross-use distribution amongst official and non-official DLEs.

Figure 1 shows a heat-map on the regionalization of DLEs from Table II. The black line distinguishes between the official systems, i.e., the system that is official to the HE organizational entity, such that they are proposed, indicated, maintained, and secured by the HE organization itself. We organized the DLEs units used by the participants in six categories: official systems (dark green), third party applications (pink), social media (blue), quiz input systems (yellow), virtual games environments (orange), and specialized software applications (light green).

The set of official DLEs {#1, #2, #6, #7, #12} is represented by five DLEs. However, we can observe that only five out of 23 DLEs in use are official systems, whereas the majority of the systems, precisely 18 of them, are not official ones, i.e., neither maintained nor secured by the HE organization personnel. Next, we can observe that six DLEs used to subscribe to the *third-party applications* category. Examples of these are the use of a third-party application (#8), web service for forum discussions and wikis (#10), MOOC or MOOC like platform (#11), learning analytics (#16), cloud-based storage (#21), and third party plugin used in the official DLE system (#23). Several specialized software applications were used – the set represented by {#17, #18, #19, #20}. Virtual game environments were used in a number of three: the set composed of {#13, #14, #15}, as well as quiz input systems – the set represented by {#3, #4, #5}. Finally, only two social media platforms were mentioned as used by the participants in their students-teaching/learning HE context, the set composed of {#9, #22}.

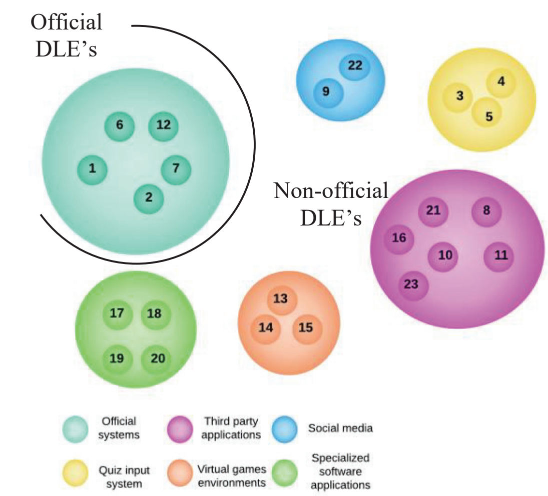

Figure 1. Heat-map over the types of DLEs used.

Further, Figure 2 illustrates a heat-map over the DLEs handled by each of the interviewees, including their types, which is color-coded. It indicates a regionalization of DLEs units based on an *individual regionalization* for each of the participants.

We can observe from Figure 2 that participant #3 used all five official systems, participant #2 used only three of them, whereas participant #1 used four of them. However, it seems that only participant #3 used social media and quiz input systems, and only participant #1 used virtual games environments. Participant #3 was also the youngest amongst the interviewees, which can perhaps be one of the reasons for being more prone to adopt DLEs. However, this is less important. More interesting is to look at the variation of the range itself, because it means that if a student takes all three courses, at the same time, from these three course instructors, the students will have slightly different CIS clusters for each of the courses (Figure 2). Such a situation may take place since all of the participants belonged to the same HE organizational entity.

At the same time, we can observe that each course's CIS is formed out of at least two DLEs units, and a maximum of five. This means that the student's virtual information space is not solely formed out of a single DLE unit, but of at least two. As many as DLE units are included in the information space, as more fragmented, the information space becomes. Nevertheless, once with the fragmentation, more coordinative practices are also needed: the student, as well as the course instructor, needs perhaps to have an account on each of these information spaces, to log in, to log out, to download or upload course material, to share, read or write information to space, etc. This may contribute to fragmented information awareness [22].

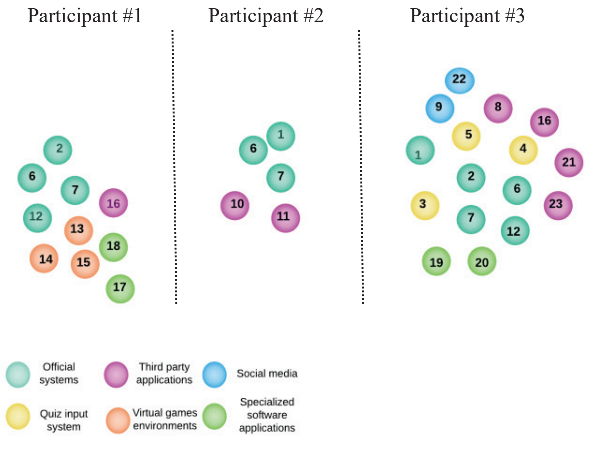

Figure 2. Heat-map over each of the participants' DLEs units used.

B. DLEs as Information Spaces

This subsection analyzes DLEs as information spaces, based on the Bossen's seven parameters [17] of CIS and the CIS's characteristics (Section III).

The physical distribution of the cooperative work (parameter #1 in [17]) across space and time calls for the need of a number of DLEs, both common and hybrid information spaces. However, what is essential to do is not to disregard the amount of *articulation work*, which is a "supra-type of work" (see [12], [31]–[33]) that comes once an information technology or system is introduced in an organization, to facilitate the work. In the examples presented earlier in the previous sub-section, it seems that often the CI is the decision-maker on what DLEs units are to be used in the course as CIS. Thus, the CI is often the decision-maker of the information spaces to be used by students. In some cases, students also suggest some new channels of communication as DLEs units to be included in the course's CIS. However, as the literature shows, it seems that it is very much overlooked or underestimated the disadvantages of adopting specific interfaces, the decision is mostly based on intuition, rather than on a thorough or elaborated process [34]. Nevertheless, according to Bossen's parameter #3 on articulation work, this depends on the character of cooperative work [17]. We argue that the amount of articulation work required by information spaces is given not only by the cooperative work but also by the number of DLEs units included in an information space, being it *hybrid* of *common*.

A *hybrid* information space composed by DLEs units refers to the information space created by both the private or peer group notes of a course attendant or course instructor and the information that is put in common in such an information space. For instance, the CIS that participant #3 is using is, in fact, a cluster of DLEs units, or individual hybrid information spaces, such as social media platforms. A social media platform used both as a DLE unit and as a CIS is a hybrid information space, in this sense. The cluster of information spaces used by participant #3, together with her students, is hence a hybrid one.

Further, the information spaces' multiplicity [17] is given by the number of entities or artifacts that intersect in the collaborative work and form the CIS. In the illustrated examples on the cross-use of DLEs, we can say that the students' or course instructors' information spaces' multiplicity is given by the number of DLEs units used in a course. However, while this number of DLE unit types (e.g., official systems, third party applications, social media, etc.), varies between 2 and 5, for the students or course attendants taking courses from all the three course instructors, the number of DLE units in use may vary up to 23.

Moreover, multiplicity is also given by the multiple webs of significances (parameter #2 in [17]) of the users: students and by the course instructors, each having different backgrounds, skills, different levels in digital literacy, etc. The web of significance is given by the number of users (students, CI) and the context the DLE units are used within. The multiplicity and intensity of the means of communication (parameter #4 in [17]) are illustrated by the majority of DLEs units, as many of them include some form of communication channels, especially the official systems and social

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media. Moreover, the web of artifacts (parameter #5 in [17]) distributed across different DLEs units form the students' respectively, the course instructors' information space. The web of artifacts is also given by all the resources provided by the CI, and by all assignments or submissions provided by the students.

The immaterial means of interaction (parameter #6 in [17]) consists of all the habits, procedures, and division of labor shared amongst the stakeholders. When these routines are well known to all of the stakeholders, the coordinative work will decrease [17]. However, as shown in [35], the lack of procedures and rules around a newly adopted groupware system puts particular demands on the quality control of the data gathered, the privacy of the organization and the individuals' using the system, and it can become a liability to the organization, rather than an asset. Similarly, in the case of students that do not know how to use DLEs as their common or hybrid information space, the articulation work for making the work *work* will most likely increase on the teacher's side. Specifically, one of the participants explained how she had to do some coordinative work in the form of articulation work when students with a lower digital literacy did not know how to use or navigate the information spaces, although she explained during class where the web of artifacts is available and how to use those. As one of the participants specified, "*students coming from other parts of the world, don't have this ingrained experience, or simply experience of using the technology in this way.*" (Participant, Interview).

In terms of needs of precision (parameter #7 in [17]), the participants did not express any concern regarding time- or safe critical issues for the availability of information. Perhaps the *deadlines* can be regarded as such, but other than that, there are not such critical time aspects. However, compared to physical information spaces, such as a whiteboard during a class filled with notes co-created through discussion by students and CI, that's is dynamic, momentary, and transitory, in a way – it will be deleted by the end of the class, virtual information spaces are seemingly slightly different. Virtual CIS and their objects seem to have a more extended temporality, i.e., the course material objects are available online over a more extended period of time throughout the semester, rather than only for one hour during the class. Moreover, virtual information spaces, such as DLEs units forming clusters of information spaces, seem to be more malleable and plastic than the physical ones: while they still keep their constant variable over time, they can yet be changed, updated, modified, deleted, and re-created. However, they are still present in the system. Their temporality, in this sense, can, in a way, be episodic.

Finally, the dialectic nature of DLEs clusters forming the hybrid or CIS is given by the openness and closeness of the DLEs units. For instance, we can notice the dialectic feature for the DLEs used by participant #1 and #3. The findings show that both participants use both official systems, being those closed (e.g., system #7, #9) or open (e.g., system #1), and other external systems – they also closed (e.g., #9, #13) or open (e.g., #3, #4, #10).

C. Cross-use of DLEs

Each of the DLE units can be considered as CIS or hybrid information spaces, based on two conditions: 1) the functionalities they provide, and 2) the perspective from which they are analyzed (student/CI). The clusters of information spaces, as shown in the figures (Figure 1 and 2), are indicated based on the data collected from the CI. However, for the students, the information spaces may cross different information spaces regions, depending on which courses they take, and the DLEs CI use in their teaching.

Several studies from the existent literature showed (see, for example, [35]-[36]), the introduction or integration of information technology or information technology devices in various organizations with the purpose of office automation [11] challenges the respective organizations their local procedures, rules, habituated practices, and coordinative practices. Similarly, our study shows some of the challenges posed when un-official DLEs are used: the information becomes fragmented across different information spaces, the distribution of DLEs may cross different information spaces regions, for the students; the degree of articulation work increases with the number of DLEs in use; the multiplicity and intensity of the means of interactions depends on the type and number of DLEs used, as well as on the number of users;

Finally, using such complex information spaces that are formed out of DLE units and clusters of DLEs give some freedom and flexibility to its users, but it also puts some responsibilities or expectations on them, such as collective expectations on one's availability at all the time, everywhere, increased commitment in communication, changed practices and norms, or experiencing an intensified communication, similarly to the findings from [37].

VII. Conclusion and Future Work

This paper has presented DLEs viewed through the lens of CIS. The research question addressed was: *what challenges do they set for the students, respectively, for the course instructors;* how *do DLE translate as CIS: what type of CIS are they, how are those represented, and used in a HE setting?* Specifically, the article has focused on how DLEs can be designated as complex information spaces. DLEs are often seen, analyzed, and discussed about as educational environments. Moreover, it seems that CIS addressed in educational settings seem not commonly explored. The contribution of the paper consists of discussing the cross-use of DLEs from a CIS perspective, moving beyond looking at DLEs just through an educational perspective. This makes the contribution of the article interesting and relevant. As future work, it would be interesting to investigate the articulation work necessary to be performed when large DLEs clusters are in use, and how these affect the work and performance of CI and students. Moreover, addressing these information spaces from a universal design perspective would be both interesting, relevant, and timely.

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REFERENCES

[1] P. G. T. Healey, G. White, A. Eshghi, A. J. Reeves, and A. Light, "Communication Spaces," vol. 17, no. 2, pp. 169–193, Apr. 2008, doi: 10.1007/s10606-007-9061-4.

[2] K. Knarlag, "Nye krav til universell utforming av IKT - Universell utforming av læringsmiljø - Universell utforming - Universell.no," [in English: New requirements to the universal design of ICT - Universal Design of Learning Environments, Universal Design] 10-Feb-2017.

[3] Kommunal- og moderniseringsdepartementet, "Forskrift om endring i forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger - Lovdata," [in English: Ministry of Local Government and Regional Development, Regulations on amendments to regulations on universal design of information and communication technology (ICT) solutions, Law data] 20-Sep-2017.

[4] Oxford Eng, Dictionary, "teach, v.," Oxford University Press, 2020.

[5] Oxford Eng. Dictionary, "learn, v.," Oxford University Press, 2020.

[6] Swedish Council for Higher Education, "antagning.se," Antagning.se, 2020. [Online]. Available from https://www.antagning.se/se/start, 25.02.2020.

[7] Kompetanse Norge, "utdanning.no," utdanning.no, 2020. [in English: Competence, Norway]. [Online]. Available from https://utdanning.no/front, 25.02.2020.

[8] "SAP" SAP. [Online]. Available from https://www.sap.com/index.html, 25.02.2020.

[9] "What is SharePoint?" [Online]. Available from https://support.office.com/en-us/article/what-is-sharepoint-97b915e6-651b-43b2-827d-fb25777f446f, 25.02.2020.

[10] "Box" [Online]. Available from https://www.box.com/en-gb/home, 25.02.2020.

[11] J. Grudin, "Computer-Supported Cooperative Work: history and focus," Comp., vol. 27, no. 5, pp. 19–26, May 1994, doi: 10.1109/2.291294.

[12] K. Schmidt and L. Bannon, "Taking CSCW seriously," CSCW, vol. 1, no. 1, pp. 7–40, Mar. 1992, doi: 10.1007/BF00752449.

[13] H. Jeong, C. E. Hmelo-Silver, and K. Jo, "Ten years of Computer-Supported Collaborative Learning: A meta-analysis of CSCL in STEM education during 2005–2014," Educ. Res. Rev., vol. 28, p. 100284, Nov. 2019, doi: 10.1016/j.edurev.2019.100284.

[14] K. Schmidt, "The Concept of 'Work' in CSCW," CSCW, vol. 20, no. 4, pp. 341–401, Oct. 2011, doi: 10.1007/s10606-011-9146-y.

[15] K. Schmidt, Cooperative Work and Coordinative Practices. London: Springer London, 2011.

[16] P. G. Scupelli, Y. Xiao, S. R. Fussell, S. Kiesler, and M. D. Gross, "Supporting coordination in surgical suites: physical aspects of common information spaces," in Proc. intern. conf. on Hum. fact. in comp. sys. - CHI '10, Atlanta, Georgia, USA, 2010, p. 1777, doi: 10.1145/1753326.1753593.

[17] C. Bossen, "The parameters of common information spaces:: the heterogeneity of cooperative work at a hospital ward," in Proc. of the 2002 ACM conf. on CSCW '02, New Orleans, Louisiana, USA, 2002, p. 176, DOI: 10.1145/587078.587104.

[18] P. Vassilakopoulou, M. Grisot, and M. Aanestad, "Between Personal and Common: the design of hybrid information spaces," CSCW, vol. 27, no. 3, pp. 1085–1112, Dec. 2018, doi: 10.1007/s10606-017-9304-y.

[19] L. Bannon and S. Bødker, "Constructing Common Information Spaces," 1997, vol. ECSCW, pp. 81–96.

[20] O. W. Bertelsen and S. Bødker, "Cooperation in massively distributed information space," Bonn, Germany, 2001, vol. ECSCW, pp. 1–17, doi: 10.1007/0-306-48019-1.

[21] K. H. Rolland, V. Hepsø, and E. Monteiro, "Conceptualizing common information spaces across heterogeneous contexts: mutable mobiles and side-effects of integration," in Proc. of the 2006 20th anniversary conf. on CSCW '06, Banff, Alberta, Canada, 2006, pp. 493–500, DOI: 10.1145/1180875.1180951.

[22] D. Saplacan, J. Herstad, and Z. Pajalic, "Use of digital learning environments: A study about fragmented information awareness," Interact. Des. Archit. J. IDxA, *forthcoming*, p. 20, 2020.

[23] Z. Zhang, A. Sarcevic, and C. Bossen, "Constructing Common Information Spaces across distributed emergency medical teams," in Proc. ACM Conf. on CSCW and Soc. Comp. - CSCW '17, Portland, Oregon, USA, 2017, pp. 934–947, DOI: 10.1145/2998181.2998328.

[24] G. Munkvold and G. Ellingsen, "Common Information Spaces along the illness trajectories of chronic patients," in ECSCW 2007, 2007, pp. 291–310.

[25] V. M. González et al., "Understanding mobile work in a distributed information space: implications for the design of ubicomp technology," in Proc. Lat. Amer. conf. on HCI - CLIHC '05, Cuernavaca, Mexico, 2005, pp. 52–63, doi: 10.1145/1111360.1111366.

[26] V. Bellotti and S. Bly, "Walking away from the desktop computer: distributed collaboration and mobility in a product design team," in Proc. ACM Conf. on CSCW '96, New York, NY, USA, 1996, pp. 209–218, doi: 10.1145/240080.240256.

[27] T. E. Hjelle, "Information spaces in large-scale Org.," COOP 2008 Proc. 8th Int. Conf. Des. Coop. Syst., pp. 265–273, 2008.

[28] A. Clement and I. Wagner, "Fragmented Exchange: disarticulation and the need for regionalized communication spaces," in Proc. 4th Euro. Conf. on CSCW, ECSCW '95: 10–14 Sep. 1995, Stockholm, Sweden, H. Marmolin, Y. Sundblad, and K. Schmidt, Eds. Dordrecht: Springer Netherlands, 1995, pp. 33–49.

[29] D. Saplacan, "Situated ability: A case from Higher Education on digital learning environments," Lect. Notes Comput. Sci. Springer, 2020, *in press*, HCII.

[30] K. Malterud, "Systematic text condensation: a strategy for qualitative analysis," Scand. J. Public Health, vol. 40, no. 8, pp. 795–805, Dec. 2012, doi: 10.1177/1403494812465030.

[31] L. Suchman, "Supporting articulation work," in Computerization and Controversy (2Nd Ed.), R. Kling, Ed. Orlando, FL, USA: Academic Press, Inc., 1996, pp. 407–423.

[32] I. Hampson and A. Junor, "Invisible work, invisible skills: interactive customer service as articulation work," New Tech. Work Employ., vol. 20, no. 2, pp. 166–181, 2005, doi: 10.1111/j.1468-005X.2005.00151.x.

[33] A. Strauss, "The Articulation of Project Work: An Organizational Process," Sociol. Q., vol. 29, no. 2, pp. 163–178, 1988.

[34] J. Grudin, "Why CSCW applications fail: problems in the design and evaluation of organizational interfaces," in Proc. ACM Conf. on CSCW '88, New York, NY, USA, 1988, pp. 85–93, doi: 10.1145/62266.62273.

[35] W. J. Orlikowski, "Learning from Notes: organizational issues in groupware implementation," in Proc. ACM Conf.on CSCW '92, New York, NY, USA, 1992, pp. 362–369, doi: 10.1145/143457.143549.

[36] W. J. Orlikowski, "The duality of technology: rethinking the concept of technology in organizations," Organ. Sci., vol. 3, no. 3, pp. 398–427, Aug. 1992, doi: 10.1287/orsc.3.3.398.

[37] M. Mazmanian, W. J. Orlikowski, and J. Yates, "The autonomy paradox: the implications of mobile email devices for knowledge professionals," Org. Sci., vol. 24, no. 5, pp. 1337–1357, Feb. 2013, doi: 10.1287/orsc.1120.0806.

PAPER VI

Use of Digital Learning Environments: A Study about Fragmented Information Awareness.

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Abstract. The study focuses on fragmented information awareness as a result of the cross-use of Digital Learning Environments (DLEs), rather than focusing on the use of individual Learning Management Systems (LMSs). This study goes beyond adopting an educational perspective as the classical studies on LMSs do. DLEs are defined as a plethora of digital systems that may be used within a teaching/learning context, including LMSs, but also social media shared dashboards communication tools, etc. used in such context. The paper addresses the issues encountered by different actors (students, teaching staff) when using DLEs. The study is theoretically anchored within the Human-Computer Interaction (HCI)/Computer-Supported Cooperative Work (CSCW) concept of awareness, repurposing the concept in an educational setting. The paper introduces fragmented information awareness, which is a new concept in the extensive existent body of literature on systems supporting Situation Awareness (SA), distributed, and shared awareness. The contribution of this paper lies in defining, describing, and addressing fragmented information awareness, grounded in empirical qualitative data. Moreover, the study addresses Universal Design (UD) issues by proposing a set of recommendations for non-fragmented information awareness from within and from without. Overall, the study subscribes to the third and fourth HCI waves.

Keywords: Digital Learning Environments (DLE), Learning Management Systems (LMS), Higher Education (HE), Human-Computer Interaction (HCI), Computer-Supported Cooperative Work (CSCW), fragmented information awareness, information awareness, Universal Design (UD).

1 Introduction

With the fast advancements in digital tools and learning environments, many Higher Education (HE) institutions have moved their teaching and learning towards digital platforms. However, without a framework to regulate which of these digital tools and learning environments may be used in HE, some challenges arise.

The focus of this study is on the use of Digital Learning Environments (DLE) in HE, rather than Learning Management Systems (LMS). We define DLEs as “digital platforms, websites or specific webpages used by course instructors and students in a course for exchanging information or knowledge, relevant for their learning, respectively teaching, within the frame of the course." [1] (p. 272). DLEs comprise LMSs but are not limited to digital platforms that are built with the sole purpose of being used in a teaching/learning context. The notion of DLEs encompasses the plethora of digital platforms used in a teaching/learning context, including LMSs, email systems, social media platforms used for creating groups or teams, online-shared dashboards, or communication channels that support projects and cooperative work amongst students and teachers [1]. Each of these digital platforms is considered individually as a DLE when it is used for teaching/learning. However, a DLE is not limited to a single LMS; it is an umbrella term for all the digital platforms and tools used in a teaching/learning context.

Many studies have already been conducted investigating Learning Management Systems (LMS) over a number of years (see, for example, [2]–[5]). Such studies cover, in general, an educational perspective on systems created and dedicated *to* learning/teaching contexts. A few such examples of LMSs are Moodle, BlackBoard, itslearning, iLearn, etc. However, studies on LMSs disregard the fact that course instructors and students may use other digital environments or tools in their teaching/learning, e.g., DLEs.

Further, while LMSs are usually designed to support the management of information and mean that the user has some sort of *information awareness*, they are often analyzed from an educational perspective and less from an organizational perspective. This study goes beyond this educational perspective and assesses DLEs in the light of Computer-Supported Cooperative Work. This is both interesting and relevant because it shows how HE is more than a group of organizations "producing" or upskilling the workforce. It represents a complex public organization, similar to the National Tax Office, Public Hospitals, or The National Employment Agency, in terms of its routines, procedures, and laws, and also the digital systems it uses [1]. Moreover, analyzing HE from a CSCW perspective instead of an educational one sheds light on the use of a DLE plethora that may contribute to *fragmented information awareness* (compared to the information awareness that LMSs aim to provide). Moreover, certain situations may not be specific only to our data set as it relates to HE institutions, but also other similar institutions, both public and private, within or outside Norway. This particular perspective has not often been considered in the literature, offering another reason for the relevance of this study.

Specifically, the paper identifies a list of concerns that contribute to a fragmented awareness among students and Course Instructors (CI) in HE. The research question that we address is: *what are some of the challenges encountered by students and teachers to maintain a common awareness when using DLE in Higher Education?* Although the main focus of the study is on fragmented information awareness, the study also goes beyond the research question to locate the findings within the bigger framework of the fourth Human-Computer Interaction (HCI) wave [6], addressing issues such as the importance of universally designed DLEs.

The paper continues in Section 2 with a background to this study, positioning the study within the fourth HCI wave. Section 3 gives a detailed description of the concept of awareness. Section 4 details the data collection and analysis methods, and Section 5 presents the findings. Section 6 discusses the findings in the light of fragmented information awareness, suggesting some recommendations for the use of multiple DLEs in HE. These recommendations are both organizational and designerly, meant to contribute to awareness from within and from without. Section 7 concludes the paper.

2 Background

This study is part of the UDFeed project [7]. Specifically, the project aimed to understand users' everyday interaction and use of digital systems used in Higher Education while gaining in-depth knowledge of how they experience those as Universally Designed (UD). This approach goes beyond the desktop metaphor, hypothesis testing, laboratory experiments, or user-centered design, emphasizing values and elements specific to the fourth wave, such as accessibility, policies and laws, and activism, in the form of Sustainable Development Goal 4 (SDG4) and UD, on accessible education. SDG4 has, amongst its targets, accessible and inclusive education at all levels and good quality of education [8].

In Norwegian HE, a recent regulation has been introduced regarding the universal design of Information and Communication Technologies (ICTs) of DLEs used in HE [9], [7], [8]. UD, derived from the field of architecture, has been associated with disability studies [12], [13]. From an international perspective, UD is defined by United Nations as: "the design of products, environments, programs, and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. 'Universal design' shall not exclude assistive devices for particular groups of persons with disabilities where this is needed." [14]. Moreover, UD is often associated with people with function variabilities. For instance, a recent Norwegian quantitative study demonstrated that many students in Norwegian Higher Education face barriers to learning: physical, pedagogical, digital, or other social barriers [15]. However, the study had a focus on barriers for people with disabilities [15]. Similar studies on universal design of ICTs for individuals with dyslexia (a learning disorder, that involves difficulty reading, due to problems identifying speech sounds, and learning how they relate to letters and words (decoding) [16]), and with other disorders have been undertaken [23], [24]. However, an accessible instructional environment is achieved through inclusion rather than individual adjustments [19]. One study supporting this idea was undertaken on the acquisition and use of universally designed digital exam environments [20]. The study suggested an iterative process model, ensuring that UD requirements are fulfilled and in line with quality assurance [20].

However, as previously mentioned, UD stands for *designing for as many people as possible*. However, as we can observe, all these studies reported, amongst their findings, problems, and issues that students with various disabilities or disorders encounter in Higher Education. Moreover, much of the focus to date has been on people with disabilities or cognitive disorders. We argue that users with or without any known physical or cognitive disabilities, face certain challenges in their interaction with these DLEs used in HE, regardless of their particular abilities [21]. This idea is supported by Martha Nussbaum (2004, p. 341) in [12] (p. 207), who states that "we all have mortal decaying bodies and are all needy and disabled in varying ways and to varying degrees."

Studies on LMSs can be framed within the first, second, or third wave of HCI, or floating between different HCI waves (for HCI waves, see [22]). During the first wave, a lot of focus was placed on human factors and ergonomics, and experimental HCI (see [23]). During the second wave, the focus was on cognitive models and experimental HCI [24], i.e., for instance, how an LMS works for a number of students or course instructors, trying to improve the interface of specific LMS hypothesis testing, laboratory experiments, and on user-centered design. During the third wave, the focus was on the user experience [22], exploring the relationship between the researcher and the researched [24].

However, as several researchers [25], [26], [6] have pointed out, we should move beyond the user-centered design, focusing on the complex relationships between humans and computers and between different stakeholders within society. We should ask philosophical questions that do not limit themselves to the questions asked during the third wave regarding situatedness, values, and embodiment [25] but pushing beyond the institutional limits, focusing on accessibility, diversity, policies, and laws [6]. Questions regarding ethics and the individual's and society's responsibilities, as well as activism, should constitute the focus [25]. This study contributes to an understanding of these complex relationships between humans and computers, systems, and the use of various interfaces, by going beyond the desktop metaphor, moving beyond the concept of the use of LMSs, and rather focusing on the complex use of DLEs. Moreover, the paper goes beyond the instrumental use of the HCI/CSCW concept of awareness, bringing matters such as UD to the forefront of the paper. This makes the study potentially interesting for the fourth wave of HCI.

3 Theory: On the Concept of *Awareness*

The concept of *Awareness* has a long history across various fields, from Ubiquitous Computing and Context-Aware Systems to Intelligent Systems to Human-Computer Interaction (HCI) to Collaborative and Virtual Work Environments, and Computer Supported Cooperative Work (CSCW). This section gives a detailed account of the concept.

3.1 Defining Awareness

Awareness has its etymological roots in *awaredom*, which is defined as "the state of being on one's guard" [27]. *Awareness* is translated into German as *Bewusstsein*. In Norwegian, it is *bevishet om*, whereas, in Swedish, it is *medvetenhet*. In German and Norwegian, the term can be described as *paying attention to*, whereas the Swedish translation has a sense of *with knowledge, with consciousness (med + vetenhet)*. Being *aware* can be explained as the state of paying attention to something, of being knowledgeable about something, and of perceiving, recognizing, and understanding something. Creating awareness amongst people regarding a specific situation, topic, or context, refers to creating a shared understanding [28].

Awareness systems are defined as "systems intended to help people construct and maintain awareness of each other's' activities, context or status, even when the participants are not co-located" [28] (p. iv). We can, however, distinguish between *awareness of people* and *awareness between systems* or *environments* [28]. Awareness is also defined as "the knowledge about the attention of others" [29].

3.2 Framing Awareness in HCI and CSCW

According to [30], the concept of awareness in HCI and CSCW dates back to the mid-1980s. First, the concept of awareness in informal communication was discussed in a study investigating collaboration amongst researchers [31]. The study addressed the importance of collaborative technology supporting this type of communication [31]. It laid the foundations for flourishing awareness research in the decades which followed. An extensive overview of awareness research is given by [32]. Amongst the types of awareness distinguished are: individual vs. group awareness, local vs. distributed awareness, mutual awareness, awareness of information taking place in the background, shared awareness, general awareness, or workspace awareness [32].

In CSCW, *awareness* is defined as: "practices through which cooperating actors while engaged in their respective individual activities and dealing with their own local urgencies and troubles, manage to pick up what their colleagues are doing (or not doing) and to adjust their own individual activities accordingly" (based on Gutwin and Greenberg (2002) in [33], p. 290). Awareness in cooperative work addresses cooperation amongst individuals in meaningful ways, where the actors' distributed activities are integrated and aligned with each other [33]. Further, within CSCW, awareness is described imprecisely as "actors' taking heed of the context of their joint effort" [33] (p. 286). Awareness is an *attribute of action* and should stand for something that one has knowledge about, or is consciously aware of: it "is only meaningful if it refers to a person's awareness *of* something" [33] (p. 287). Awareness refers to "a person's being or becoming aware of something," being "an integrated part of the practice and must be investigated as such," sometimes "an aspect of human interaction" [33] (p. 288). It is not considered to be separate from someone.

Situation Awareness. Situation Awareness (SA) was initially based on user-centered design, and it originated in the military, where a high level of awareness was needed [34]. It was defined as "being aware of what is happening around you and understanding what that information means to you now and in the future" [34] (p. 13). SA supports decision making and action [34]. Besides the time-critical fields, SA is also studied in weather forecasting, sports, acting, and, additionally, education [34]. SA is also a construct related to cognitive engineering and psychological processes [35]. SA includes three levels: perception comprehension, and projection [34]. It consists of a visual level, such as alerts and attention guidance, and a computational level focusing on display integration and predictive displays [35]. This construct is not only a "folk model," lacking a scientific ground, but it has a point. It is "a continuous diagnosis of the state of a dynamic world," specifically in time-critical situations [35] (p. 144). SA, as a theoretical construct, was found to be very valuable in the Air Traffic Control (ATC) systems [35], [36]. SA in ATC emerged from studying the mental workload available during the flight of the pilot, co-pilot, and flight engineer [35]. Once studies had been undertaken on mental workload and the actors' residual attention, and SA, the flight engineer position was removed [35].

Another model of SA was developed by [37]. According to the model, awareness can be spatial, can cover a mode, or can be talked about as awareness of others in collaboration [37]. The latter includes informal awareness, conversational awareness, structural awareness, and workspace awareness [37]. Awareness in the context of cooperative settings refers mainly to the awareness of one another's work, activities, and tasks, with the purpose of coordinating the work of a cooperative ensemble [28].

The concept was later discussed again in connection with the case of the London Underground [38]. The *awareness* concept was not explicitly addressed in [38]. However, it was presented implicitly through the idea of making one's (own) work visible through "self-talk," making *the other* (e.g., the passenger, the controller, Divisional Information Assistant) *aware* of the ongoing activities, tasks, or eventual errors.

Distributed and Shared Awareness. Studies on media spaces on the geographical distribution of teams have also observed that awareness is an essential element that has to be taken into consideration when designing systems for cross-site cooperative work [39]. Videos, protocols, and other documents were initially introduced, followed by real-time transmission of audio and video, to maintain awareness across different sites [39]. Systems supported occasional discussions, video phone conversations, group discussions, video recording, presentations, and project work [39]. Portholes was one such project at Rank Xerox EuroPARC in Cambridge (UK) and Xerox PARC in Palo Alto (California) [40]. The project was one of the first media space projects to focus on real-time remote collaboration supported by audio and video [40]. The project aimed to promote shared information and distributed awareness [40]. Other similar systems are Polyscope and Imager [40], Peepholes, VideoWall, Telemurals, Thunderwire, Audio Aura, Nomadic Radio, Team Portal, Electric Lounge, Slideshow, Awareness, PRAVTA, and WatchMe [41]. These were also implemented to support awareness for distributed work [40]. Similar projects on media spaces included: VideoWindow, Belicore, Ravenscroft Audio/Video Environment (RAVE), Computer Audio Video Enhanced Collaboration, and Telepresence (CAVECAT), TeleCollaboration, and Kasmer [39]. There are some other early examples where shared awareness was studied within collaborative writing systems, such as Quilt, PREP, GROVE, and ShrEdit [42].

Further, with the World Wide Web and evolution of mobile phones to smartphones, today, we can find a number of technologies that support or are designed for awareness, not only in the systems used at work, but also those designed for leisure, or used in the home. Instant Messaging (IM) programs such as Yahoo! Messenger or Microsoft MSN support various kinds of awareness, e.g., statuses as *Available, Away, Do Not Disturb*. Skype and other chat programs, as well as email platforms, also have built-in features supporting these types of awareness functionality. More modern systems of collaborative virtual environments, e.g., document sharing systems: Google Drive, Dropbox, Slack, Microsoft Teams, also embed awareness in different ways. They make visible which of the team members are online and which are offline, by showing in real-time who is editing a document, or by showing the history log of a document.

Further, the literature also talks about collective awareness, as a result of social and sensor networks [43]. Finally, hyper-awareness refers to the continuous social awareness shared amongst individuals, by staying in touch with each other, regardless of individuals' locations [44]. Hyper-awareness involves forms of micro-coordination, where people coordinate with each other everything related to time and place, at short time intervals [44]. This type of awareness is very similar to passive context-awareness systems, where the users distribute information about themselves passively, i.e., without the need to have direct access to mobile technology [44]. One such example is the use of scheduled Facebook posts. An example of a system supporting hyper-awareness is Swarm, a group-based messaging system [44]. Further, Vertegaal (1999) defines micro-level awareness as including the implicit collection of awareness information, i.e., requiring low mental load and fewer interruptions in activities [29]. This type of awareness is referred to as *peripheral awareness* [45].

Although the concept of *awareness* in its various forms has been much discussed in CSCW and HCI fields, *fragmented information awareness* is not common within the available HCI and CSCW literature. Based on this study, this issue is defined and discussed in Section 7 of the paper.

4 Method

We collected the data for this study through the Story-Dialogue Method (SDM) and interviews. The SDM was undertaken with students and Teaching Assistants (TAs), whereas the interviews were conducted with Course Instructors (Cis). Both participant groups were part of the same HE institution.

4.1 Story Dialogue Method

To access students' personal experiences and involve students equally at all stages of data collection, we chose the SDM as our method. SDM is a narrative method based on an in-depth structured dialogue [46]. In-depth reflections on the advantages of this method over other methods, such as digital storytelling [47] or co-construction of stories [48], are given in [49]. The theme of the SDM was: HE students' experiences with DLE used in HE. The data collection was structured into three stages: recruitment, SDM process, and closure. Below, we discuss the recruitment process, the participants, their roles during SDM, and the data collection and analysis method.

Recruitment. The student participants were recruited from a Norwegian university in Southern Norway. The invitation to take part in the study was issued through an open call for participation on repeated occasions by the authors (DS, JH). The recruitment of the participants was achieved through both purposeful and snowball sampling: the participants were HE students. The participation required the preparation of a *personal story* – a self-interview related to the study's theme. The method also required time for the data collection to be allocated on a pre-set date.

The initial intention was to recruit two groups of bachelor students for the data collection through SDM. Over 300 students following ICT-oriented bachelor programs were invited to take part in the study, with no obligation to take part. Three bachelor students registered initially for the study but later showed no further interest. However, one master student present during the open-call expressed an interest in taking part in the SDM. Further, the authors (DS, JH) gave a presentation to 17 TA students. TAs were both bachelor- and master-level students. Two other master students registered to take part in the study. Finally, it seemed the study and method used was more attractive for students at master level, due to their interest in the method being applied in their master theses eventually, but also perhaps being more used to participating in research projects. Reflections on this method, its advantages, and disadvantages, were reported in [49].

Participants. Five master students from one study program responded positively to the call to take part in this study. All of them participated in all stages of the data collection and analysis process. Four of the participants were first-year master students, whereas one was a second-year master student. None of the participants reported any disabilities. Three of the participants were interested in universal design. Two had their background in pedagogics, whereas two were, at that time, working as TAs. However, only one of them chose to explicitly relate to the experience of being a TA during the study.

Roles. For each of the stories shared, the participants had one specific assigned role: story-teller, story-listener, or story recorder. Each of the stories was regarded as a *self-interview* in a particular situation. Each of the participants had at least two roles, during the study period: story-teller, story-listener, story recorder, and facilitator. The roles were shared, in a regular pattern, amongst participants. The authors (DS, ZP) facilitated the SDM, with the following roles: primary facilitator (DS), and observer (ZP). Besides their pre-assigned roles, the facilitator and observer, the authors (DS, ZP), also acted as participants, taking on the role of story recorder, jotting down notes or quotes while listening to the participants. Neither of the authors (DS, ZP) presented any stories.

Data Collection and Analysis. One hundred and ninety-seven (197) story cards were collected during SDM. Each of the story cards contained textual data ranging from one word to several sentences. The data collection was divided into five steps, as follows: a descriptive and reflective part comprising introduction and story-telling (Step 1); a reflection circle (Step 2) resulting in 57 story cards; an analytical part comprising a structured dialogue (Step 3) resulting in 132 story cards; reviewing the story records (Step 4); and a concluding part comprising: creating the insight cards which represented the theory notes, and the end of the study (Step 5), resulting in 8 insight/theory notes. Each of the study parts was documented through story cards. Color codes were used for each of the steps.

4.2 Interviews

Four interviews were undertaken with the teaching staff. The interviews lasted for about one hour each. These resulted in about 100 pages of text transcribed verbatim by the author (DS). The textual data were analyzed through systematic text condensation [50]. The analysis was done in four steps: (Step 1) getting an overview of the data (themes: n=8, prioritized themes n=3); (Step 2) identifying and categorizing meaning units (codes: n=245); (Step 3) condensing the codes into meanings (meaning units organized in subgroups: n= 73, categories n=27); (Step 4) finally, during the last step, synthesizing the condensed data into concepts.

4.3 Ethical Considerations

All the participants were given detailed information about the study, with a chance to ask questions prior to and during the study, and they could withdraw at any time without giving any explanation and without any consequences for them. The participation was based on free will. All the participants willing to participate in the study signed informed consent before taking part in the study. The study follows the ethical guidelines from the Norwegian Center for Research Data (NSD) ref. number: 55087/589513). This work was performed at the Services of Sensitive Data (TSD) facilities, owned by the University of Oslo, Norway, operated and developed by the IT service group at the University of Oslo, IT-Department (USIT) (project number: p400).

5 Findings

In this section, we present the findings from each of the data collection methods: SDM and interviews.

5.1 Story Dialogue Method – Findings

Fragmented Understanding of Course Instructors' Mediated Feedback through DLEs. In general, the students noticed that the course instructors' feedback mediated through DLEs was mostly textual. One student noted that although human feedback is important, short textual feedback is not helpful, classifying it as "careless." In general, the students seemed to dislike vague feedback or a lack of Course Instructors' (CIs') feedback. They pointed out that such mediated feedback through DLEs is not "rich enough" or "nuanced" enough for effective communication. They stressed that the information that needs to be communicated is often lost in this way. The students concluded that textual feedback from the CIs is hard to interpret.

Moreover, the participants felt that human-mediated feedback that was only textual (unimodal) was, at times, difficult to interpret. They argued that alternative solutions should be provided, such as multimodal feedback supported within DLEs, through textual, audio, video, schematics, and diagrams. In this way, according to the participants, the synchronous or asynchronous communication supported by DLEs would be richer. However, one of the participants noted that multimodality could also be perceived as *clutter*.

DLEs’ System Feedback and Languages. The students offered reflections on the challenges of designing DLE virtual interfaces in terms of supporting several languages. They focused especially on the fact that Norway has two official languages (the old language, Norwegian Bokmål, and the new language, Norwegian Nynorsk), and how this poses challenges for the design of DLEs. This is of relevance for UD, concerning students with an immigrant background that have learned only one of the official languages.

(Dis-)Empowerment of the User through DLEs’ Design: Fragmented Control. In general, students claimed more empowerment on the user’s side. The story cards revealed that one should focus on the adjustments of the existing DLEs rather than developing new ones. From the user perspective, the students mentioned that the systems are “*too loose*,” and the issues that the users encounter are often fragmented. They noted that the user usually needs to act in case of a system failure and “*break the system walls*,” meaning that there are often quick fixes carried out instead of the underlying design issues being addressed. The students mentioned that, in case of system failures, the involvement of the user is usually required to report the problem. But many users choose to stay silent, and no real changes take place. They also pointed out that when there is a system failure, an alternative solution should be pointed out by the system itself. The students also indicated that there is often an issue of power relations between systems and humans. The students also pointed out that the systems are designed in such a way that there is no opportunity to give negative feedback and that DLEs must invite human feedback.

DLEs’ Design Generates Fragmented Emotions: “I am Personified with my Problem.” The students perceived DLEs as a barrier, where the user had to accommodate the DLEs and not the opposite. They indicated that there is an imbalance between what the systems look like they do vs. what they actually do. This imbalance in expectations often triggered emotions in the user. For instance, the students pointed out feelings of frustration when the DLEs did not work correctly, and the situations occurred repeatedly. They also pointed out feelings of sadness or confusion when the DLEs’ feedback was vague, and they did not understand how to navigate the system further. Some cards indicated that emotions are strongly connected to the system feedback one receives. One participant stated both verbally and on the story card that he planned to take extreme measures, such as installing a video-camera because a DLE system breakdown had occurred multiple times, which generated strong emotions of frustration for him.

The presented findings above are supported by the illustrated examples from different story cards in Table 1.

Table 1. Examples of illustrative story cards

#	Examples of story cards
Human mediated feedback through DLEs	“the existing system is only text-based”; “desire for a “richer” environment“; “want more/different kinds of media representations”; “Would combining different types of communication like voice/text in a single ‘thread’ of discourse create clutter?”; “Written feedback can be hard to interpret.”
DLEs’ system feedback and language	“It’s a challenge for Norwegian speaking to understand Nynorsk vs. bokmål.”; “The options in technology have to do with language – it is not understandable, clear.”; “Nynorsk vs. bokmål”; “Language can be a problem, and it is necessary to deal with it. Bokmål vs. Nynorsk”.
DLEs’ design gives fragmented control to the user	“I wish to troubleshoot issues myself, less dependent on others”; “If you end up asking yourself <<how can it be so difficult?>>, there is something probably difficult to it”; “I can share my story with others. I know more people have the same problem. Even if the problem is small and fragmented, many of us have the same problem. This shouldn’t be disregarded”; “Make other people complain because others have the same problem”; “Lower the barrier: design the system, so it doesn’t break down. Design for people”; “If I have control over the system, I wouldn’t be dependent on it”; “Even though you are right, constantly having to complain about minor issues might feel uncomfortable. → Might lead to minor issues not being reported”; “I am ‘stuck’ because it’s someone else’s responsibility & I am relying on that service”; “I don’t have control”; “We do have power with our voices, and if we keep quiet, then nothing will happen. I think maybe we should contact actual people who are responsible for the system. Not just ignore this issue,”; “Being able to combine multimedia. That would be great”; “We make things work regardless but at some costs (time, resources).”
DLEs’ design generates fragmented emotions	“I chose the story because many emotions are involved”; “many emotions involved because it [the system] did not work; it happened multiple times; I am personified with my problem.”

Condensation of Learnings. Finally, in the last step of the SDM, the participants were asked to condense their learnings, in such a way that they could be generalized for others who had not taken part in the study. The learnings are represented in Table 2 below, as initially formulated by the participants.

Table 2. Theory notes created by the participants themselves at the end of SDM

#	Theory notes from the insight cards
1	Human and system feedback is a 2-dimensional entity, where one axis is represented by: • the richness of information (a property of feedback; • and the other by the age, potential, and the capacity of interpretation (properties of the receiver of the feedback).
2	Textual feedback is different for different people.
3	The systems are a good representation of the "people" behind the system.
4	It is important to know/understand who you are giving feedback to.
5	How the feedback is understood depends on the receiver.
6	Feedback or lack of feedback can cause emotion.
7	Invite collaboration on: • feedback; • equalizing power or perceived power; • communication.
8	Create open systems (open door metaphor) that are open for: • giving feedback and • fixing it yourself.

5.2 Findings from the Interviews

Use of Different DLEs. Eighteen DLEs were mentioned by the CI participants. We divided these into official and non-official. The official DLEs are required by law to be universally designed. However, we wish to point out that non-official DLEs are also in use. This means that some of the students may be affected indirectly, i.e., by not being able to use these DLEs due to these not being universally designed.

The official publishing system was used only by three of the CI participants. Only two participants were aware of the introduction of a new DLE, whereas only one was using it. The only communication channel that was used by all CIs in their communication with students was the official email system. Several of the participants used different external systems in their teaching. Moreover, only one was using the official examination platform. One of the participants developed their DLE for the assessment of students. The same participant found the use of different social media and other external tools in a teaching and learning context to be distracting. However, all the other participants were using some kind of external system (DLEs).

Although 18 systems were identified as having been used by different CIs, one of the interviewees still mentioned that there is a lack of supervision for DLEs. He mentioned that it is very hard to keep track of all the projects and students through the email system, without having a dedicated platform for this. The current DLE that they were using appeared not to support the supervision of students or be structured well enough to support this. However, while we saw that many DLEs were in use, we could also observe that many of them were used for specific purposes. In essence, they were dedicated systems for a particular aim: a publishing system, submission system, quiz tool, assessment system, examination system, communication systems, etc. Table 3 gives an overview of the systems in use, as described by the CI participants.

Table 3. Overview of the digital learning environments and tools

#	Participant (CI) / Systems used in an HE Institution	#1	#2	#3	#4
1	Publishing system	X		X	X
2	Internal submission system	X	X	X	X
3	Internally and externally used submission and assessment system	X		X	
4	External communication system				X
5	External quiz and input system 1	X		X	X
6	External quiz and input system 2	X			X
7	Administrative system		X		
8	Own developed assessment system		X		
9	Email	X	X	X	X
10	New DLE system		X		
11	Third-party application		X		
12	External quiz application		X		
13	Social media platform 1		X		
14	Social media platform 2		X		
15	Web service for forum discussions and wikis		X	X	
16	MOOC platform				X
17	Examination platform				X
18	Screen and speech recorder software				X

Tensions in Expectations amongst Different Actors.

One DLE vs. Several DLEs. While some of the CI participants were hoping for one integrated system, some pointed out that it would not be the right solution to build one "*mammoth*" system: "*I wish that everything was in one system*." The interviewee continued:

> *P: "Absolutely, I do have a strong opinion on this. In the sense that, that I don't really like the idea of building a mammoth, doing it all, because it is not really possible for a software to do it all, like discussion, and courses, and projects, and everything. If you try to build a mammoth, then everybody would want a different thing."*
> *F1: "By a mammoth, you mean?"*
> *P: "A big elephant. So, if you try to build something big that will try to do it all, then it's no success."*

Visualization of Information in DLEs. Based on the SDM, students seemed not to be very satisfied with the way DLEs provided supported feedback from CIs. We also found that they were looking for *nuanced* and *rich* feedback that is personalized and explicitly aimed at them. They also mentioned that they wished for visual representations of feedback that is easy to understand. However, one of the CIs seemed not to agree. According to the participant, students *preferred* textual feedback, claiming that less than 5% understand visual feedback represented through diagrams. However, one of the CIs agreed with the students that the DLEs should support visuals, such as drawings. She found this relevant, especially for the DLE used in the examination.

While students were able to draw schemes and diagrams on the earlier paper exams, with the digitalization of examinations, it seems that students encounter challenges when they need to draw on computers. The CI participant found this challenge relevant for students from different fields, including medicine, where students need to draw a lot, for instance, in anatomy. She also stated that, currently, it takes a lot of time to complete the drawings with the existing software.

Fragmented Expectations of the Course Material Format in DLEs. One of the CI participants was complaining that he is almost forced to record his lectures. Although he considered it not to be very enjoyable to be listened to, he felt that he had to log them to avoid complaints from students. While this was experienced as stressful for one participant, one CI participant explained that the HE environment should be inclusive. She meant that people who cannot attend the lectures should still be able to access the course materials. The same participant expressed how she likes that the systems are open and accessible for everyone, instead of having closed systems that ask for credentials of the users, saying: "*everybody can see it, but not everybody can edit it*."

Fragmented Awareness in Universal Design. One of the participants pointed out that the DLEs need to be developed *for* the users, but also by not dismissing to obey the Educational Laws:

> *P: "So, this is kind of the problem: the developers and the end-users. The user can be stuck in their own ways and can be stubborn, but sometimes the developers do not make life easier for the users. What users like is easy tools to use, and easy to manage and easy to do things in it. […]. So yeah, the developers need to make the life of the users a little bit easier, because the users will always go to the easiest options. And for now, for instance, the easiest option is Google Docs or Dropbox, or stuff like that, because it is very, very easy to manage. But now it depends. Because the Educational Tools have to obey Educational Laws as well, right?"*

One of the laws that we mentioned in this paper is the application of UD in DLEs in HE. Concerning UD, the majority of the students were aware of it, but they often associated it with people with disabilities. On the other hand, only one CI had a deeper knowledge of UD, with regard to accessibility and usability testing. However, none of the CI were aware of the One of the CI associated UD with the idea of ethics and that it should be some support for students with disabilities at the institutional level. In contrast, one of the CIs said that their own developed system is only click-based. Moreover, he confirmed that the system did not use any colors, and therefore should comply with UD principles and standards. As he said:

P: "I mean, if you can use [system #10], you should use this. I mean [system #10] is approved, and this isn't doing anything, anything which [system #10] isn't using. Actually, we are using, we are doing less than it's expected from [system #10]. So if [system #10] is accepted, this should just fit in."
F: "Okay."
P: "Because you are not using any colors, in terms that you cannot see any colors, little text, and it's structured, you just click, drag-and-drop."
F: "Do you plan to change the interface for the app, or is it going to be the same?"
P: "No, it's going to be approximatively the same, because it's going to be very clinical, very straight. Because the magic happens underneath the interface. It's going to be very neat, very boring, just click. It should be as simple as possible."
F: "Aha. Okay. And what's your experience with [system #10] with regard to universal design?"
P: "It works for me."
F: "It works for you. Okay."
P: "Yeah. So I… yeah."
F: "Any bad experiences?"
P: "No, not from a universal design point of view. I just… It works for me. I am happy."

The general impression was that both CI and students had a shallow understanding of UD except for one CI who had somewhat more in-depth knowledge on a micro-level, in terms of technical expertise on UD.

Fragmented Awareness.
Fragmented Distribution of Course Materials in DLEs. One of the participants pointed out that using dedicated DLEs or tools is fine if multiple DLEs are not being used for the same aim. The same participant mentioned that it is very difficult for the students to find the course material spread over different DLEs. She also pointed out that there are no agreements or sets of rules amongst the CIs on how to publish and distribute course materials:

"*So I think that more dedicated tools are fine. But the main problem is that maybe that there is no common approach by lecturers in what they use. So, one holds their lecture material on [C], one holds it on [A], one holds it on their USB key, whatever. So, it's very difficult for students to understand where to find the material, if all the material is there, and when it is uploaded and so on and so on. I see the problem not in using 20 tools, but in using 20 different tools to do the same job. So, it would be nice if we were using much fewer tools when it comes to content and holding, to chats, to whatever, and to, of course, project deliveries. I think it would be much easier for the students to have these tools of choices.*"

Moreover, it also seemed that the students had *to adapt* to the various choices that CIs were making concerning publishing, submission of assignments, and examination. At the same time, students missed out on the feedback received from the TA because of the use of different various DLEs. Further, while each of the 18 DLEs was useful in its own way, the participants were complaining about the structure of the system, in terms of what has to be learned for each of the DLEs.

Fragmented Awareness: Email as a Solution? One of the participants mentioned, however, that one of the issues with having multiple DLEs in use is that the user does not get notified about eventual updates in each of the systems, and it is hard to find the relevant course material. One of the CIs proposed that *email* could be the junction point where the user, whether student or CI, could receive notifications from various DLEs. The same participant mentioned that while almost every DLE has a built-in *Calendar* function meant to be used, the user will only stick with one of those: usually, the one connected to the *email* (Outlook or Gmail). Therefore, she concluded that having a *Calendar* function in each of these DLEs is not relevant, and such functions could perhaps be removed.

6 Discussion

Practice refers to what people actually do and what they experience when they are doing things [51]. Practice is the symbiosis of action accompanied by meaning [51]. When action and meaning are divorced, there is a lack of context, and thus, fragmented awareness follows.

In this study, we have studied the practice of using DLEs and digital tools by both students and CIs, and how the use of multiple DLEs may lead to *fragmented information awareness*. The research question that we addressed at the beginning of the paper was: *what are some of the challenges encountered by students and teachers in maintaining a common awareness when using DLE in Higher Education?* It seems that the rapid proliferation of systems and a lack of policies places certain demands on users: students, CIs, and the HE as an institution. A byproduct of our findings is the theme of fragmented information awareness. This is defined and described as part of an ecological system, and explained in terms of context and orderliness, as follows. At the end of the section, we come back to the UD matters presented in the background and suggest some recommendations for HE institutions where several DLEs are used.

6.1 Defining *Fragmented Information Awareness*

Awareness is always related to the *awareness of someone about something*. As we have seen in the previous sections, situation or context-aware systems have been used for a long time in the design of time-critical systems: in the automation of power plants, aircraft and air traffic control systems, or more recently in smart cars, industrial robots, or other autonomous devices. Giving control to the user relates to keeping the user situation-aware [34]. While others have defined awareness as knowing what is happening in the work environment surroundings [40] (p. 541), some have established awareness as "an *understanding of the activities of others*, which provides *a context for your own activity*" [42] (p. 107). The authors talk about awareness information for coordinating activities between several actors [42]. Based on this study, we argue that, due to a high increase in the digitalization of HE, a fragmented information awareness has been introduced by the use of multiple DLEs.

Fragmented information awareness is a byproduct of the study performed. Before we go further, we wish to define and describe fragmented information awareness.

A *fragment* is a detached, isolated, or incomplete part from a whole, a portion, or a fraction of something [52]. When we talk about fragmented information awareness, we refer to a type of awareness that is incomplete, that is missing parts that are de-fragmented. The fragments are here pieces of information that are missing. Awareness is not perception, but it embeds perception along with comprehension and projection [34]. Awareness is not attention, affordance or familiarity, nor consciousness. Awareness is given by a sense of presence in a dynamic context. It fluctuates, it is relational, and it is shown through user activities and their actions. Too little information awareness creates a lack of context understanding, whereas too much information awareness creates a mental workload. Fragmented information awareness is generated either through too little or through too much information awareness. When the user is no longer able to deal with and make sense of the information awareness, fragmented information awareness occurs.

Although a DLE is not a collaborative system per se, it is still regarded as an environment fostering cooperative settings that requires some coordination amongst the actors and their roles. It seems that when the individual needs to support awareness of the informational systems, some additional workload is added for the human. As a result of fragmented information awareness, users' actions change their course: new and different workflows are introduced to cope with it, and the workaround is performed. As a result, this creates overheads in terms of the consumed time resources, and additionally, increases the cognitive load of the user.

6.2 Information Awareness as Part of a System Ecology

This study showed an example of how the DLE used in HE institutions may create a complex, fragmented information awareness. This can be described as overwhelming: as many as 18 DLEs were used by the CIs, and many of those are used even by the students. SA regarding the use of DLE's amongst CIs is lacking or is characterized by disagreements, lack of rules, or information. SA amongst CIs and students is also flawed and depicted by a general one-to-many relationship. While, for a CI, somewhere between four to eight of the DLEs are visible, for a student, the DLEs from each CI are visible.

Switching context between these DLEs, as well as not all of these systems being universally designed, creates a fragmented information awareness amongst the CIs, and amongst the students. Moreover, some of these virtual environments are not complying with the UD law in Norway. The issue of fragmented awareness is similar to the studies talking about the ecology of artifacts [53]. However, it deals mainly with information ecology, which often becomes lost in-between systems, and with cognitive overload among users. Information ecology is a "system of people, practices, values, and technologies in a particular local environment. In information ecologies, the spotlight is not on technology, but on human activities that are served by technology." [54] Some examples of information ecologies are: a library, a hospital, a school, a university, a shop, or an institution. According to the authors, information ecology's focus is on the relationship between "tools and people and their practices," "it is a complex *system* of parts and relationships" [54] (p. 50). The information ecology components develop and *coevolve* with each other in a dynamic fashion by complementing each other and forming a unity. While the elements in an information ecology are supposed to form some sort of dynamic symbiosis, we can say that the information ecology created by a fragmented information awareness is lacking information, making a place of "wholes of information".

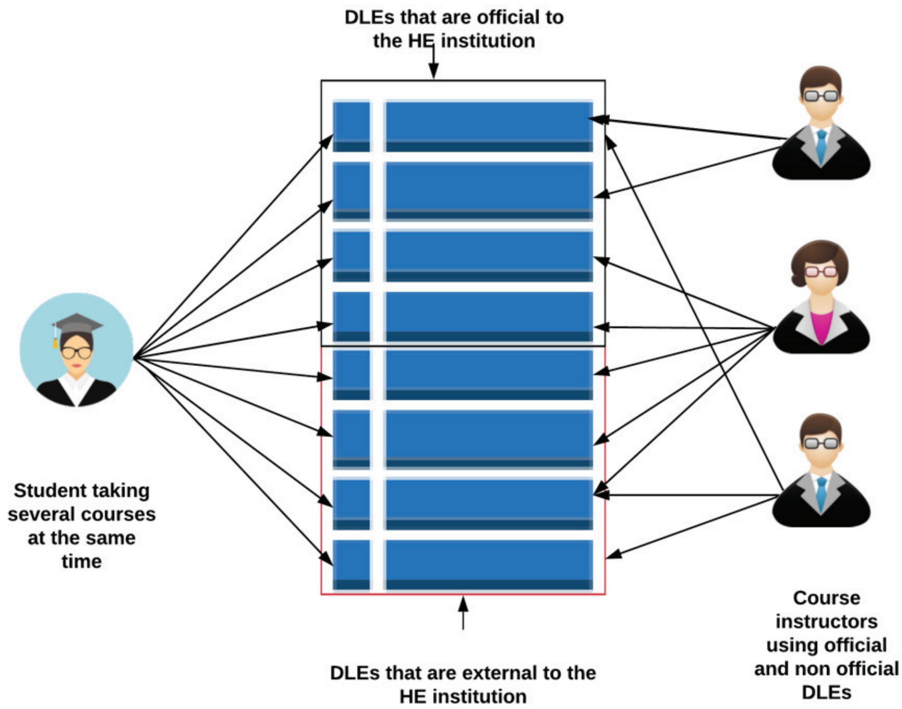

Fig. 1. An illustrative representation of students' and course instructors' relationships with DLEs

6.3 Context and Orderliness of Information Awareness

An ecological context should be presented as a context where the elements of the ecology intra-act with each other, with the aim of autopoiesis – supporting, re-producing, *befindlich* themselves virtually or physically [55]. As Dourish explains, the idea of context is dual. In essence, it has both a technical origin, representing the relationships between actions and systems and a social origin, representing aspects referring to the social setting [51]. Context as an interactional problem is presented in the literature as relational, between objects and activities, containing dynamic context features, and the context is particular to specific settings and emerges from activities [51]. Context is also linked to the idea of orderliness from within and from without [51]. Orderliness from without refers to social actions that derive from (external) rules pre-set by an external organ [51]. Orderliness from within refers to the social actions that emerge from within the action itself [51].

Information Awareness Resulting from a Lack of Orderliness from Within. The specific use of DLEs and the expectations of the users on the same tool. Fragmented information awareness can result from a lack of *orderliness from within*. This was indicated by our findings when the students sought mediated feedback from CIs that was personalized and meaningful, and between students and CIs in terms of the visualization of feedback. Further, this phenomenon is also indicated by the challenge of language barriers in design, especially in the case of having several official languages. Another concern related to this phenomenon was suggested by the students feeling dis-empowered. The users indicated that the user should be in control and feel empowered.

Another example of fragmented information awareness from within was indicated by the tensions amongst CIs regarding the use of one system vs. several systems, in terms of the distribution of course materials amongst CIs, and between students and CIs; the fact that students have to adapt to different DLEs according to CIs' individual preferences; the structure of DLEs being different, and the expectations that the students (and CIs) will be able to use those, although sometimes the structure is not logical; the fact that email could potentially be a central junction when using different DLEs.

Gutwin et al. in [29] state that relaxed "What I See Is What You See" (WISIWYS) may "lead to a lack of awareness" [29]. Nevertheless, orderliness from within is strongly related to the look and feel of the digital façades and their affordances. For instance, we could observe in our study an incongruence in system image views amongst the actors.

Information Awareness Resulting from a Lack of Orderliness from Without. A user's fragmented information awareness from without is strongly related to their knowledge on the existing official vs. non-official DLEs and the local (institutional) agreements and procedures. Further, our findings from the interviews with CIs indicate that multiple DLEs and digital tools are used, but sometimes several of them are used for the same purpose. This contributes to fragmented information awareness amongst CIs and the students. Moreover, concerns about student privacy are not taken into account to date at an organizational level, when external tools are used. Finally, organizational memory suffers from a lack of clear processes and procedures in the documentation of final evaluations. Yet, this also adds to fragmented information awareness from without, in HE. Finally, the last layer of fragmented awareness from without refers to the knowledge of current laws, rules, and regulations regarding UD in HE.

6.4 Recommendations

Based on the empirical findings, and on our discussion around fragmented information awareness from within and from without, we have compressed the learnings from this study into a few recommendations that may be valuable in other HE organizational entities, where several DLEs are used. Through our study, we have observed that: 1) many of the DLEs are not universally designed, and 2) fragmented information awareness occurs amongst the actors that use these DLEs. This also shows that there is a need for standards that also address cognitive elements. While developing those standards was outside of the scope of this study, we have developed a set of recommendations (Table 4) instead. The recommendations should support non-fragmented awareness, in the case of using multiple DLEs in HE. This set of recommendations is meant to support cognitive criteria for non-fragmented information awareness from within and from without. However, these criteria still eventually need to be transformed into measurable requirements.

Table 4. Set of recommendations

#	**Set of recommendations for the use of multiple DLE in HE** **Organizational recommendations for contributing to better awareness from without**
1	Systems should comply with existing laws and regulations at the national level.
2	No more than one DLE should be used for one purpose (e.g., publishing course material, submission, assessment, peer-review, supervision).
3	The use of multiple DLEs would benefit from agreements and rules set at a local level of the organization.
4	The DLEs used should comply with UD standards.
	Design recommendations for contributing to better awareness from within
5	The user should have the option of being notified through email when changes or updates are performed in any of the DLEs used.
6	Each DLE should follow a logical structure for the user.
7	A DLE dedicated to examination of students should include tools for performing drawing, visuals, schemes, and diagrams.
8	DLEs should support the distribution of course material in several formats and be accessible for those who cannot attend the class physically. This should not be in contradiction with personal data (e.g., voice recording) concerns of the individual who publishes it.
9	DLEs should support human-mediated feedback, that is: personal, fit the person or user receiving it, be careful (as opposed to involving careless feedback), clear (as opposed to vague), nuanced enough and represented through multimodalities (textual, audio, video, schematics), however, without being cluttered. Multimodal representation of it is recommended, such that language barriers that allow for unfortunate interpretation is dismissed or, at least, decreased at some level.
10	DLEs should support relevant, concrete, specific, multimodal, and adjustable system feedback. Each DLE's system feedback should be available in all the official languages. The system feedback should empower the user.
11	The user should be in control. The design of DLEs should: support the adjustments of the current system, rather than building new systems; have low barriers for accessing and using the system; be designed *for* people; give control to the user over the system; be universally designed, and invite human feedback.

7 Conclusion

This study focuses on DLEs, rather than on LMSs. This study goes beyond adopting the educational perspective, followed by classical studies on LMSs. DLEs are defined as a plethora of digital systems that may be used within a teaching/learning context, including LMSs, but also social media shared dashboards, communication tools, etc. used in such a context. The study is theoretically anchored within the HCI/CSCW concept of awareness, repurposing the concept for an educational setting. The novelty in this study consists of introducing a new form of awareness, namely *fragmented information awareness*. This form of awareness is described as a by-product, the overall theme of the study, generated by the use of multiple DLEs. The contribution of this paper lies in defining, describing, and addressing fragmented information awareness. The added value of the study relies upon addressing UD issues by suggesting a set of recommendations proposed for better information awareness, i.e., non-fragmented information awareness, that is presented from within and from without. However, the limitations of the study include that they only address UD from a background perspective, not rather than it being the main focus of the whole paper. Overall, the study subscribes to the fourth HCI wave, inheriting elements from both the third and fourth HCI waves.

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References

1. D. Saplacan, "Cross-Use of Digital Learning Environments in Higher Education: A Conceptual Analysis Grounded in Common Information Spaces," in *Proceedings of The Thirteenth International Conference in Advances in Computer-Human Interactions*, Valencia, Spain, Mar. 2020, pp. 272–281, Accessed: Mar. 26, 2020. [Online]. Available: https://www.thinkmind.org/index.php?view=article&articleid=achi_2020_13_30_28020.
2. H. Coates, R. James, and G. Baldwin, "A Critical Examination Of The Effects Of Learning Management Systems On University Teaching And Learning," *Tert. Educ. Manag.*, vol. 11, no. 1, pp. 19–36, Mar. 2005, DOI: 10.1007/s11233-004-3567-9.
3. S. Graf, "Adaptivity in Learning Management Systems Focussing on Learning Styles," Ph.D. Thesis, Vienna University of Technology, Faculty of Informatics, Institute for Software Technology and Interactive Systems, Vienna, Austria, 2007.
4. S. Lonn and S. D. Teasley, "Saving time or innovating practice: Investigating perceptions and uses of Learning Management Systems," *Comput. Educ.*, vol. 53, no. 3, pp. 686–694, Nov. 2009, DOI: 10.1016/j.compedu.2009.04.008.
5. M. Machado and E. Tao, "Blackboard vs. moodle: Comparing user experience of learning management systems," in *2007 37th Annual Frontiers In Education Conference - Global Engineering: Knowledge Without Borders, Opportunities Without Passports*, Oct. 2007, pp. S4J-7-S4J-12, DOI: 10.1109/FIE.2007.4417910.
6. S. Ashby, J. Hanna, S. Matos, C. Nash, and A. Faria, "Fourth-Wave HCI Meets the 21st Century Manifesto," in *Proceedings of the Halfway to the Future Symposium 2019*, Nottingham, United Kingdom, Nov. 2019, pp. 1–11, DOI: 10.1145/3363384.3363467.

7. The University of Oslo, “UDFeed,” *UDFeed: universal design for learning and instruction: What tools do we use for supporting feedback from students? - Department of Informatics*, 2017. http://www.mn.uio.no/ifi/english/research/projects/udfeed/index.html (accessed Feb. 05, 2018).
8. United Nations, “SDG 4 - Quality Education,” 2018. https://www.un.org/sustainabledevelopment/education/ (accessed Nov. 06, 2016).
9. Regjeringen.no, “Innfører krav om universell utforming av IKT i utdanningen,” *Regjeringen.no*, Dec. 01, 2016. https://www.regjeringen.no/no/aktuelt/innforer-krav-om-universell-utforming-av-ikt-i-utdanningen/id2521801/ (accessed Mar. 27, 2018).
10. K. Knarlag, “Nye krav til universell utforming av IKT - Universell utforming av læringsmiljø - Universell utforming - Universell.no,” Feb. 10, 2017.
11. Kommunal- og moderniseringsdepartementet, “Forskrift om endring i forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger - Lovdata,” Sep. 20, 2017. https://lovdata.no/dokument/LTI/forskrift/2017-09-13-1417 (accessed Apr. 20, 2018).
12. I. M. Lid, “Developing the theoretical content in Universal Design,” *Scand. J. Disabil. Res.*, vol. 15, no. 3, pp. 203–215, Sep. 2013, DOI: 10.1080/15017419.2012.724445.
13. J. Grue, “Interdependent Discourses of Disability - A Critical Analysis of the Social/Medical Model Dichotomy,” Ph.D. Thesis, University of Oslo, Oslo, Norway, 2011.
14. United Nations, “Accessibility and Development: environmental accessibility and its implications for inclusive, sustainable, and equitable development for all.” Department of Economic and Social Affairs, 2013, Accessed: Sep. 04, 2018. [Online]. Available: http://www.un.org/disabilities/documents/accessibility_and_development_june2013.pdf.
15. PROBA samfunnsanalyse, “Barrierer i høyere utdanning for personer med nedsatt funksjonsevne.,” PROBA Samfunnsanalyse, 2018–02, Project number 17040, 2018. Accessed: Jun. 22, 2018. [Online]. Available: https://www.bufdir.no/Bibliotek/Dokumentside/?docId=BUF00004579.
16. G. R. Lyon, S. E. Shaywitz, and B. A. Shaywitz, “A definition of dyslexia,” *Ann. Dyslexia*, vol. 53, no. 1, pp. 1–14, Jan. 2003, DOI: 10.1007/s11881-003-0001-9.
17. G. Berget, J. Herstad, and F. E. Sandnes, “Search, Read and Write: An Inquiry into Web Accessibility for People with Dyslexia,” *Stud. Health Technol. Inform.*, vol. 229, pp. 450–460, 2016.
18. G. Berget and F. E. Sandnes, “Do autocomplete functions reduce the impact of dyslexia on information-searching behavior? The case of Google,” *J. Assoc. Inf. Sci. Technol.*, vol. 67, no. 10, pp. 2320–2328, Oct. 2016, DOI: 10.1002/asi.23572.
19. H. J. Strømsø, K. H. Lycke, and P. Lauvås, *Når læring er det viktigste - undervisning i høyere utdanning*. CAPPELEN DAMM AS 2006, 2016.
20. R. J. Foss-Pedersen and M. E. N. Begnum, “Universell utforming og digital eksamen i UH-sektoren: 5 anbefalte tiltakspunkter,” *25*, 2017, Accessed: Sep. 11, 2018. [Online]. Available: https://brage.bibsys.no/xmlui/handle/11250/2469295.
21. D. Saplacan, “Situated ability: A case from Higher Education on digital learning environments,” in *Lecture Notes in Computer Science, Springer, Ch. 19*, vol. HCII, 2020, M. Antona and C. Stephanidis, Eds. Springer Nature, Switzerland, 2020, pp. 1–19.
22. S. Bødker, “Third-Wave HCI, 10 Years Later—Participation and Sharing,” *Interactions.ACM.org*. pp. 24–31, 2015, Accessed: Nov. 17, 2016. [Online]. Available: http://interactions.acm.org/archive/view/september-october-2015/third-wave-hci-10-years-later-participation-and-sharing.
23. J. Grudin, “Computer-Supported Cooperative Work: History and Focus,” *Computer*, vol. 27, no. 5, pp. 19–26, May 1994, DOI: 10.1109/2.291294.
24. S. Harrison, P. Sengers, and D. Tatar, “The Three Paradigms of HCI,” in *In Proceedings of Alt.chi [online]. Available: Http://People.cs.vt.edu/ Srh/Downloads/Hci%20journal%20thethreeparadigms Ofhci.pdf*, 2007.

25. C. Frauenberger, “Entanglement HCI The Next Wave?,” *ACM Trans. Comput.-Hum. Interact.*, vol. 27, no. 1, pp. 2:1–2:27, Nov. 2019, doi: 10.1145/3364998.
26. J. Forlizzi, “Moving beyond user-centered design,” *Interactions*, vol. 25, no. 5, pp. 22–23, Aug. 2018, DOI: 10.1145/3239558.
27. Oxford English Dictionary, “awareness, n.,” *OED Online*. Oxford University Press, 2019, [Online]. Available: https://www.oed.com/view/Entry/13894.
28. P. Markopoulos, Ed., *Awareness systems: advances in theory, methodology, and design*. London: Springer, 2009.
29. R. Vertegaal, “Designing Awareness with Attention-based Groupware,” *INTERACT ’99*. Edinburgh, U.K., 1999.
30. M. Rittenbruch and G. McEwan, “An Historical Reflection of Awareness in Collaboration,” in *Awareness Systems: Advances in Theory, Methodology and Design*, P. Markopoulos, B. De Ruyter, and W. Mackay, Eds. London: Springer London, 2009, pp. 3–48.
31. R. Kraut, J. Galegher, and C. Egido, “Relationships and Tasks in Scientific Research Collaborations,” in *Proceedings of the 1986 ACM Conference on Computer-supported Cooperative Work*, New York, NY, USA, 1986, pp. 229–245, DOI: 10.1145/637069.637098.
32. T. Gross, “Supporting Effortless Coordination: 25 Years of Awareness Research,” *Comput. Support. Coop. Work CSCW*, vol. 22, no. 4, pp. 425–474, Aug. 2013, DOI: 10.1007/s10606-013-9190-x.
33. K. Schmidt, “The Problem with `Awareness’: Introductory Remarks on `Awareness in CSCW,’” *Comput. Support. Coop. Work CSCW*, vol. 11, no. 3, pp. 285–298, Sep. 2002, DOI: 10.1023/A:1021272909573.
34. M. R. Endsley, *Designing for Situation Awareness: An Approach to User-Centered Design, Second Edition*, 2nd ed. Boca Raton, FL, USA: CRC Press, Inc., 2011.
35. R. Parasuraman, T. B. Sheridan, and C. D. Wickens, “Situation Awareness, Mental Workload, and Trust in Automation: Viable, Empirically Supported Cognitive Engineering Constructs,” *J. Cogn. Eng. Decis. Mak.*, vol. 2, no. 2, pp. 140–160, Jun. 2008, DOI: 10.1518/155534308X284417.
36. R. R. Harper, J. A. Hughes, and D. Z. Shapiro, “Studies in Computer Supported Cooperative Work,” J. M. Bowers, and S. D. Benford, Eds. Amsterdam, The Netherlands, The Netherlands: North-Holland Publishing Co., 1991, pp. 225–234.
37. C. Gutwin, “Workspace Awareness in Real-Time Distributed Groupware,” University of Calgary, Calgary, Alberta, Canada, 1997.
38. C. Heath and P. Luff, “Collaborative Activity and Technological Design: Task Coordination in London Underground Control Rooms,” in *Proceedings of the Second Conference on European Conference on Computer-Supported Cooperative Work*, Norwell, MA, USA, 1991, pp. 65–80, [Online]. Available: http://dl.acm.org/citation.cfm?id=1241910.1241915.
39. S. A. Bly, S. R. Harrison, and S. Irwin, “Media Spaces: Bringing People Together in a Video, Audio, and Computing Environment,” *Commun ACM*, vol. 36, no. 1, pp. 28–46, Jan. 1993, DOI: 10.1145/151233.151235.
40. P. Dourish and S. Bly, “Portholes: Supporting Awareness in a Distributed Work Group,” in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, New York, NY, USA, 1992, pp. 541–547, DOI: 10.1145/142750.142982.
41. C. Röcker, “Universal access to awareness information: using smart artefacts to mediate awareness in distributed teams,” *Univers. Access Inf. Soc.*, vol. 11, no. 3, pp. 259–271, Aug. 2012, DOI: 10.1007/s10209-011-0237-9.
42. P. Dourish and V. Bellotti, “Awareness and Coordination in Shared Workspaces,” in *Proceedings of the 1992 ACM Conference on Computer-supported Cooperative Work*, New York, NY, USA, 1992, pp. 107–114, DOI: 10.1145/143457.143468.

43. J. Pitt *et al.*, “Transforming Big Data into Collective Awareness,” *Computer*, vol. 46, no. 6, pp. 40–45, Jun. 2013, DOI: 10.1109/MC.2013.153.
44. S. Farnham and P. Keyani, “Swarm: Hyper Awareness, Micro Coordination, and Smart Convergence through Mobile Group Text Messaging,” in *Proceedings of the 39th Annual Hawaii International Conference on System Sciences (HICSS’06)*, Jan. 2006, vol. 3, pp. 59a–59a, DOI: 10.1109/HICSS.2006.445.
45. D. B. E.R. Ruyter, C. a. G. J. Huijnen, P. Markopoulos, and W. A. IJsselsteijn, “Creating social presence through peripheral awareness,” in *Human-computer interaction : theory and practice Vol. 2 of the proceedings of HCI International 2003, 22-27 June, Crete, Greece*, 2003, pp. 889–893, Accessed: Sep. 18, 2019. [Online]. Available: https://research.tue.nl/en/publications/creating-social-presence-through-peripheral-awareness.
46. R. Labonte and J. Feather, *Handbook on Using Stories in Health Promotion Practice*. University of Saskatchewan, 1996.
47. A. C. Willox, S. L. Harper, V. L. Edge, ‘My Word’: Storytelling and Digital Media Lab, and R. I. C. Government, “Storytelling in a digital age: digital storytelling as an emerging narrative method for preserving and promoting indigenous oral wisdom,” *Qual. Res.*, vol. 13, no. 2, pp. 127–147, Apr. 2013, DOI: 10.1177/1468794112446105.
48. D. O. Buskermolen and J. Terken, “Co-constructing Stories: A Participatory Design Technique to Elicit In-depth User Feedback and Suggestions About Design Concepts,” in *Proceedings of the 12th Participatory Design Conference: Exploratory Papers, Workshop Descriptions, Industry Cases - Volume 2*, New York, NY, USA, 2012, pp. 33–36, DOI: 10.1145/2348144.2348156.
49. D. Saplacan, J. Herstad, N. M. Elsrud, and Z. Pajalic, “Reflections on using Story-Dialogue Method in a workshop with interaction design students,” *Proceedings of Fifth International Workshop on Cultures of Participation in the Digital Age - CoPDA 2018, International Conference on Advanced Visual Interfaces (AVI 2018)*, vol. 2101. CEUR Workshop Proceedings, Castiglione Della Pescaia, Grosetto, Italy, pp. 33–43, May 29, 2018, Accessed: May 23, 2018. [Online]. Available: http://ceur-ws.org/Vol-2101/paper5.pdf.
50. K. Malterud, “Systematic text condensation: a strategy for qualitative analysis,” *Scand. J. Public Health*, vol. 40, no. 8, pp. 795–805, Dec. 2012, DOI: 10.1177/1403494812465030.
51. P. Dourish, “What we talk about when we talk about context,” *Pers. Ubiquitous Comput.*, vol. 8, no. 1, pp. 19–30, Feb. 2004, DOI: 10.1007/s00779-003-0253-8.
52. Oxford English Dictionary, “fragment, n.,” *OED Online*. Oxford University Press, 2019, [Online]. Available: https://www.oed.com/view/Entry/74114.
53. H. Jung, E. Stolterman, W. Ryan, T. Thompson, and M. Siegel, “Toward a Framework for Ecologies of Artifacts: How Are Digital Artifacts Interconnected Within a Personal Life?,” in *Proceedings of the 5th Nordic Conference on Human-computer Interaction: Building Bridges*, New York, NY, USA, 2008, pp. 201–210, DOI: 10.1145/1463160.1463182.
54. B. A. Nardi and V. O’Day, *Information ecologies: using technology with heart*. Cambridge, Mass: MIT Press, 1999.
55. K. Krippendorff, “On the Essential Contexts of Artifacts or on the Proposition That ‘Design Is Making Sense (Of Things),’” *Des. Issues*, vol. 5, no. 2, pp. 9–39, 1989, DOI: 10.2307/1511512.