Thesis for The Degree of Licentiate of Engineering

From the Ground Up

Designerly Knowledge in Human-Drone Interaction

Mafalda Gamboa

CHALMERS
UNIVERSITY OF TECHNOLOGY

UNIVERSITY OF
GOTHENBURG

Department of Computer Science and Engineering
Chalmers University of Technology | University of Gothenburg
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Department of Computer Science and Engineering
Division of Interaction Design and Software Engineering
Chalmers University of Technology | University of Gothenburg
SE-412 96 Göteborg,
Sweden
Phone: +46(0)31 772 1000

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"I am not doing science – I am flirting with science.
Do not quote me on this."

- William Gaver

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Abstract

There are flying robots out there – you may have seen and heard them, droning over your head. Drones have expanded our human capacities, lifting our sight to the skies, but not without generating intricate experiences. How are these machines being designed and researched? What design methods, approaches, and philosophies are relevant to the study of the development (or decline) of drones in society? In this thesis, I argue that we must re-frame how drones are studied, from the ground up, through a design stance. I invite you to take a journey with me, with changing lenses from the work of others to my own intimate relationship with this technology. My work relies on exploring the fringes of design research: understudied groups such as children, alternative design approaches such as soma design, and peripheral methods such as autoethnography.

This thesis includes four articles discussing perspectives on designerly knowledge, composing a frame surrounding the notion that we may be missing out on some of the aspects of the wicked nature of human-drone interaction (HDI) design. The methods are poised on phenomenology and narratives, and supported by the assumption that any subject of study is a sociotechnical assemblage. Starting through a first-person perspective, I offer a contribution to the gap in research through a longitudinal autoethnographic study conducted with my children. The second paper comes in the form of a pictorial expressing a first-person experience during a design research workshop, and what that meant for my relationship with drones as a research material. The third paper leaps into a Research through Design project, challenging the solutionist drone and offering instead the first steps in a concept-driven design of the unlikely pairing of drones and breathing. The fourth paper returns to the pictorial form, suggesting a method for visual conversations between researchers through the tangible qualities of sketches and illustrations.

Central to this thesis, is the argument for designerly approaches in HDI and championing the need for alternative forms of publication and research. To that end, I include two publications in the form of pictorials: a publication format relying on visual knowledge and with growing interest in the HCI community.

Keywords

human-drone interaction, design epistemology, first-person methods, sociotechnical systems

List of Publications

Appended publications

This thesis is based on the following publications:

[I] **M. Gamboa**, *Living with Drones, Robots, and Young Children: Informing Research through Design with Autoethnography*
NordiCHI'22, October 8–12, 2022.
https://doi.org/10.1145/3546155.3546658

[II] **M. Gamboa**, *Conversations with Myself: Sketching Workshop Experiences in Design Epistemology*
C&C'22: Creativity and Cognition, June 2022.
https://doi.org/10.1145/3527927.3531450

[III] **M. Gamboa**, M. Aydın Baytaş, S. Hendriks, S. Ljungblad, *Wisp: Drones as Companions for Breathing*
TEI'23, February 2023.
https://doi.org/10.1145/3569009.3572740

[IV] **M. Gamboa**, S. Ljungblad, *Conversational Composites: Conversational Composites: A Method for Tangible Illustration Layering*
TEI'23, February 2023.
https://doi.org/10.1145/3569009.3572793

Research Contribution

In this section, I describe my contributions to the appended papers.

Paper I is an autoethnography and naturally a single-authored paper, although written with the invaluable contribution of my family. The idea of autoethnography as a method was already suggested in our funding, and became particularly helpful in the context of the COVID-19 pandemic. I followed the suggestion with the full support of my supervisor, who reviewed the paper multiple times. I wrote and envisioned the whole paper from there on, including conceptualisation, combination of methodological framing, documentation, data analysis, and writing.

Paper II is yet another autoethnography, and also single-authored. This paper is a pictorial, and hence most of the work is based on visual expressions. I conceptualised, illustrated, and wrote the pictorial.

I led the work in **Paper III**, together with a team of researchers. I conducted the initial interviews with experts, transcribed, and analysed them. I conceptualised the project and its theoretical framing, and produced the first sketches and ideas for the prototype. Together with the second author, we implemented the ideas into a prototype. I documented the whole design process. I conducted the evaluation of the prototype, including the post-experience interviews. Along with the third author, we analysed the results of the evaluation. I developed the combination of frameworks and final contributions. I wrote the majority of the paper with contributions and supervision from the fourth author.

Paper IV, another pictorial, was led and conceptualised by me. It is the result of an exercise conducted together with the second author. I imagined the method and implemented it with the second author, who contributed with her reflections and illustrations. To conduct the method, we gathered data through a short online survey developed with the second author. Along with the third author, I formulated the conclusions and instructions for appropriation of the method. I designed all the method illustrations.

Other publications

[a] **M. Gamboa**, *My Body, My Baby, and Everything Else: An Autoethnographic Illustrated Portfolio of Intra-Actions in Pregnancy and Childbirth*
TEI '23: Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '23), February 26-March 1, 2023.
https://doi.org/10.1145/3569009.3572797

[b] B. Baldursson, D. Peterson, **M. Gamboa**, *Nebula: Artistic Somaesthetic Appreciation with Biosignals in Virtual Reality*
NordiCHI '22: Adjunct Proceedings of the 2022 Nordic Human-Computer Interaction Conference, October 2022.
https://doi.org/10.1145/3547522.3547710

[c] **M. Gamboa**, S. Ljungblad, *Designerly Ways of Knowing in HCI Education: A Case Study of a Peer Community-Based Studio*
Frontiers in Computer Science, May 2022.
https://doi.org/10.3389/fcomp.2022.793968

[d] M. Sturdee, M. Lewis, **M. Gamboa**, T. Hoang, J. Miers, I. Smorgun, P. Jain, A. Strohmayer, S. Alaoui, C. Wodtke, *The State of the (CHI) Art*
CHI EA '22: Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems, April 2022.
https://doi.org/10.1145/3491101.3503722

[e] P. Alves-Oliveira, M. L. Lupetti, M. Luria, D. Löffler, **M. Gamboa**, L. Albaugh, W.Kamino, A. K. Ostrowski, D. Puljiz, P. Reynolds-Cuéllar, M. Scheunemann, M. Suguitan, D. Lockton, *Collection of Metaphors for Human-Robot Interaction*
Designing Interactive Systems Conference 2021 (DIS '21).
https://doi.org/10.1145/3461778.3462060

[f] **M. Gamboa**, M. Obaid, S. Ljungblad, *Ritual Drones: Designing and Studying Critical Flying Companions*
Companion of the 2021 ACM/IEEE International Conference on Human-Robot Interaction, March 2021. https://doi.org/10.1145/3434074.3446363

[g] S. Ljungblad, Y. Man, M. Aydın Baytaş, **M. Gamboa**, M. Obaid, M. Fjeld, *What matters in professional drone pilots' practice? An interview study to understand the complexity of their work and inform human-drone interaction research*
Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. https://doi.org/10.1145/3411764.3445737

[h] S. Hendriks, S. Mare, **M. Gamboa**, M. Aydın Baytaş, *Azalea: Co-experience in Remote Dialog through Diminished Reality and Somaesthetic Interaction Design*
Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. https://doi.org/10.1145/3411764.3445052

Acknowledgment

I always write the acknowledgements right before a paper is to be published. This time, I am struggling to see how I can even fit all the names of the people that have contributed to my work! It makes me immensely happy to think that the list is so long, and grateful that I have such a wide and generous safety net. I wanted to mention most of them.

Everything I do and all my achievements would be impossible without Magnus' steady support – even though he has never really read any of my work. He keeps me sane, and is the most incredible father to our three children. To Tesla, Lyra, and Alvar, the stars in my sky and most precious co-authors. All of them have been both motivation and participants in our joined autoethnographic studies. I hope you will look back into your childhood and find that our research together helped you see the world through a critical and yet caring lens. To Judite, my mother, who will probably also never read any of my work (it does not quite matter because, according to her, everything I do is amazing. Wish she would review all my papers).

My supervisor and friend Sara Ljungblad, who is the most kind and supportive supervisor, reminding me often to take a break. I could not have imagined someone better to have by my side in this PhD journey. My co-supervisor Mohammad Obaid, who is excellent at giving feedback, and my examiner Morten Fjeld who has been a fantastic examiner despite my unusual way of doing research. All three have been able to guide my work by facilitating the path through each threshold. Everyone involved in following up my process have been incredibly kind and supportive, including Agneta Nilsson and Wolfgang Ahrendt.

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I have probably forgotten someone. I apologise. Truly – this list was almost impossible to do.

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[1] https://wasp-hs.org/projects/the-rise-of-social-drones-a-constructive-design-research-agenda/

Contents

Part I

The Compilation

Chapter 1

Introduction

Explaining the theme of my research – the design of social drones – has been an experience throughout the time it took to write this thesis. The reactions divided themselves into a mixture of assumptions about my work and perceptions of drones. Most of course, involved the words "cool" and "exciting", but many evolved towards stories of their encounters with drones in real life.

Those working within Human-Computer Interaction (HCI), or Human-Robot Interaction (HRI), will know that it is not unusual for articles within the field to start with a statement such as: "As robots become increasingly prevalent in everyday life..." However, many robots seem to remain elusive and expertly avoid being seen in society, particularly humanoid ones. What we know is that our skies are rapidly being populated by flying robots, both for hobby and professional use [1]–[3]. Tourists and police alike are adopting the technology at a rapid pace, with the legislation framing their use barely catching up. The Swedish news channel SVT reported in August 2022 that the entity that approves commercial use of drone pictures expected to take 49 working days to approve an image. The number of applications in the last five years has increased from around 700 to over 23 000, with the entity expecting 30 000 just this year. This approval is necessary due to a legal framework to avoid the spread of sensitive military information [4]. The increase in waiting times has resulted in a lot of frustrated pilots, many of them taking on the social networks to complain about the absurdity of the situation. According to some, at times the same picture could be taken with a camera on a stick, but in that case, it would not have to go through approval.

At the start of this research, I had not had any significant contact with drones. To be fair – as many others [5], [6] – my associations were primarily military. That, and the one time many years ago my brother gifted a small toy drone to my husband. The drone worked a couple of hours, as he managed to immediately fly it against the garage ceiling and wreck it beyond (at least novice) repair. In retrospect, this experience proved to be a portentous moment to this thesis.

My research is framed by the WASP-HS grant named *"The Rise of Social Drones: A Constructive Design Research Agenda"*, funded through an initiative for humanistic and social scientific research in AI and autonomous systems. The project is grounded on making connections between the spreading of consumer drones in society and the growing research field of HDI through design research in a critical manner. It included the need to take a stance on drone technology and drones as a design material, and this licentiate thesis is a reflection of that personal process. As I started investigating drones, I realised my questions required

much more than good knowledge of the state-of-the-art drone research. They demanded a renewed look into what it means to be an interaction designer[1], how the discipline of design is (or should be) relevant to Human-Drone Interaction (HDI)[2], and a more developed situated and first-hand understanding of drones.

This meant I needed to define my own approach – and in the process – my goal became to re-frame HDI through (at least some) designerly perspectives. Framing and re-framing is a recognised approach to wicked problems [7], [8]. Dorst suggests methods for re-framing (open, complex, dynamic, and networked) problems: *"These design practices are well positioned to help us develop the problem situation, consider a broader context, build a deeper understanding of the underlying factors behind the problem, and most importantly to then create a new approach (or frame) to the problem situation"* [9, Ch.4]. As noted, *"frame creation entails a shift in perception, seeing the problem situation differently than before. This is problematic because the problem-solving capacity in our society is implicitly organized by type of solution, rather than by type of problem."* [9, Ch.7]. In my work, I seek to find ways of steering *"conversations away from specific outcomes to an exploration of deeper situational values."* [9, Ch.3]

Hence, I formulate the goal for my work as:

G: Re-framing human-drone interaction research through a designerly lens.

The work in this thesis is guided by the following research questions:

RQ1: How might ethnographic methods and narratives ground design knowledge in human-drone interaction?

RQ2: How might visual and concept-driven approaches inform human-drone interaction design?

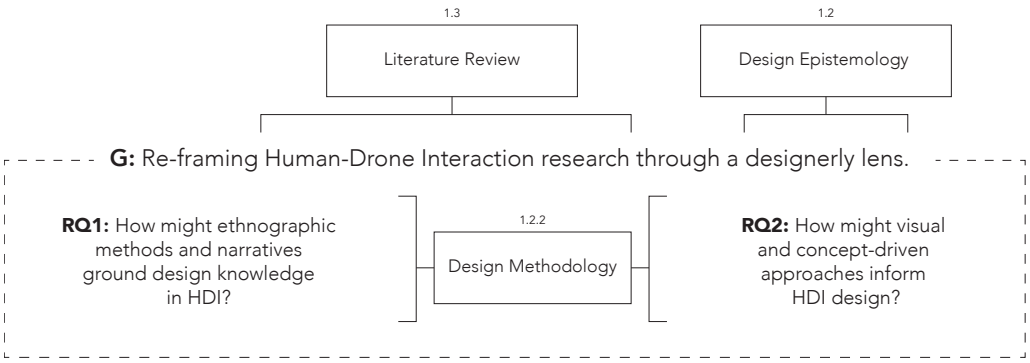


Figure 1.1: Diagram representing the goal of the research and the research questions in this thesis. The concepts given are developed in the sections represented in the diagram.

[1]The double meaning behind the title of this thesis is not incidental – drones fly from the ground up – but I also seek to frame the knowledge in human-drone interaction from a grounded and situated perspective informed by designerly approaches.

[2]HDI is here seen simultaneously as a subset of HCI and a subset of HRI.

This thesis includes therefore four pieces of research, exemplifying ways to surface and re-frame some of the aspects of the wicked nature of interaction design when developing drones which may otherwise be missed. For example, I make extensive use of ambiguity and open-endedness through tools such as narratives and sketching. The methods are poised on phenomenology, and supported by the assumption that any subject of study is a sociotechnical system/assemblage. The processes currently reported in Human-Drone Interaction (HDI) research points towards a general lack of design knowledge in the field, along with the underdevelopment of critical stances, and the absence of ethnographic studies and situated engagements with drones.

Starting through a first-person perspective, I offer a contribution to the gap in research through a longitudinal autoethnographic study conducted with my children. Results indicate design opportunities for drones, but also a challenge to the dichotomy of 'user-bystander' in HDI. The second paper comes in the form of a pictorial narrating in text and visuals a first-person experience during a design research workshop, and what that meant for my relationship with drones as a research material. The third paper leaps into a concept-driven Research through Design project, challenging the solutionist drone and offering instead the first steps in a critical design of the unlikely pairing of drones and breathing. Results are centred on the role of critical design programmes for the framing of drones as companions. The fourth paper returns to the pictorial form, suggesting a method for visual conversations between researchers through the tangible qualities of sketches and illustrations. An application of the method is exemplified by a drawing exchange between two researchers interpreting hobby drone pilot statements gathered through an online questionnaire. This method is developed as a way to incorporate the diffractive and ambiguous nature of visual knowledge in design research.

1.1 Positionality

In line with a feminist approach to research as situated [10]–[12], I disclose my positionality as a framing for understanding the work behind this thesis. My positionality is, in fact, a strong component of the re-framing suggested above. In truth, the work presented here was invaluable as a reflexive activity in order to articulate positionality. As noted by Holmes [13], the current statement is unavoidably volatile, and will change both with time and context.

I was raised in Portugal, in a white family of academically educated public service employees. I attended private schools until enrolling in public university at the age of eighteen. My family always voted in left-wing parties, although nobody was particularly active in the political discourse. I am a member of the Swedish left-wing party and an advocate for socialism. I suffer – since a very young age – from a condition called misophonia, making me very sensitive to certain noises. My background is in arts, with a master's degree in architecture from Lisbon University. At the end of the master's degree, I moved to Sweden to marry a Swedish man, and have since lived in a hetero relationship, and became the mother to three children. I am a cis-gender woman, and my pronouns are she/her.

During my education as an architect I (unknowingly) became a phenomenologist. The degree was poised on philosophies of the primacy of experience and embodiment authored by philosophers, anthropologists, and architects alike [e.g. 14]–[19]. The

tacit and subjective nature of architecture, as well as the necessity for a visual language were undisputed notions. Simultaneously, much of my education was grounded in authors such as Edward Hall [20] and Christopher Alexander [21], who aimed to find ways to create a common language for architects and urban planners.

Due to my academic and personal background, I usually present my stance as follows:

- No separation researcher-research – knowledge is situated.
- Being human is being subjective – I favour the immeasurable.
- No such thing as mind-body dualism – all experiences are embodied.
- All things are entangled – research should be messy.
- Everything is ethics.

1.2 Design as a Discipline and Designerly Knowledge in HCI

Although we thread towards a transdisciplinary approach to Human-Computer Interaction [22], understanding the epistemological tensions present in the field is fundamental to recognise the necessity of continued work in developing design methods and approaches. Design has not always been perceived as a discipline of its own – and its place within HCI is still not a given. Because my background is in design – I present first my own epistemological assumptions grounded in design knowledge[3].

What is remarkable about design, is that it connects theory and practice through artefacts and processes, bridging scientific and creative limits in order to address ill-structured and open-ended problems [23]. As early as 1979, Archer [24] argued for 'Design' as the third area of education, poised between sciences and humanities; defined as "Design with a capital D" which means, according to Cross *"the collected experience of the material culture, and the collected body of experience, skill and understanding embodied in the arts of planning, inventing, making and doing"* [25, p.221]. Cross frames 'designerly ways of knowing' by positioning design as a discipline of its own paired with a particular epistemology, noting that *"we are certainly faced with the problem of being more articulate about what it means to be 'designerly' rather than to be 'scientific' or 'artistic"'*. There are many discourses surrounding ways of knowing in design – for example when contrasting designerly ways of knowing and design thinking [26]. However, *"from an academic perspective, this plurality in discourses within designerly ways of thinking is not a sign of weakness but rather a sign of maturity."* [26, p.132]

It is reasonable to claim that the socio-technical design issues being tackled in HCI can be described as 'wicked problems' [7]. Indeed, Buchanan [8] uses this notion and argues that design tries to get rid of the "wickedness" through placements – *"the tools by which a designer intuitively or deliberately shapes a design situation"* [8]. A placement comes in distinction to a category, it is not fixed: it is a guiding position with negotiable boundaries and yet representing a *"systematic approach to the invention of possibilities"*. As he notes, *"design is a remarkably supple discipline, amenable to radically different interpretations in philosophy as well as in practice. (...) It is a history of the changing views of subject matter held by designers and the concrete objects conceived, planned, and produced as expressions of those views"* [8, p.9]. What is remarkable about Buchanan's description of conceptual placement is that it is grounded on the assumption that each designer has a a set of placements which they have developed and tested through experience, and that can be described as intuitive or serendipitous. Therefore, the skills of a designer lie in *"natural or cultivated and artful ability to return to those placements and apply them to a new situation"* [8, p.13].

The overlap of humanities and arts, led through a scientific mindset is echoed by Fallman [27]. Figure 1.2 shows a model of what interaction design research can look like, as a triangle stretching towards three different edges described as 'design practice', 'design studies', and 'design exploration'. Fallman's argument is that while the methods can be similar, research in positioned within these triangles

[3]This decision to structure the thesis as such was curiously questioned more than once by those around me. For them, HCI is the umbrella term and design a subset of it. However, I see design first as an approach and lenses to see HCI. Hence, I saw it more fruitful to present it first.

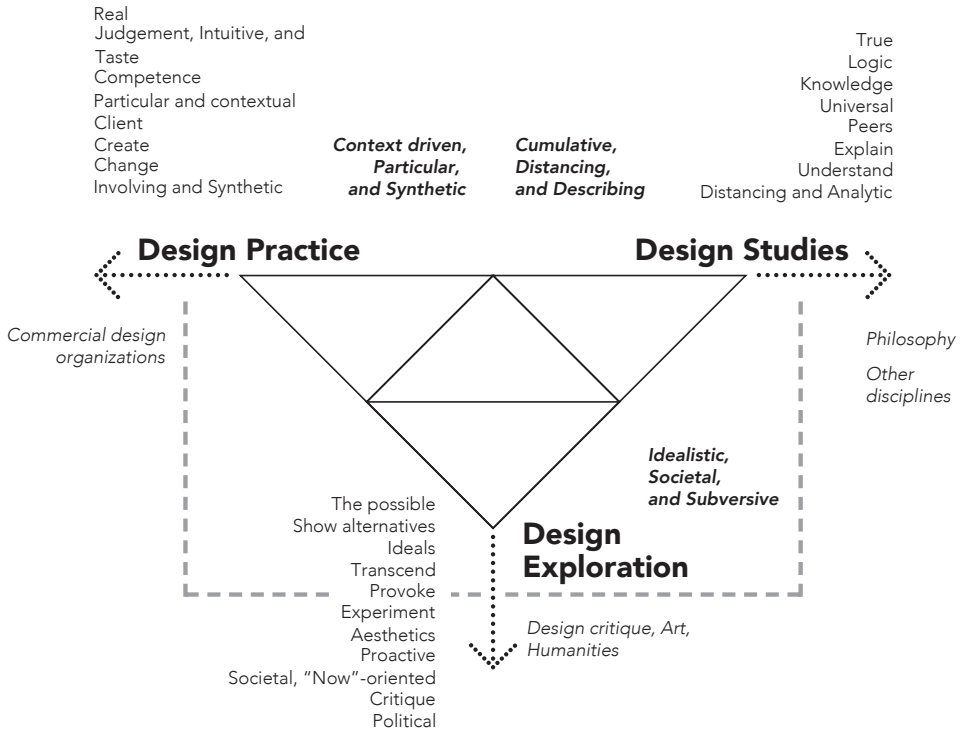


Figure 1.2: A "more complete model of interaction design research" as presented by Fallman [27]. Re-drawn from the original paper.

differs in tradition and perspective. My work navigates precisely these triangles, presenting different perspectives, and grounded in different traditions.

In my work, however, I seek ways to stay with the wickedness. In what could be described as 'staying with the trouble' [28]. The position as a designer is framed by my background as an architect, where the embedded artistic and poetic way of thinking, making, and feeling are an accepted and applauded way of working. In *'Thinking Architecture'*, Zumthor writes:

> "There was a time when I experienced architecture without thinking about it. Sometimes I can almost feel a particular door handle in my hand, a piece of metal shaped like the back of a spoon. I used to take hold of it when I went into my aunt's garden. That door handle still seems to me like a special sign of entry into a world of different moods and smells. I remember the sound of the gravel under my feet, the soft gleam of the waxed oak staircase, I can hear the heavy front door closing behind me as I walk along the dark corridor and enter the kitchen, the only really brightly lit room in the house." [29, p.9]

These notions travel through the architect and formalise themselves often into new designs, practically traversing time. This too happens in other design fields, more or less explicitly. There was a time when I experienced drones without thinking about it.

1.2.1 Design Epistemology

Design is indeed a discipline on its own, and like any discipline, it has its own set of theories and practices. One way to tackle the difficulties that arise from the combination of theory and practice in design is to approach the discipline in a holistic manner, taking into account both the theoretical and practical aspects of the field. This means considering both the conceptual and the technical aspects of design, and striving to find a balance between them in. However, these negotiations bring issues in what is considered knowledge within the discipline – a discipline's epistemology.

The concept of 'reflective practice', introduced by Schön [30], focuses on the reflective aspects of practice-based work as a way of learning. For him, the experiences gained by being a practitioner are insufficient to result in knowledge – it is only through reflection upon and with the experience that design knowledge can surface. Schön identified two types of reflective practice: *reflection-on-action*, which involves reflecting on past experiences and actions to evaluate what could have been done differently, and *reflection-in-action*, which involves reflecting on actions during the process of designing, and using knowledge of best practices to guide decision-making. The latter relies on improvisation but also the ability to constantly adopt a critical posture. Reflective practice is important for developing skills in design, as it allows practitioners to evaluate their experiences and make informed decisions. Schön's ideas on design epistemology, including tensions between *technical knowledge* and *artistry*, are still influential today. Connecting back to my work, many of his notions were defined through observations of architectural practice – I suffered personally from his critique of higher education. He believed that institutions of higher learning often do not adequately prepare practitioners to handle improvisation, and suggested that a focus on educating reflective practitioners would be more beneficial than letting technical rationalism and positivism drive the wheel. Schön's message exhibits "distrust and dislike of positivism" [30], emphasising rather the importance of experience in the creation of knowledge. Reflective experience of design practice is but one way of attempting to bridge tacit and explicit knowledge.

Stolterman [31], [32] has been influential in making explicit that design practice challenges the experimental nature of complexity and rigour. As such, design does not deal with what is true (universal or generalisable knowledge such as statistics coming from controlled experimental studies/trials) but with what is real (particular or concrete knowledge, such as a perspective, context, and temporal notions)[33]. See Figure 1.3 for a visual explanation of this relationship. These difficulties in negotiating rigour become tangible in reconciling the nature of design practice with interaction design research, and transferring scientific methodologies and approaches to design practice may not be suitable. Stolterman argues that *"it is possible to predict the potential success of new approaches, methods, and tools based on how designerly they are"* [31], giving the example of the notion of *affordance*, as a tool to be used as inspiration in design practice rather than prescribing action.

As with any other research field, there are mainstream frameworks within HCI which generate what can be considered accepted knowledge [34]. This is what Kuhn would call normal science [35]. Many of these designerly tools or methods tend to fall outside of the mainstream approach, but have the potential to become widely appreciated. Non-prescriptive high level approaches such as user-centered

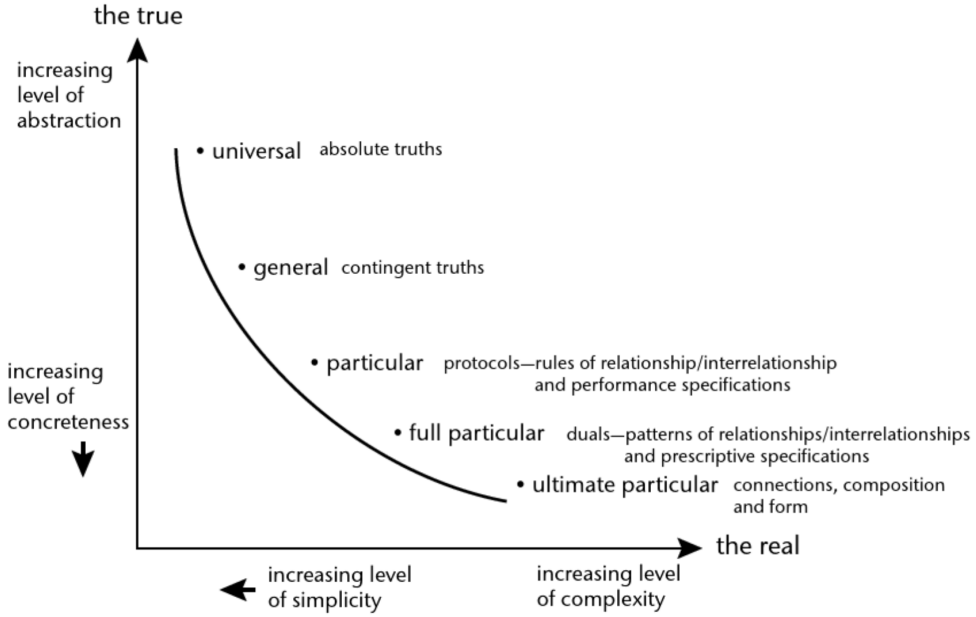


Figure 1.3: Graph illustrating the difference between Design and Science. Design does not deal with what is True (universal or generalisable such as statistics) but with what is Real (particular or concrete such as a perspective). The intention of design is not to replicate or reproduce knowledge but to shape reality (etc). Illustration from the book *'The Design Way'* by Nelson and Stolterman [33].

design are a great example of that. It is important to remind ourselves that research conducted well within a paradigm tens to lead to assumptions with more or less visible impact in what types of knowledge is accepted within a field. This may result in homogeneous types of argumentation supporting certain embedded beliefs [36], [37].

Designerly approaches have instead the great ability to break assumptions and prioritise critical thinking over simplification, for example through re-framing. While many activities that benefit a designerly stance may at first be considered fringe [35], they are essential to articulate situated knowledge [10] through unique lenses.

In this thesis, I choose to build on a variety of methods that have been seen as outside the mainstream in HCI, and started their journey from fringe activities [34], towards a wider acceptance. There are well known pieces of research, such as authored by Frayling, describing different approaches and contributions of design research [38]. The role of design theory and critical design has been presented as an important contributor to HCI [39], challenging a certain coherency and widening the possible goals of research within the field. However, we do know that the presence of competing paradigms of inquiry is beneficial and generative, where *"each paradigm orients to a particular kind of research program, and admits different objects and activities into its mode of enquiry"* [40, p.3543].

Redström's book *Making Design Theory* is dedicated to revealing the possibility of design practice to also be about making theory: *"exploring the idea that as design research engages in making many different kinds of things, theory might well be one of those things it is – or could be – making. And so the question is, what design theory could be made in research through design?"* [41, p.1]. However,

the theory making of design is not like that of other disciplines. There are two points from this book I would like to bring forward as they are essential to my work. First, it is the distinction between a *definition* and a *proposition* when considering design theory is often 'transitional':

> "Consider completely letting go of the idea that what we offer are different definitions of what design is, and instead just refer to them as different propositions. Would that help? It would certainly cast the idea of 'unified theory' in a different light, as an ambition to achieve 'unified propositions' sounds far less exciting. At the same time, however, it certainly feels as if something more is at stake here. Consider a more concrete definition made through design: having created this object for you to sit on, I can, of course, *present* it by saying, I'd like to *propose* that this is a chair,' but this is not quite the same as to say, This *is* a chair." [41, p.138]

The second is connected to the idea of artefact as a carrier of knowledge:

> "When our objective is to uncover and articulate the general, the exception becomes a problem, a disturbance or nuisance. In statistical analysis, for instance, extreme outliers are more likely to be considered extraneous experimental errors than actual data. Indeed, when studying what is, what is created during the process of observation is often considered a problem – and thus the notion of 'artifact' is used, along with other notions such as noise, to denote errors stemming from the experimental setup. When we turn to the artificial, to the artifact not as error but as intention, the issue of exception is also reversed." [41, p.140]

This thesis is therefore composed of a collection of artefacts, be them in the form of design ethnographies [42] or prototypes [43] – intentionally looking to be the disturbance or nuisance rather than the point of convergence. The work presented here is often at odds with the positivist expectations of scientific research, engaging instead with the particular.

1.2.1.1 Phenomenology

Within the understanding of (interaction) design as its own epistemological island inside HCI, there is an unavoidable connection made to phenomenology, particularly through the notion of embodiment [44], [45]. There is no place here to dig deeper into the philosophy, but it is nonetheless essential to know that the work in these pages is tightly connected to Merleau-Ponty's phenomenology of the *lived body* [46]. Interaction design is deeply engaged with understanding experience [47]. In this case, even the embodied experience of design processes is a valuable input for design theory. Merleau-Ponty is influential in HCI, with many researchers referring to the importance of a unified view of the body (refusing the Descartes' dualist ontology of mind and body). Within HCI, Svanæs discusses the concept of embodiment connecting it to recognising the importance of the designer's first-person experiences of design artefacts, both through analysis but also throughout the process of design. As noted *"if we take Merleau-Ponty's perspective seriously, we need to stop talking about the user's body. Users do not have bodies; users are*

living intelligent bodies. The concept of the user as an intelligent living body is hard to grasp." [48, p.8:25]

As Svanæs points out when discussing interpretative social sciences relying on phenomenology, *"valuable theoretical contributions can result from reflections that do not originate from a 'scientific' basis of hard data. In the present context, the value of the theoretical contributions must be judged by their applicability to real problems, and by the extent to which they have explanatory power and provide inspirations for design. Others will have to make that judgement."* [48, p.8:27]

The results presented in this thesis are open to interpretation of others, but include abundant dedication in expressing reflections and presenting the issues in a manner that can be inspiring to others.

1.2.1.2 Waves in HCI

Human-computer interaction (HCI) is often debated in terms of whether or not it falls within the discipline of design. There have been many discussions about the epistemology of design knowledge and its relationship to HCI [31], [34], [48], [49]. Some argue that HCI is a part of design, while others resist to the types of design knowledge and their unclear contribution to HCI. These debates often center around the role of HCI in shaping the user experience and the ways in which it intersects with other design disciplines. Ultimately, the relationship between HCI and design is a complex and nuanced one that continues to be a topic of discussion and debate.

The field of HCI has gone through at least three waves or paradigm shifts with marked effects in the applied methods. In short, the first wave is tightly connected to engineering and human factors, particularly dedicated to avoiding human error. The ultimate goal is to *"optimize the fit between humans and machines; the questions to be answered focus on identifying problems in coupling and developing pragmatic solutions to them. Occupying the center of the first paradigm are concrete problems that arise in interaction and cause disruption (...)"* [50, p.3].

The second wave represents rational approach to human-computer interaction, grounded on an understanding of the human mind and cognition as a computer, and how these two coupled processors handle information. Research prioritised causality and finding central tendency [50]. Essentially, from the first wave to the second, the focus shifted from issues of control and error prevention to issues of communication and efficiency [51]. Popular evaluation methods such as cognitive walkthrough surfaced to fit this wave.

The third wave is composed of many perspectives informing the study of interaction as phenomenologically situated. *"The goal for interaction is to support situated action and meaning-making in specific contexts, and the questions that arise revolve around how to complement formalized, computational representations and actions with the rich, complex, and messy situations at hand around them. Because of its emphasis on multiple meanings made in context, we term the third paradigm situated perspectives."* [50, p.8]. The third wave recognises the prominence of relationships and meaning-making between humans and machines in context. This wave brings an emphasis on experience as the primary object of study, bringing to surface the issues of subjective experience. Many methods within ethnography and participatory design serve well to study within this tradition.

We move now towards what can be called the 4th wave, or entanglement

HCI [52]. This wave shifts the focus towards a political, ethical, accountable view of research. There is also an interest on including more-than-human design (MTHD) methodologies, driven by a world in environmental crisis, and including actors such as things, animals, or robots [53]. As a personal critique to this wave, the heavily philosophical grounding may alienate many of those who do the practical work. Coulton and Lindley [54] offer an excellent example of how IoT demonstrates the need to consider more-than-human perspectives. They use the metaphor of a constellation to frame a speculative design illustrating one example of the complexities of IoT and how their metaphor could be applied: *"this metaphor represents the idea that, as with the cosmological constellations in the night sky and their constituent stars, IoT things are simultaneously 'stars' in their own right, as well as being part of groups, or constellations. Depending on what perspective an observer takes, how these constellations appear varies wildly."* [54, p.473] But as they state: *"Articulating how a metaphor impacts on design work, as with articulating what it is to 'do design', is more of an art than a science. Hence, though we cannot didactically tell the reader how the constellation metaphor 'should' be applied in terms of a step-by-step method, the following commentary is intended to put flesh on the skeleton described thus far and give one example of how it could be util."* [54, p.474]

Resonating with the message of more of an art than a science, this thesis lies on the verge between these two last waves, navigating back and forth. I will not delve into what the 4th entails, but acknowledge the direction of the work in HCI. The work I present seeks to find translations from the complexity of design philosophy through combinations of methods. The methods used in this thesis paint a picture that sometimes is in detail, and at times an overview. More importantly, my work is grounded on lifting situated knowledge [10], [11] to the limelight, often through unexpected means of knowledge creation. I am not attempting to be objective or unbiased, but rather transparent about which situations led to the research currently present. Below, I give examples of how the methods applied transition between these waves.

1.2.1.3 Systems Theory and Sociotechnical Systems

Historically, the notion of *Systems Theory* has been important to support a holistic, and yet delimited approach to research. One of its most important contribution is precisely the definition of system boundaries – and the premise that design processes should take in account both the technical and social factors of computer-based systems. The human factors and ergonomics community has been particularly active in developing research supported by Systems Theory frameworks, when in connection to applied cases in workplaces or other complex organisations or contexts. There are a number of theories within Systems Theory that have been generative for HCI, one example being Activity Theory [e.g. 55]–[59]. Both could be considered as perspectives on 'soft systems' [60] (See Figure 1.4). The difference here is that *"hard systems thinking assumes that the world is a set of systems (i.e. is systemic) and that these can be systematically engineered to achieve objectives. In the soft tradition, the world is assumed to be problematic, but it is also assumed that the process of inquiry into the problematic situations that make up the world can be organized as a system. In other words, assumed systemicity is shifted: from taking the world to be systemic to taking the process of inquiry to be systemic"* [60, p.S49]

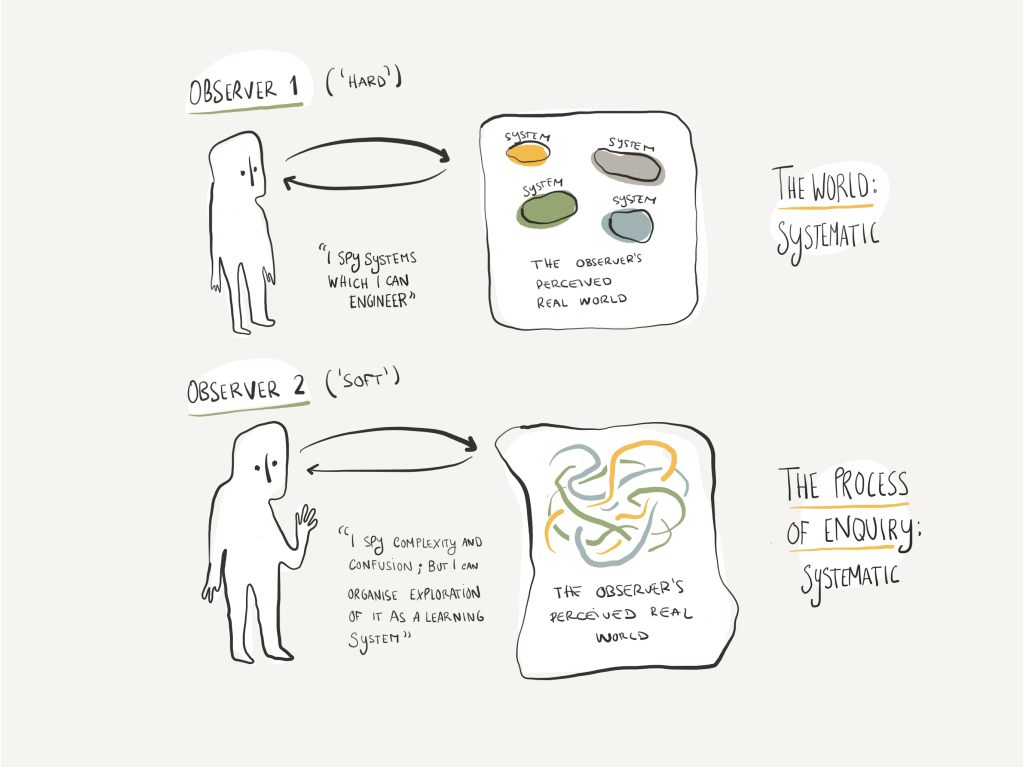


Figure 1.4: Illustration of the hard and soft system stances. Figure redrawn from Checkland's paper [60].

This idea may seem almost rudimentary for designers – but I find the theory surrounding system's theory and in particular 'soft systems' to be helpful when establishing groundwork for research in multidisciplinary teams. In a perhaps too harsh manner, Norman and Stappers, when discussing complex sociotechical systems, comments that *"engineers have been heard to say 'if it weren't for people, our systems would work just fine,' usually uttered after some accident has been blamed on 'human error.' On the contrary, when it comes to complex systems, if it weren't for people, the system wouldn't have worked at all."* [61, p.86] As exemplified by Kirwan [62], the application of StS and 'soft systems' seems to have more uptake when studying large systems such organisations and industries [62], but 'soft systems' can be found anywhere and on any scale.

The field of HCI is centred on the design of computational things – not just the technology – but the sociotechnical systems. Therefore, it is necessarily poised on the verge between many disciplines, which makes for a difficult description of what the research is actually concerned with. Baxter and Sommerville believe that *"... it is not enough to simply analyse a situation from a socio-technical perspective and then explain this analysis to engineers. We also must suggest how socio-technical analyses can be used constructively when developing and evolving systems. (...) We must avoid terminology that is alien to engineers, develop an approach that they can use, and generate value that is proportionate to the time invested."* [63, p.4] While this perspective seems to assume that an engineer is unable to do some of the translation work themselves, or that they are too busy to care, it is still a valid endeavour to make sure to not alienate other disciplines through vocabulary. The use of perspectives presented under sociotechnical systems may be a good strategy

to make clearer some of the 'softness' of systems, as well as negotiating levels of abstraction balancing for example the role of the context and of an individual.

The emphasis of sociotechnical system research has been on complex organisational systems. But smaller arrangements of technology, humans, and other agents, can be as complex. Silverstone denominates "domestic socio-technical systems" when studying the combination of once static (and now mobile) everyday technology such as televisions, telephones, computers [64]. As noted, '*'families are social units, systemic, more or less clearly bounded through networks of kin, more or less coherent or secure in the patterns of relationships through which they are defined, but the basis from which individual identities are forged and sustained."* Hence, *"the domestic socio-technical system consists of a bundle of skills, tastes and competences, expressed in styles and practices that construct and mark the cleavages of gender and age-based relations within and beyond the household"* [64, p.138]. These arrangements have implications both for the possibilities of design but also for research within HCI. For example, Slovák, Theofanopoulou, Cecchet *et al.* incorporate the multiple stakeholders in families in order to inform the design of a robot for children [65]. Their work is an example of how designing for and with children involves more than just the children themselves or the robot on its own. *"The principles of socio-technical design then apply on multiple levels: how the (technology-enabled) intervention becomes embedded into the current practices of an individual or the family unit; which mechanisms are assumed to lead to shift of these practices; and on which timescales and through which 'levers' this happens in the family context."* [65, p.160:6]

As a related notion – the concept of sociotechnical assemblages is widely used [10], [11], [66], [67]. In particular, Latour's 'matters of concern' describe the understanding of scientific and technological assemblages as something beyond objects but rather fluid arrangements of political and social interests [68]. The frameworks usually described under the label of sociotechnical systems represent the potential inability to incorporate the changing nature of assemblages (even if time is one of the aspects of the framework), but strive often to catch some of the parts of a system that may otherwise be neglected. As I see it – it is less helpful in design epistemology to strive for the use of a single unifying framework, and prefer the capacity to tolerate a multiplicity of approaches that may aid in re-framing knowledge in a pluralistic manner while still making bridges between multiple disciplines.

1.2.2 Design Methodology

What methods should be used to tackle what is possible to know (epistemology) within design is a large portion of a both a designer's and researcher's job[4].

[4]Years ago, when I attended my first course in Interaction Design Methodology, we were instructed to devise a toolbox of methods. The aim of the exercise was to consider what is important to know about methods to be able to correctly sort them and pick the most appropriate one for the situation at hand. My first go at the exercise was a tangible slot machine: at the time I was convinced the best attempts at sorting methods were already done, and that we should rather just give ourselves the playful mission of incorporating random methods into the design process. As part of the final exam in the course, we were asked to redesign said toolbox. I eventually wrote that I had understood that the most important way of sorting methods is by recruiting diverse people into design teams: we bring through the interdisciplinary combination of individuals the possibility for people themselves to be the toolbox. This brings great advantages, as we become experts in the methods we practice. I am of the opinion that often we hide the

There are many expectations as to what the output of research ought to be, and as discussed above, within HCI, there are mainstream ways of tackling these expectations. The methods described in this subsection gained a place here in many ways, often to fill a methodological research gap in Human-Drone Interaction as discussed in Section 1.3, but at times by mere chance of being the methods that I was interested in at the time.

When the work included in this thesis started we were still suffering from effects of the COVID-19 pandemic. Ethnographic studies were particularly difficult to conduct, for example. I place the description of some of the methods here as an introduction to what types of approaches were considered in my work, leaving out however descriptions of common methods such as interviews. This section is non-exhaustive and leaves outside many other relevant methods tried during the process, focusing instead on the most fundamental methodological discussions that surface through my work.

1.2.2.1 Ethnography

Ethnography, in its many forms, is a method widely used in third wave HCI. The issue of validity of empirical studies evaluating systems has been debated for decades [e.g. 69], [70]. Empirical research conducted in context of use is widely seen as more valuable from an ecological validity perspective, for example through the use of ethnography, particularly when aiming at triangulation through mixed methods [71], [72].

The issue of the compatibility between ethnographic research and design work is central to the practice-driven and pragmatic attitude usually preferred within the field of HCI [73]–[77]. Dourish questions in particular the use of ethnography in his influential paper called *Implications for Design* [77]. The issue here is that ethnographic research, when published in HCI venues, tends to close with an Implications for Design section, being otherwise at the risk of negative reviews. Dourish problematises the idea that such implications became the primary evaluative criterion for ethnographic research – proposing instead that *"what matters is not simply what those implications are; what matters is why, and how they were arrived at, and what kinds of intellectual (and moral and political) commitments they embody, and what kinds of models they reflect"* [77, p.7]. He dedicates considerate discussion to the issue of understanding ethnography as a tool to close the gap between society and technology. But *"seeking to close the gap through the application of ethnographic methods is a contradiction in terms; the gap is where all the interesting stuff happens, a natural consequence of human experience. Design is critical, but designs must always be put to work in particular contexts, adopted and adapted by people in the course of practice"* [77, p.6]. His critique is not that ethnography does not have implications for design, but rather that those implications can be difficult to trace, diffuse, or inappropriate to summarise into a list. The impact of ethnography is in providing new viewpoints in the imagination of relationships between people and technology, drawing on *"on the fundamental repudiation of a traditional separation between designer and user, between technology and practice. To the extent that these implications are not formulated as 'implications for design,' it is because the categories of design, user, and designer, are themselves in question"* [77, p.8].

true reasons as to why a method is chosen in the discourse of a research gap.

More than 10 years later, Khovanskaya, Sengers, Mazmanian *et al.* looked back into this discussion in an attempt to rework the gap between design and ethnography, recognising that design goes beyond the making of innovative things but rather is also a form of inquiry into the world [75]. They use speculative design as a way to 'get design wrong' and 'making tacit ideas and assumptions concrete'. This mixture of design with ethnography as knitted practices resulted in making misunderstandings – here perceived as productive rather than destructive to the research practice.

Along with all these critiques and tensions in the use of ethnography, the spectrum of available ethnographic methods is expanding, necessarily bringing new issues of how they can be made compatible with design practice, but also how they can be ethically applied. All ethnographic methods – participatory, observational, or covert – bring ethical issues in the relationships between researchers and participants [78]. When conducting ethnographic work, there both general concerns in the form of consent and procedural ethics (e.g. [79]); as well as situated issues such as unexpected effects (e.g. over-researching [80]), the need for unplanned action (e.g. micro-ethics [81]), and unexpected intrusions (e.g. sensitive data in the digital age [82]).

Two examples of growing ethnographic methods with their own set of difficulties both in compatibility with design and negotiating ethical issues are cyberethnography and autoethnography. The internet has created a new space for ethnography through social media, online fora, and news articles. It seems that this dear child has many names: cyberethnography [e.g. 83], netnography [e.g. 84], online ethnography [e.g. 85], virtual ethnography [e.g. 86], and probably many others. However, using data from online media is not without ethical issues to be considered [87]–[90].

Another form of ethnography comes in an approach where personal experience and first-person understandings of the researcher are at the centre [91]. Ellis, Adams and Bochner [91] describe how autoethnography challenges the notion of separability between researcher and research product by through the merging of an autobiographical method with the ethnographic one. This method is increasingly popular in HCI, which is unsurprising given the pull to make political agendas more visible in research [52].

The use of the method has had its presence in the field for many years. For example, Ljungblad [92] was part of her own study alongside her participants in using a life-logging passive camera. Höök [93] offered an account of her own practice of horseback riding and how it developed into ideas for soma design. Lucero [94] challenged himself to live without a mobile phone, and through ethnography reports on a set of themes to be considered when designing mobile interactions. Similarly, Homewood, Karlsson and Vallgårda [95], present two autoethnographies on self tracking and propose removal of technologies as a method for fourth wave HCI.

A similar approach (but connected to research through design) is autobiographical design, where probes are used by the designers themselves [96]. Desjardins and Wakkary present a twenty-three month long project of converting a van into a camper van together with her partner [97], and Lockton, Zea-Wolfson, Chou *et al.* [98] develop the notion of autoethnographic 'kits' through the work of undergraduates related to their sleep routines. Yang and Neustaedter [99] report on the use of a telepresence robot to support a long distance relationship during three months.

Autobiographical design serves well as a method to surface insight in intimate contexts. Helms [100] uses the method to surface concerns on more-than-human agents and materials in breastfeeding. Framed by speculative ethic, she also presents notions on the emotional cost of this research with her own bodily fluids [101].Devendorf, Andersen and Kelliher produce, as a community, a set of *design memoires* manifesting in wearable artefacts stories of their personal struggles with motherhood.where stories from their personal struggles with motherhood. These memoires *"can lean against emergent solutionist narratives about technology in early motherhood that I find inadequate for addressing the totality of a complex felt experience."* [102, p.2].

Desjardins and Ball [103] dedicate themselves to finding best practices for autobiographical design in HCI through the analysis of their own work. Their findings discuss: genuine needs, design participation, intimacy, reflexivity, and authorial voice. They offer recommendations for other designers interested in using this method[5]. They reflect extensively on the role of the families as changing roles between participants, users, designers, and many others. Naturally, the boundaries between work and private life become diluted, but *"part of the value of doing autobiographical design is to embrace these dual roles (researcher and everyday person) and to observe new types of reflections emerging from a convergence of thinking"* [103, p.760]. This type of work brings the need for making decisions for example on the use of voice (first person singular, plural, or third person), and what the consequences of that choice are to the written articles [103]. Finally, Desjardins and Ball suggest a set of recommendations for future autobiographical research: sincerity in the 'original stories' that led into the projects but also to intentionally design time into the process to allow for reflection and hindsight; transparency on who are the collaborating and authoritative actors of the research; and inventiveness in the approach to the method [103].

It is important to remember that autoethnography carries a weight. Only researchers in positions of certain power and privilege are allowed the possibility to tell their stories. However, the process is not without a cost to the researchers themselves, both in their personal lives but potentially also in difficulties publishing [104].

1.2.2.2 Visual Methods

While scientific publications have primarily focused on the written format [105], many academic papers include diagrams and other types of illustrations to make clear points on structural relationships and hierarchies. One interesting example of a primarily visual document that came hand-in-hand with scientific and design research is a patent. Hence, the value of visual methods (drawing, illustration, photography, videography, etc) should not be alien to science.

The use of visual methods supports other methodologies and aids in re-framing them, and aiding them beyond traditional and normative boundaries [106]. For example, in the phenomenological framing mentioned above (Section 1.2.1.1, the use of pictures to express embodied experience is justified, at times surfacing the constant re-emergence of the cartesian dualism [107]. Gillies, Harden, Johnson *et al.* found through the use of painting in their otherwise linguistic and text based research that: *"In contrast [to written accounts], the paintings had a looser*

[5]That would be me!

narrative structure, as they were generated in a medium that allowed for the expression of feelings in response to the trigger, rather than a more formulated description of events with the aim of telling a story" [107, p.209]. Visual data is argued to be more ambiguous than verbal:

> "Further, the lack of agreement about the translation of visual symbols, and the fact that we are used to being able to display these symbols in a slippery ambiguous way in order to control the amount of information we reveal, means that analysis becomes as much a matter of translation as interpretation. These features arguably make visual data more difficult to under- stand and interpret than verbal data. How- ever, while these problems and difficulties may be highlighted in relation to visual data, they can also remain problematic in the analysis of verbal data." [108, p.188]

While this can be a bigger issue for many other fields (such as psychology [108]), it is not necessarily an issue for design. Design knowledge favours ambiguity as a resource [109]. More importantly, the use of visual methods is inclusive to marginalised groups, making visible issues of intellectual ownership and ethics [105]. The necessity of considering visual media in research is made more urgent with the popularity of virtual spaces [105] – and hence a good match for the ethnographic methods mentioned in Section 1.2.2.1.

Design knowledge is often communicated through the combination of visual media and text [110]. Blevis has contributed extensively to HCI in clarifying the roles that visual thinking may take, for example as a material of interaction design, as a contrast and synthesis of analogue and digital world, as a form of information, as mechanisms of identity, or as documentary observation and photo-ethnography [110]. Returning to ethnography and its logical connection to visual thinking: *"the most important concern of still-image making, in a professional sense, is to make sense of the world and reveal what is extraordinary and meaningful about everyday scenes"* [110].

As noted, images play a definitive role for designers as *"as a key component of professional presence and portfolio construction"* [110]. For example, annotated portfolios [49] are a popular way of documenting the design processes in a manner that makes design particulars useful and understandable to others[6]. In the context of design practice, rigour is exhibited through systematic and careful documentation of the process. Often, such documentation comes in visual form through for example sketches, photographs, diagrams, illustrations, and videos – often paired with an annotation or explanation of their relevance.

All of these visual forms bring their specific set of characteristics. Sketching, for example, is commonly recognised as a technique intrinsic to design practice [111]. There is more to sketching and drawing than the final product, it is often the conversational process that conveys value: *"Drawing is both an active and subjective engagement, valued by artistic researchers, not only for what may finally be encrypted in the drawing, but more significantly for the access provided through drawing to thinking that is close to the unconscious"* [112]. This dialogical nature of sketching is a common notion [113]. As Goldschmidt notes: *"The self-generated sketch talks back, and its backtalk reflects some of the sketcher's innermost, tacit,*

[6] I offer a more extensive discussion on intermediate-level knowledge and making design particulars contributions to knowledge in Sections 2.3 and 3.2.

otherwise untapped knowledge, biases, concerns, and preferences" [114, p.87]. This makes sketching an excellent tool for, for example, first-person methods.

Ings describes these effects beautifully as a justification to the notion of enstasis – a meditation-like state when drawing:

> "In design research I would suggest enstasis might refer to an induced interior state of self hood where one dwells in the creative potential of what is not yet formed. This process may involve the deployment of drawing in a slow, reflective process that allows the designer to become immersed in the world of the emerging image and story. In this approach, thinking becomes contemplative; the designer converses with drawing and the drawing talks back to him. This talking is generally more nebulous than literal. One talks in tone and weight, emphasis and potential. Ideas are coloured and lit and their parameters are nuanced. Thinking is not prescribed by the territorial limitations of words. Images operate with a more flexible grammar and one is able to connect possibilities in comparatively abstract and intangible ways." [115, p.2.4]

The field of HCI is aware of role sketching plays. Buxton and Buxton's seminal book in *'Sketching User Experiences'* is widely used both in research and in the education of interaction designers [116]. Sketching is also an integral part of ideation techniques [117]. To be able to quickly represent ideas is essential to become proficient in common methods used within HCI such as storyboards and paper prototypes. As an example of research hinging on sketching, Koulidou, Wallace, Sturdee *et al.* present dialogical sketching as a participatory design method, arguing that it supports and enriches the use of probes by facilitating discussions and maintaining sustained engagement [118].

But as noted by Sturdee, Lewis, Strohmayer *et al.*,

> "The current lack of perceived value, support and training for creative practice within HCI remains the biggest limitation of the approach. Sketching and drawing is often seen as a "soft" skill, of lower value than technical practices and outputs such as coding and writing, or a 'hobby' – but we show here the added value they can bring to the research table." [119, p.11]

They argue that sketching practice have a role supporting more-than-human approaches in HCI, adding value to ethical and futuring enquiries [119], definitely positioning sketching as an essential technique for 4th wave HCI [52].

The ACM CHI Conference on Human Factors in Computing Systems, which is the premier international conference in HCI, has had multiple workshops and courses dedicated to sketching [e.g. 120]–[134]. Within ACM there are many forms of publication that rely heavily on visual methods, even though full papers and text are still perceived as more important than any other contribution. But most remarkably, pictorials have become increasingly popular – as a sign of the growing acceptance of designerly visual knowledge in the field. Pictorials started in 2014 at the ACM Designing Interactive Systems (DIS)[7] and continued to successfully spread across other HCI venues such as the ACM International Conference on

[7] https://dis.acm.org/2022/

Tangible Embedded and Embodied Interfaces[8] (TEI), and the ACM Conference on Creativity and Cognition[9] (C&C). There are a number of pictorials visually discussing the pluralistic, unresolved and yet incredibly generative tensions between theory, text, artefact creation, visual documentation, and design knowledge in HCI [e.g. 119], [135]–[139]. Sturdee and Lindley present a curated pictorial exhibiting the arts practice of a range of HCI researchers, reflecting on the relationship between creativity and computing, and exemplifying how artistic narratives in HCI contribute to a desirable plurality, encouraging other researchers to make hidden artistic practices visible [140]. These examples agree on the necessarily incomplete, open-ended, situated, subjective, speculative, and qualitative nature of design knowledge which is compatible with visual methods.

The emergence of pictorials within these popular HCI conferences is a clear advancement in the field towards the inclusion of visual methods as a respected and rigorous approach to research. The ACM DIS call for Papers and Pictorials describes them as:

> "DIS pictorials are archival publications in which the visual components (e.g., diagrams, sketches, illustrations, renderings, photographs, annotated photographs, and collages) play a significant role in conveying the ideas and contributions in addition to the accompanying text. Pictorials leverage the power of visual communication with the effective use of high-quality images. They may have a practical or theoretical nature or both. As design perspectives have increasingly become integrated in HCI practice and research, new approaches are needed to communicate design practices, processes, products, and artefacts to the HCI community. Through pictorials, researchers, practitioners, industry professionals, artists, designers, and students from various disciplines, including interaction design, engineering, computer science, product design, social science, media studies, and the arts are encouraged to express and unpack their design practices and projects in visually rich ways. The pictorials format helps foster discussions among authors, conference attendees, and the wider community by sharing novel methods, insights, and lessons learned from engaging in or with the design of interactive systems and artefacts." [10]

At the ACM C&C conference the following is found: *"Pictorials are papers in which the visual components (e.g. annotated photographs, art work, collages, diagrams, field notes, illustrations, photographs, renderings, sketches) are the primary means of conveying information with at least, if not more, importance as the accompanying text. Pictorials are part of the technical program. Pictorials are equivalent contributions to Full Papers in every way (e.g. production standards, archival qualities, reviewing standards, presentation times, institutional reporting). The differences are in the format."* [11]

Therefore, to fully emerge myself in the explorations of visual knowledge in HCI, I have included two pictorials as part of the appended papers in this thesis. In the context of my research in HDI, the relevance of visual knowledge can not

[8] https://tei.acm.org/2023/participate/pictorials/
[9] https://cc.acm.org/2022/pictorials/
[10] https://dis.acm.org/2022/papers-and-pictorials/
[11] https://cc.acm.org/2023/pictorials/

be neglected. Drones themselves are often used as tools for the production of photography or other imagery.

1.2.2.3 Narratives

Stories are a cornerstone of life. *"Story is central to human understanding—it makes life livable, because without a story, there is no identity, no self, no other."* [141, p.505] Hence, storytelling ought to be a natural component of research. Many common methods within HCI – such as for example use cases, personas, and scenarios – already make use of narratives as an essential component.

Narratives are a natural result of ethnographic methods – and exhibit some resistance in their analysis. They tend often be analysed and summarised into themes through thematic analysis (TA) [142]. Preserving narratives along with the themes is a good strategy to present reflexive thematic analysis [143] – allowing for the above-mentioned tensions between ethnography and the knowledge it produces. Braun and Clarke note that *"Reflexive TA has been used in case study research, where the focus is on a small number of cases, or even one case (e.g., [144], [145]). Furthermore, some researchers have combined reflexive TA with narrative methodologies and procedures to produce distinct 'hybrid' methods that are concerned with both narrative structure and 'across case' patterning of meaning (e.g., [146], [147])"* [143, p.13]. These hybrid approaches have the potential of being helpful in design research, which is usually not concerned with the narrative structure or use of language, but rather dedicated to understanding experience in its many forms.

It is important to remember that:

> "The narrative text refuses the impulse to abstract and explain, stressing the journey over the destination, and thus eclipses the scientific illusion of control and mastery; and the episodic portrayal of the ebb and flow of relationship experience dramatises the motion of connected lives across the curve of time, and thus resists the standard practice of portraying social life and relationships as a snapshot. Evocative stories activate subjectivity and compile emotional response. They long to be used rather than analysed; to be told and retold rather than theorised and settled; to offer lessons for further conversation rather than undebatable conclusions; and to substitute the companionship of intimate detail for the loneliness of abstracted facts." [148, p.744]

As HCI moved from the lab to the field, qualitative research surfaced often in the form of narratives. Methods pertaining the social sciences have an increasingly prevalent role in HCI – the project I belong to is dedicated to understanding technology from a societies and humanities perspective. It is undoubtedly relevant to my work: *"narrative research is particularly useful for exploratory research projects, which seek to engage with experience and meaning-making processes of diverse individuals or groups"* [149, p.299]. Golsteijn and Wright note however, how although narratives are fairly popular in HCI, they are often restricted to an outcome or goal of design research *"rather than being fully embraced as a research approach across the entire process"* [149, p.299]. However, with the raising popularity of a variety of longitudinal ethnographic and autoethnographic methods, we see more holistic narratives surface in the field. Núñez Pacheco and Loke for

example, present narratives of use through focusing as a method to facilitate articulation of tacit experiences [150]. Narratives are a favoured way to explain intricate embodied experiences, particularly when they challenge the mainstream or the familiar [151]. They can be composed of text, imagery, or most likely in HCI through the use of designed artefacts, a combination of both [e.g. 92].

The practice of design is also strongly grounded in fiction: *"Some HCI work also included entirely fictional narratives developed in the process of design. Design is a fundamentally imaginative act that involves picturing the world as other than it is. Many forms of design (e.g. scenarios, personas, sketches, speculative design and design fictions) can be thought of as research fictions, in the sense that they are imaginative responses to questions"* [152, p.5400]. In an *Interactions* column, Tanenbaum explains why HCI should care about stories: *"The interpretation of a reader or viewer – what we might call the user experience – is equally important. Good design fictions incorporate the elements of good storytelling alongside an understanding of how readers interpret and understand narratives to create compelling (and believable) fictional worlds around an imagined technology."* [153, p.23]. Blythe analysed which types of plots researchers make in HCI design fiction [152], and calling for more proficiency in becoming more purposeful in picking which plots we construct in our research.

Stories and narratives generated through ethnography and situated engagements with technology bring the great advantage of opening up for relatable and more engaging representations of research. But they are not without ethical issues of their own in terms of for example vulnerability of participants [e.g. 149], [154]. It is the role and duty of the researcher to be able to negotiate disclosure and consent during the research process – always remembering that the stories captured in research are often presented with ending conclusions – but all of these are provisional. The stories do not stop beyond research, and the lives of those researched keep being lived.

1.2.2.4 Research through Design

The theory-practice tensions presented above are also represented in the type of work that is produced in research. Frayling identifies three ways of approaching research in arts and design: research *into* design, research *through* design, and research *for* design. The first encompasses the ground-laying work of information and reference material gathering done to feed into the design itself in order inspire and justify design decisions. Research *into* design is the work dedicated to studying the practice of design. Much of the work presented in this thesis falls within these two categories. But along with them, there is research *through* design – research done through practice and craft, through exploration and manipulation of the design material.

Research through Design (RtD) is now a substantial tradition within HCI, owing largely to the theoretical scaffolding established in the last two decades [49], [155]–[158]. Said manipulation of materiality is precisely what defines RtD. While it is easy to understand why exploring materiality is important for example to a furniture maker, it is less obvious what its role is in computational matter. However, materiality is precisely as important, as argued by Wiberg, materiality transcends any distinction between the physical and digital [159]. The definition of materiality in interaction encompasses things such as time [160]. Much of what is RtD is exploring materiality without one unified objective or hypothesis. RtD

is important to the research field precisely because it implies a closing of the gap between practice and theory through making. For a commercial designer, the value is in the artefact itself, but for a researcher there are two important notions to consider: research products and intermediate level knowledge.

To probe into forms of knowledge without a commercial motivation, [161] discuss the difference between a prototype and a research product. A research product is one that exhibits qualities such as: inquiry-driven, finish, fit, and independent [161]. While prototypes are provisional, unfinished, and exploratory, design products are artefacts that are independent[12] and with a finished quality and intention for design inquiry. Research products are designed for actuality, focusing on the design product as is rather than what they may become [161]. But research products are not just about 'use' – they are meant to inform theoretical framings of design. For example, Hauser, Oogjes, Wakkary *et al.* use research products *"to advance the idea of seeing the empirical efforts of research products as an experimental way of doing postphenomenology or in other words doing philosophy through things by making this theoretical framework more intelligible and actionable to other HCI researchers"* [162, p.468]. Research products have in this sense a similarity with 'provotypes', which are provocative prototypes that *"embody tensions surrounding an area of interest, in order to support collaborative analysis of that area and to collaboratively explore design possibilities"* [163, p.389].

The ways of knowing in RtD are not straightforward. Research through Design's produced knowledge is provisional, contingent, and aspirational [164]. One specific way of creating bridges between design knowledge, theory, and exchanges between practitioners and a wider audience is through what is called *Intermediate Level Knowledge*. The design-oriented and playful practice presented in this thesis brings implications in terms of knowledge creation, which must be contemplated throughout the research by supporting a transparent documentation of the RtD process but also a careful consideration of the 'showroom' as a possible platform for the interpretation of our design experiments and how it can inform the development of different forms of intermediate-level knowledge. Koskinen, Zimmerman, Binder *et al.* suggest that RtD in the 'showroom' tradition *"relies on debate,"* enriching communication about how we experience the material world [158]. The work in this thesis includes well studied approaches to the problem of intermediate-level knowledge [31] which *"is more abstracted than particular instances, yet does not aspire to the generality of a theory"* [165]. Beyond guidelines, patterns, methods, and other tools; a common approach to the creation of this abstraction is Gaver and Bowers's *Annotated Portfolios* where visual explanations are paired with reasoning and reflections by the designers [49], [166], [167]. Another example is Höök and Löwgren's *Strong Concepts* which focuses on the expression of abstract ideas that can be appropriated by other designers in a generative manner [165].

However, key many challenges and lost opportunities remain, including the following: (a) The realities of the design process are 'messy' – mismatches between how RtD ensues and how it is reported in scholarly publications are unavoidable. (b) RtD is difficult to penetrate for novices. Practitioners are challenged when they must simultaneously acquire knowledge in its philosophy, in addition to the design challenge at hand, as well as material and craft knowledge. (c) Practitioners are largely disconnected from the world of academic RtD – the nomenclature and

[12] As an architect I would call this an artefact that speaks for itself.

ethos of commercial design research is quite different[13].

Hence, while the overarching philosophy and certain genres of RtD are currently well-articulated, I see a need to advance the discussion on the *process* and *purpose* of it – how and why it is done. Rationales for the value of need-driven (i.e. user-centered), vision-driven [168], and concept-driven [32] design research have been well-defined by scholars; while the notion that exploratory research in itself is a valuable contribution [169] is comparatively rare. Indeed, Ishii, Leithinger, Yao *et al.* imply that 'technology-driven' research meant to explore materialities of design is inferior to approaches with specific humanistic, artistic, or philosophical ambitions [168].

But many design researchers would agree that a research project can *begin* as an open-ended 'playful' exploration and converge to a purpose over its course. Exploratory design research can itself generate research contributions, for example: unfinished or discarded prototypes can be picked up by the research community in future work [169]. What we need to understand is instead how to encourage the community to engage with these discarded ideas in a productive way.

When approaching design projects with a RtD agenda, we must understand that the designer themselves are deeply embedded into the process. But at times it may be difficult for the designers to identify what is relevant for their positionality. Therefore, the use of autoethnographic methods tightly weaved with RtD is beneficial, as exemplified by the practice of autobiographical design mentioned above. Ellingson [170] emphasises the importance of considering the embodied experiences of the researcher, including how they feel and how their body is positioned and understood in space. This first-person perspective is particularly important when defining the design space in RtD. However, there can be challenges in analysing the outcomes generated by the researcher themselves and in communicating design knowledge that can be applied in future research.

1.2.2.5 Concept-Driven Interaction Design Programs

As mentioned above in Section 1.2.1.2, the paradigms in HCI have changed. Within these traditions, user-centered design became a favoured approach for most researchers and practitioners. Stolterman and Wiberg argue however that a concept-driven approach (which has been implicit for a long time in the field) can explicitly contribute to a valuable exchange between the production of design artefacts and the development of design theory [32]. They propose *concept-driven interaction design* as defined by:

- "The point of departure is conceptual/theoretical rather than empirical.
- The research furthers conceptual and theoretical explorations through hands-on design and development of artifacts.
- The end result – that is, the final design – is optimized in relation to a specific idea, concept, or theory rather than to a specific problem, user, or a particular use context." [32, p.98]

Here, the distinction is made towards situation driven research: *"Although situation-driven research has a client and a problem to solve, concept-driven*

[13] See: the 'research/practice barrier' described in [155].

research is an exploratory investigation of established theories with the overall aim of improving and widening the range of theory and knowledge." [32, p.102]

In agreement with Stolterman and Wiberg, I consider that many of the design approaches in HCI fall partially or entirely under the category of concept-driven. My research agenda is mostly worried with the construction of future worlds, and the re-framing of the role of drones in society. Therefore, I need to recruit a combination of theories and practices that allow for a plurality and negotiation between particular use contexts and the formulation of theories for future design.

Below, I present a set of design research programs that favour the exchange between concept-driven and situation-driven design. Research programs, as described by Redström, *"characterizes a research programme that it contains a hard core of theories and beliefs that are held to be true"* [41, p.88]. Accordingly, design research programs are provisional combinations of defining world views and design experiments, in constructive expansion (or alternatively, the defining world views no longer suit, discarded). Below, I present some of these programs which have had a strong influence in the papers appended to this thesis.

Soma Design is a design programme [171] framed by phenomenology. It is informed by a philosophy of somaesthetics [172], [173], emphasising subjective knowledge and favouring the 'felt dimension' of experiences. In this philosophy, the division of body and mind (the cartesian dualism) is rejected: we are one unified bodymind – *"the soma – the living, sentient, purposive body – as the indispensable medium for all perception"* [174]. Within soma design, anyone involved in the process of designing or using interactive 'things' [175] are expected to cultivate and be engaged in their sense of (soma)aesthetic appreciation towards living better lives. Therefore, it is central to this design program to engage in movement, feeling, and in curiously exploring the connections between our soma, the world, and others. Teaching soma design [176] exhibits dimensions of temporal considerations, involving exercises that vary from slow to fast, contradicting much of what is favoured in many trends of design thinking (e.g.: agile and sprints). Soma design does not try to generalise experience, instead focusing on the pluralism of bodies [177] and how well documented experiences can contribute to a generative collective understanding of what designs are desirable. There are a number of methods habitual within this program, one example being body maps [178]: a technique for discussing bodily experiences through drawing them on a piece of paper prepared with prompts and the outline of a human body. Another common method is expert interviews with somatic connoisseurs [179]: people with in-depth knowledge of a bodily practice. First-person methods are also favoured and embraced [180]. It is also common to attempt to disrupt habitual [181] through defamirialisation methods [182] and estrangement [183].

Soma design relies on a number of conceptual and foundational groundings such as the concept of *Somaesthetic Appreciation* [184] – four qualities to be considered both during the design process but also expressed in the final artefact: 'subtle guidance,'making space,' 'intimate correspondence,' and 'articulating experience'. Another guiding pillar is the Soma Design Manifesto as developed by Höök [171]:

- "We design for better lives - not for dying
- We design to move the passions in others and ourselves
- We are movement, through and through

- We design with ourselves - through empathy and compassion
- We design slowly
- We cultivate our aesthetic appreciation
- We disrupt the habitual & engage with the familiar"

This manifesto connects well with Slow Technology, and is a useful set of thought-provoking and challenging prompts to design in HDI.

Slow Technology is *"a design agenda for technology aimed at reflection and moments of mental rest rather than efficiency"* [185] proposed by Hallnäs and Redström. In short, this design program departs from conventional approaches to interaction design such as optimisation for efficiency and usability. It instead puts *"focus on slowness of appearance (materialisation, manifestation) and presence – the slow materialisation and design presence of form"* (F); and *"focus on aesthetics of material and use simple basic tools of modern technology – the clear and simple design presence of material"* (M) [185]. Slow technology seeks to develop artefacts that support meaningful reflection, presence, and at times inefficiency rather than 'use' [186], [187]. There are three conceptual themes that support this core vision: 'reflective technology', 'time technology', and 'amplified environments' [185]. [188] extended on Hallnäs and Redström's initial ideas through the analysis of artefacts produced within the program and produced eight key qualities to them: implicit slowness, explicit slowness, ongoingness, temporal drift, pre-interaction, temporal modality, temporal interconnectedness, and temporal granularity [188]. While I will not develop on these qualities here, it is evident that the interest in this design program continues to produce both design particulars and extensions of the theory. Considering this design program within HDI is valuable as a contrasting stance to a rapidly expanding technology.

Critical and Speculative Design [189]–[191] initially coined by Anthony Dunne, has been discussed and redefined by many authors within HCI [192]–[194]. There is no unified agreement on what it entails, but most authors seem to agree that design as provocation is one of its most important pillars. Dunne & Raby explain their design approach in their A/B manifesto[14], contrasting the design program with conventional ideas of the role of design. This manifesto (see Figure 1.5) is particularly useful when creating designs that seek to challenge rather than solve, in the spirit of anti-solutionism [195], at times producing essentially useless (but not worthless [196]) applications, probes, or 'provotypes' [163]. Here, researchers intentionally generate probes and artefacts that pose questions rather than offering answers, supporting critical enquiry through actual artefacts (see also *material speculation* [197]).

Critical design is connected with speculative design – at times used interchangeably with design fiction [198] – an approach to design through the development of probes that belong in fictional worlds. Drones play a significant role in our imaginary worlds, and there is research dedicated to creating probes to critically question the future of the technology [199], [200]. Blythe uses design fiction to create abstracts of imaginary research through design articles [201]. For example

[14]Work in progress since 2009 available at http://dunneandraby.co.uk/content/projects/476

Figure 1.5: The Dunne & Raby Design Manifesto: *"a manifesto that positions what we do in relation to how most people understand design."* Work in progress since 2009 available at http://dunneandraby.co.uk/content/projects/476

Lindley and Coulton develop a fictional world involving drones only to reveal at the end of the paper that it *"presents a fictional account of plausible future HCI research its purpose is not only to highlight potential usability or utility issues such systems might present but to also create a discursive space in which researchers can consider the wider societal and ethical issues of technological futures in which drones might be widely adopted"* [202, p.618].

1.3 A Narrative Literature Review of Human-Drone Interaction

Propelled by the research agenda in my project, I needed to focus on understanding in what ways current HCI research in drones applies design knowledge, approaches, and methods. I do not seek to find or offer a converged definition of social drones[15] – instead, I am concerned with understanding what is the impact of design knowledge in the drones currently studied within HCI (and usually described as studies in HDI). In this section, I build on previous drone research through a narrative literature review [203], in order to understand the role of design knowledge and processes in HDI.

Drones are an emerging technology with an established research domain of their own on Human-Drone Interaction (HDI). They are undeniably becoming integrated in society as tools in a variety of work practices, such as mining, energy engineering, forestry, cinematography and police work [3] and in leisure activities such as photography (see e.g. [2]). This ongoing and advanced development suggests that we need to understand the different types of practices of drone use in society to guide future design. For example, several new application areas are emerging which utilise drones, including non-military surveillance, navigation, delivery, photography, and more, and researchers are currently exploring new drone concepts and contexts of use. There is also an increasing research interest in the area of so called social drones or domestic drones [204]–[206] – drones being used in inhabited environments such as public spaces, the home, and the workplace, leading complex interactions in social settings.

While there are survey and review articles focusing on drones, none are fully invested in understanding the surrounding situation of the studies and the design methods used. Arafat and Moh [207] focus on technical aspects of drone control, building a comprehensive list of routing protocols for Unmanned Aerial Vehicle (UAV) networks. Also from a technical perspective, Cai, Dias and Seneviratne [208] report on the advances of small scale drones based on the analysis of 132 models available worldwide, forecasting possible applications. Other surveys put an emphasis on applications, such as Otto, Agatz, Campbell *et al.* [209], who conducted a literature survey on optimization within civil applications of drones, offering a number of interesting application areas. There are also user-centered surveys exploring users' perception of drones and their attitude towards possible applications [e.g. 210]–[214]. In these surveys, a nuanced perspective of drones is offered, with space for negative impressions on the technology, and the opportunity to poise critical questions on the use of drones in society. Baytaş, Çay, Zhang *et al.* [205] present a literature review resulting in the collection of human-centered design knowledge on social drones, particularly focused on the evaluation of these drones. This specific review defines social drones as applications where autonomous agents cohabit the same spaces as humans [205]. They then present their findings as a set of drone design concerns and human-centered concerns, although these are

[15] Similarly to finding a definition of design, in the words of Redström: *"we do not settle for just one definition of design is not because we do not understand the essence of design, but because it is much more powerful to work with difference as a basis when coping with complexity and change. And to work on the basis of (making a) difference, we need alternatives, and we need diversity. This is still a conversation between us about what design is , but it is one centered on its potentials for change, not its eventual convergence."* [41, p.141]. Just replace the word 'design' with 'social drones' for the same effect.

not directly connected to actual applications. Other surveys focus on particular applications, such as for example Liew and Yairi [215] who centre their efforts on companion drones, defining these as autonomous social drones, and Kim, Kim, Ju *et al.* [216], who offer a literature review of specific applications within agriculture, including control technologies. Obaid, Johal and Mubin [206] look into domestic applications. In their review, Obaid, Johal and Mubin [206] explore applications and context of use, identifying trends in the research and identifying future work on interaction modalities and novel contexts.

My work however, is more concerned with finding more detailed descriptions of how these applications are taken in account in the research processes and build further on how design knowledge is essential to properly approach these opportunities. Also, Herdel, Yamin and Cauchard [217] offer a comprehensive scoping review, resulting in 16 domains of applications where drones and humans interact. I argue this brings the need to identify design factors beyond applications. Herdel, Yamin and Cauchard [217] concluded with under-explored use cases with great potential, while I am more preoccupied with finding underused design methods, approaches, and perspectives that may be used to research those use cases.

1.3.1 A Summary of Applications and Interaction Modes in HDI

As mentioned, the field has had considerable advances in studying drones as agents for a number of useful applications in society such as delivering, guiding, leading, and safety [e.g. 218]–[228]). They seem to be perceived as a good platform for emergency situations [e.g. 229]–[236].

But within my work, I focus on the design dimensions of these drones [237]–[240]. Previous work in the design aspects of HDI have suggested a variety of applications for drones which are described as 'social'. In particular, there are mentions to the posibility of developing personal 'companion drones'. Karjalainen, Romell, Ratsamee *et al.* [204] identified some of these possible denominations such as 'butler', 'assistant', 'toy', 'pet', and others. In terms of accessibility, there is a relevant body of work suggesting drones as a technology to guide people with visual impairments, or used as assistance in leisurely activities by people with disabilities [241]–[244]. The pairing of drones with an assisting role brings many challenges to the table, and opens many research gaps to be filled in terms of how the drones are perceived, controlled, and how they navigate the environment.

These gaps in control and perception are essential to HDI. Kim, Kim and Kim [222] show how participants in their study favoured teaching drones rather than expected full autonomy – just as one would with a pet. There is research zoomorphic assignments to drone behaviour [245], offering possibility for developing user-friendly metaphors. Wojciechowska, Frey, Mandelblum *et al.*'s paper is dedicated to the design aspects of drones (such as the need to design better propeller guards), and agrees once more with a certain preference for animal-like appearance.

Drones afford many modalities of interaction, which can be made bespoke to different applications. The body of the research in HDI uses headsets, controllers, or mobile phones, including studies dedicated precisely to these modalities (e.g. Pittman and LaViola [247] compare a game controller to a head mounted display). There is an interest in 'natural interfaces' with drones which are usually approached through hand/foot gestures (e.g. [224], [248]–[252]), to body movements (e.g. [253]–

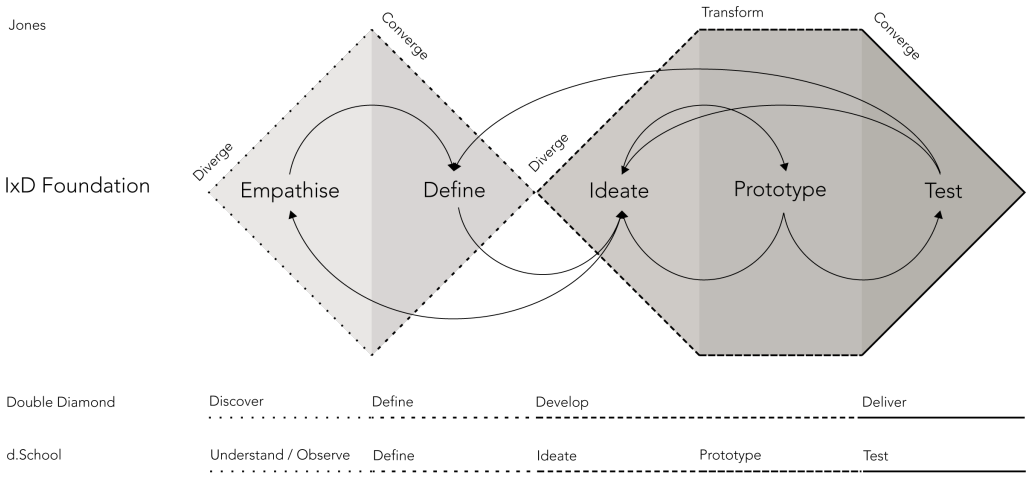


Figure 1.6: A diagram combining different models of the design process. The models are mostly overlapping and can be superimposed without major conflict. We mean to illustrate that a design process does not necessarily follow a linear progression between phases, but can instead take place in messy ways, with iterative transitions back and forth through the phases.

[255]), and proxemics (e.g. [256]–[260]). There are other less common approaches to control drones such as brain-control [261] and muscle and motion sensors [262]. Most notably for my work, the combination of soma design and Tai Chi has inspired coordinated gesture control in deep embodied engagement [253] and creating personal close experiences with micro-drones [253], [263], [264].

1.3.2 Design Processes in HDI

The following results were built on examples of drone research found in the literature. I paid particular attention to articles explicitly describing the design of drones and resulting in robotic artefacts. It appears there is a large focus on prototyping and testing in HDI, while ideation activities were rarely described. I found a severe lack of diversity among recruited participants in the user testing. Some articles had complete descriptions of their design process [204], [234], [253], [259], [265]–[268] acknowledging specifics of design knowledge by pairing the research with HCI design programmes and theories such as, for example, soma design.

Keeping in mind a user-centred design perspective, I sorted some of the HDI literature contemplated here under the five phases of the design process as initially introduced by the Hasso Plattner Institute of Design and described by the Interaction Design Foundation. These are: Empathise, Define, Ideate, Prototype, and Test. There are many models of the design process, and the one I adopted is but one example. Figure 1.6 shows the chosen process, but pairs it with many other common approaches such as the understanding of design as a space of divergence, convergence and transformation [269]; an inspiration to the famous double diamond model. Most complete design projects will fit any model of the design process, with an important feature being the iterative nature of design. Here, I am less interested in the sequential steps of the process or in promoting a specific model, and more invested in understanding to what extent there were different drone-specific design challenges in each step of a process.

1.3.2.1 Empathise

This is the phase of the design process where user needs and other details on the context are gathered. A great portion of a user-centred design process happens during this phase. This phase is not exclusive to the start of a project; it can be repeated at any point in the design process whenever a need for insight is discovered. When looking into the applications suggested, I regularly noted that the publications would only briefly mention a potential drone application without presenting any type of formative user-centred data collection [e.g. 270], [271]. Many of the applications in literature have tone of speculation. While commercial drones already take part in many different work and hobby practices in society, the current trend in HDI research is to focus on generic applications with no or little connection to contexts where drones are already in use.

The reason why design research on the current use of consumer drones is missing in HDI could be partially explained by this lack of reporting on explicit empathise phases. The mismatch between how drones are currently used and proposed research applications has previously been pointed out, grounded in interviews with professional drone pilots [3]. Another example, offered by Wojciechowska, Frey, Mandelblum *et al.* [246], used a questionnaire to evaluate the current perception of the form factor of existing drones in order to establish design guidelines. The lack of user-centred design processes and ethnography applied into design importantly, illuminates a gap between current research and society. I believe that this is a missed opportunity, hindering successful applied research. While Herdel, Yamin and Cauchard [217] advocates for mapping all potential roles of drones, I believe that research in existing real-world practice would contribute to developing new roles in a nuanced manner where, for example, drones may transition between several roles.

1.3.2.2 Define

In the define phase, the analysis and synthesis of the previous phase is developed to synthesise the overall goal and key questions guiding the project (i.e a design brief [272]). The absence of reported define phases in the papers reviewed often resulted in a lack of clarity on what a real-life application would be like, whereas a possible application of drones and their intended contexts of operation and target users should clearly go hand in hand. However, even when no specific application was mentioned, I found distinctions being made in terms of the context the drones were being developed and tested for. Since drones are particularly sensitive to environmental changes, this justifies that the research focuses primarily on either indoor or outdoor use, without considering a transition between environments. Much of the work found required a complicated technical setup which would not be possible outdoors nor accessible to a large pool of users (e.g. studies with VR applications requiring motion capture for tracking the drone and wearables to interact with it, such as SlingDrone presented by Tsykunov, Ibrahimov, Vasquez *et al.* [273]).

Most of the publications discussed a context of use, albeit from different levels of detail. While the majority only offered a distinction between indoor (74 mentions) and outdoor (27 mentions) use, others offered a more detailed account of what the expected context of use would be. It is noteworthy that a great number of publications indicated that the drones would be operating in public

spaces (31 mentions). Furthermore, it is relevant to mention that although context is important for a stable control of the drone, it was seldom noticed that the research included a thorough analysis of constraints specific to the context where the technology would ideally operate. (e.g. FlyingHand by Duan, Punpongsanon, Iwai *et al.* [249] suggests a drone to create haptics for a remote museum visit, but does not include constraints or current restrictions that could support defining the overall design, such as museum rules and goals, or the safety of artworks and visitors).

1.3.2.3 Ideate

Ideation is about the creation of multiple ideas and concepts, preferably divergent or even provocative options. Ideation should be grounded in the synthesised knowledge from the empathise and define phases (the user needs, context, business and other prerequisites). Some ideation activities and alternative designs could be found [225], [226], [274]–[286].

Reporting on early studies and ideation would indeed be useful for other researchers who intend to explore the same design spaces, while expanding on the contribution and overall research knowledge. There are research approaches surrounding design and evaluation in HCI and HRI which also contribute to a more holistic understanding of drones from a user experience perspective. For example, research through design [155], [164] is important for HRI. In this type of work, ideas appear in the making and explorative tinkering with the technology. In La Delfa, Baytaş, Luke *et al.* [264] all the phases of the design process come from a strong theoretical standpoint such as somaesthetics, applying theories of interaction design into a design particular. This theoretical framing is a strong aid when creating ideas.

There is a lack of drone-specific methods for ideation. It may be helpful for example to develop an ideation kit tailored to drone technology shaped by an interdisciplinary design team. Such a kit could be composed of cards representing some of the most interesting challenges with drones, such as international laws, common payloads, levels of noise during flight, etc.

1.3.2.4 Prototype

Prototyping is about implementing ideas into materialisation, with the intention to test design assumptions and ideas. It is common for HDI publications to describe their prototyping activities. The interaction modes concerned types of input and output in the system have a major impact in how prototyping was conducted.

The modalities prototyped for input included either a device dependency or a natural interface. Most of the studies either relied on some type of XR Headset or mobile device to control and interact with the drone. The most popular ways of interacting with the drone without depending on an external device and supporting a more natural interface were hand/foot gestures and body movements or proxemics. It is noteworthy that touch, speech, and facial recognition were not particularly prevalent, unlike many other fields of HRI. There is a great variety of possible devices, often combined in the same study, or even evaluated in comparison (e.g. Pittman and LaViola [247] compare controlling a drone through a head mounted display with a more traditional game controller).

There was not as much variance in the feedback or output supported by the drones as there was in the prototyped modes of interaction. Most contemplated only the movement (flight) of the drone, and a smaller portion the output of images or videos, either directly as a display or to a another peripheral device. Audio feedback was not common, but also, unexpectedly, neither was feedback through lights. Two interesting examples are Ibrahimov, Zherdev and Tsetserukou's DroneLight [287] which allowed users to create long exposure light paintings with drones to communicate messages to others; and Szafir, Mutlu and Fong [282] who explored lights as an output to communicate directionality.

The core reason for prototyping is to create design instances that can be tested empirically. Even if testing is preferably done with users and in realistic settings, the prototype itself can affect the possible set up for testing. This is why it is important to consider how the choice of prototypes may impact the choice of evaluation studies. The majority of the evaluation studies in the publications took place in labs and (mostly) controlled environments. As mentioned by Obaid, Johal and Mubin [206], a likely reason for this is that many of the drone control set-ups are reliant on hardware systems that can only be installed indoors (e.g. motion capture systems [238]), or heavily impacted by the difficulties or legal limitations in operating drones outdoors [259]. Many applications with an intended outdoor operation still had studies conducted in a lab context. In many studies involving visual projections, it was necessary to ensure controlled lighting and stable weather conditions for flight. However, the majority of the indoor study settings reported were not only indoors, but also in a lab rather than in other naturalistic settings such as homes, schools, or offices. The uncertainties surrounding drones are likely a heavy factor leading to the decision to operate these robots in invigilated and highly constrained environments, but remain a necessary factor to consider in research. Oversimplification of the environmental factors in combination with technically fixed prototypes may hinder rather than aid the design process. A better match between the prototypes and expected contexts of use is the only plausible way to understand the real constraints pertaining drones that can inform design.

1.3.2.5 Test

Testing concerns the evaluation of one or several prototypes (or parts of them) with people, preferably relevant stakeholders such as intended users. Testing was a fairly common phase to be found: 79 publications conducted some form of testing. However, only 11 reported on an evaluation with users, and only six actually involved target users. For most publications, the methods used to test the system were typically well established quantitative evaluation methods conducted in labs, such as SAM [e.g. 260], SUS [e.g. 270], and NASA-TLX. For example, NASA-TLX was often used to measure cognitive load related to the use of drones [e.g. 225], [277], [288]–[291]. It seems to be most usual to test drones during the test phase took place in a lab. In contrast but when conducting empathising studies, I found a more widespread naturalistic context is indicated.

Many of the evaluations in HDI do not involve target users, and tend to be one time studies. Two exceptions were Eriksson, Höök, Shusterman *et al.* [255], and Kim and Landay [292], who conducted long-term studies of drones used in artistic performances. Another longitudinal approach was described together with participatory design activities, to achieve speculative design of drone supported

foraging [280] and emergency response system design [234]. Garcia, Chevrier, Jestin *et al.* [244] investigated more accessible drone interaction and conducted two sequential studies, in which the second was a follow up study with the same participants. There were several examples of sequential studies, where different groups took part in studies or trials at different points in the process [e.g. 204], [219], [257], [277].

There is also a lack of diversity in the reported participants during testing. Most of the user studies reported on an adult user pool with a rather low median age, usually recruited on campus and consisting of able students with good vision and no reported accessibility needs. Some publications with a specific application area had a paired target user group, but most other studies did not investigate a target audience or identified who the target audience would be. Some cases present possible applications as assistive technologies, such as controlling a drone with gaze developed by Hansen, Alapetite, MacKenzie *et al.* [293], where the recruited participants were young (mean age 27.7 years, SD = 5.4) video game players rather than disabled people. Garcia, Chevrier, Jestin *et al.*'s HandiFly [244] on the other hand, studies the accessibility needs of a group of target users when designing a remote control, including experts, both when gathering requirements and when pilot testing.

As reported, many of the publications tested through the use of standardised questionnaires within HRI. These methods are not usually focused on understanding or incorporating the context of use, which needs to be complemented with other qualitative methods. This is particularly relevant for HDI given that drones interact in multiple dimensions within their context of use as they have an increased level of movement flexibility. Additionally, it is not guaranteed that the use of well established methods will match the phenomena to be tested. The possible levels of anthropomorphism afforded by flying robots are necessarily limited, but the use of the Negative Attitude Towards Robots (NARS) questionnaire [294] could potentially be more tailored to drones. For example, one of the NARS scales reads *"I would feel very nervous just standing in front of a robot."*, which could be extended to HDI as drones afford other approaches such as from above. Furthermore, as reported by Nomura, Kanda and Suzuki [294], *"...novel types of robots or robots related to battle evoke negative attitudes toward human interaction with robots."* Thus it is particularly important to consider the cultural context of drones and how they are perceived by the users, as UAVs are a technology with a heavy history of military applications. Many of these aspects can only be tapped into through qualitative studies.

The lack of specific methods to study the user experience of drones, combined with the near absence of longitudinal studies, suggests the need for field-specific methods tailored to the design and evaluation of flying systems, as well as a critical review of the methods currently being used. It is worthwhile to consider how complementary methods could be developed. Herdel, Yamin and Cauchard [217] call for the need to *"identify metrics to quantify the value of HDI across various situations of use to provide ecological validity to current and future research works"*. While I recognise the need for metrics, I also see the need for a broader qualitative understanding which can also provide ecological validity. Questionnaires, interview methods, co-design tools, and heuristics shaped to drones could together contribute to a more informed approach to design in HDI. For example, an interview paired with a flying session, and a set of heuristics that would include the constraints of

drones such as weather sensitivity and reduced battery life would be beneficial.

Drones are often tested with one participant at a time, without taking into consideration an environment with obstacles or multiple bystanders. Thus, the complexity of environments is currently largely missing. Herdel, Yamin and Cauchard [217] mentions this transition from user to bystander as a research challenge for HDI [217]. I reiterate the need for understanding different roles and would also like to suggest this as a strong argument for qualitative studies in less controlled environments, including ethnography, where results can be transferred to similar situations rather than generalised and replicated. Situated edge cases can also contribute to design work, such as through the use of design probes where users engage in more extreme practices or demonstrate specific needs.

Typically, young and non-disabled participants took part in the tests; which means that people without impairment in vision, hearing, or motoric function etc participated in the great majority of the studies. Thus, the studies did not adequately address diversity or the multitude of accessibility needs that exist in society. Among the surveyed publications, there were some exceptions where the studies actually did involve people with disabilities. This included Avila Soto and Funk [221], who tested how a drone could navigate blind people, and Garcia, Chevrier, Jestin *et al.* [244], who involved people with motoric and cognitive disabilities to develop an accessible drone controller. Regulatory, safety, ethical, and other obstacles could be behind the reduced number of papers in health and accessibility. For example, recruiting and involving vulnerable groups in empirical studies poses a number of challenges [295], which may become particularly complex in the case of drones where there are already legal frameworks to navigate, and considerable risk of physical damage exists. Still, as these are unavoidable aspects in the use of drones, they should also be covered in research. I foresee the need of HDI research addressing ethics, accessibility and other related areas as the increasing presence of drones in society will necessarily also involve contact with a more diverse set of participants. Continued work in involving disabled individuals in the role of experts, for example through participatory design practice is necessary.

1.4 Designerly Perspectives on Human-Drone Interaction

In the combination of the theoretical framing of designerly knowledge, the literature review of HDI, and my personal experience, I identified a set of perspectives on HDI which which were inspiring to the work of this thesis. In my view, HDI is currently missing out on knowledge that could strengthen the research through the use of designerly methods and perspectives [e.g. 25]. The experiential qualities of drones should preferably be studied through a plurality of interdisciplinary approaches.

Below, I summarise a set of perspectives pertaining HDI, identified as methodological and epistemological opportunities in the research. I present suggestions of methods for involving design knowledge in HDI in relation to previous work and leave space for the same categories to fill in with their own perspectives. The presented perspectives are but examples of what can be done throughout the design process, and include a non-exhaustive list of design methods. Each design perspective brings different wicked problems [7] to the table, which must be tackled in a bespoke and careful manner.

These perspectives are offered from my own understanding of the ongoing research work, combined with my background and perceptions of the field. Hence, I see a need to expand on these notions in a transdisciplinary way. The intention of the list presented below is to give examples of perspectives, but most of all, to also leave room for others to fill with their own understanding and suggestions.

The methods and approaches presented can be applied throughout the design research process, and can be helpful towards many of the aspects of HDI; not only limited to the perspective they are described presented under. Many of these suggestions are the seed to the work I have conducted in this thesis.

Figure 1.7: The first Designerly Perspective on Human-Drone Interaction: Drones are Here Now. The icons reveal the two important aspects of drones – they are both already situated in our real world under active use, and hence, studying them in a situated manner is an urgent endeavour.

1.4.1 Drones are Here Now

Drones are already used in society in many work practices and as a hobby, which is currently not reflected in the HDI field. This suggests that ethnographic methods are a highly appropriate approach to complement existing methods in HDI and could thus be used more extensively: only in the field can the intricate relationship between users, technology, weather conditions, legal frameworks, and other factors be understood in a critical manner. Further, while interview studies are important, participatory observation is likely to bring a more qualitative, rich, and contextual understanding of the impact of drones. Unlike other robots, drone pilots can already be easily accessed in the real world. Cyberethnography [296] may, for example, be an appropriate and accessible method for capturing the already existing nuances in the intimate [86] relationships between drones and humans.

Some examples of research using this method can already be found in the field [2]. For example Pometko, Dagan, Altarriba Bertran *et al.* [297] illustrate examples of drone-based play potentials found on social media in a pictorial. The commercial availability of drones also allows the researchers to have first-person experiences with several types of drones and evoke more embodied perceptions of the research material.

Figure 1.8: The second Designerly Perspective on Human-Drone Interaction: Drones are Technically Complex. The icons reveal that the development of drones does not only include the need for advanced engineering competences, but they also come with a set of limitations regarding the context where they fly – naturally bringing implications as to where and how they can be tested.

1.4.2 Drones are Technically Complex

Drones bring particular design challenges to the table – and such complexity often steer methods away from situated research. Their technical complexity is naturally different from many other robots, and as any drone developer or researcher could report, bring considerable frustration with them. While frustration can be universal when developing robots, the ones associated with drone development are of a complex and under-explored nature, including for example extremely limited battery power, fragile parts such as propellers, omnidirectionality, low payload, the need for offloading sensors, unpredictable flight paths, and more. Many of these limitations (along with ethical ones such as the physical risks for participants) result in the impossibility of conducting studies in uncontrolled environments. Drones cannot easily be directly implemented in their intended context of use without massive technical considerations. It may therefore be valuable to consider the development and research of designs based on off-the-shelf systems.

But whenever field testing is not possible or desirable and new technological approaches are applied, I find an interesting space for considering the showroom as an excellent alternative to the lab. As pointed out by Koskinen, Zimmerman, Binder *et al.* [158], not all design problems are appropriate to the lab, and the issue is understanding which are. In their book, they bring attention to the showroom as a space for HCI research. Drawing from the context of art, the showroom can also be interpreted as a semi-controlled space where technology can be engaged with in ways that promote critical thinking rather than allowing for the strict measurement of variables. It combines the controlled technological context with the freedom of qualitative research. The *"showroom relies on debate rather than statistics, like Lab, or precedents and replication, like Field. It questions the way in which people see and experience the material world and elicits change through debate"* [158, p.94]. Openness to a showroom-like testing affords research with a wider user group. For example, Rubens, Braley, Torpegaard *et al.* [298] do this by working together with the toy company LEGO®, to design and evaluate a 'build and fly' experience with 240 children in a public exhibition. Such collaborations and settings are fortuitous to the study of drones.

Figure 1.9: The third Human-Drone Interaction Design Consideration: Drones Engage the Body. The icons represent both the current issue with research not considering accessibility and inclusiveness enough to have an appropriate view of the different bodies in HDI, as well as the fact that drones fly in 3D space creating unique opportunities for truly engaging with theories of embodiment.

1.4.3 Drones Engage the Body

A clear trend that could be noticed was the increased interest in using drones in combination with extended reality, for example as as mediation for haptics [e.g. 299], [300], remote exploration [e.g. 301], [302], or even representing forces [e.g. 303]–[306]. This type of research is likely not as common with other robotic forms (e.g. humanoid robots), as it is the flight capability of drones that affords this type of application (i.e. they can maneuver around the user freely). In a sense, these applications open up HDI to a rich set of possibilities, where the drone can become a platform to support other entities. Games in particular are an area of interest which could contribute positively to the variance of possible relationships that can be formed between users and drones. Overall, I consider that applications could open up design spaces between sports, games and art, for example employing drones designed for engaging body movements [e.g. 253], [255], [292], or as sports companions [254] could be combined with a variety of cage designs [307] to open up new perspectives and experiences of sports, games or art supporting movement.

Using either hand gestures, foot gestures, proxemics, facial expressions or a combination of these is quite common in HDI [243], [253], [254], [307]–[309]). Such embodied interactions, are usually described as being user-friendly and intuitive, with the argument of also supporting the development of a sense of social empathy with the robot in certain use scenarios. However, I find it vital to remember that they can also result in even more conflict when different bodies are not considered. Spiel [310] tackles precisely this issue by reviewing the International Conference on Tangible Embedded and Embodied Interaction (TEI) proceedings and identifying *"a fairly constrained set of represented bodies, generally normativising tendencies on expected embodiments, an implicitly imagined body ideal that is never made explicit"*. While I did not analyse the literature in search for norms, I could not find great variance in the bodies considered as the humans in HDI – in this case, one must consider if research is incorporating an inclusive and comprehensive view of the bodies (i.e. young, old, disabled, non-human) involved in the interaction.

Furthermore, the 'natural interface' trend brings methodological difficulties which also require their own research – most methods do not acknowledge the multiplicities of the human body. The theoretical framing of the aforementioned research seldom builds on existing theory and practice on embodied interaction (as presented by, for example, Dourish [45], Svanæs [311], or Höök [171]). I believe an approach to the strongly embodied aspects of the interactions between humans and drones is a valuable starting point to bridge this gap. Body Maps (or body sheets) are one example of a qualitative method successfully used in combination with drones by La Delfa, Baytas, Patibanda *et al.* [253] (see the example of a filled in body map by a participant on page 6). This method offers a visual support for

participants in the research, including the researchers themselves, to report on felt embodied experiences by drawing on paper. The template includes the outline of a human body, and can be used before and after the experience, for example. Anne Cochrane, Mah, Ståhl *et al.* [178] offer a detailed description of the method and how it can be applied.

Figure 1.10: The fourth Designerly Perspective on Human-Drone Interaction: Drones are More-than-Human. The icons depict two actors in More-than-Human-Drone Interaction: the sea and a bird. As drones populate the sky and collide with flying creatures, they also collapse into the sea, or into the far reaches of a forest.

1.4.4 Drones are More-than-human

The free flight capacity of most commercial drones means they can reach contexts unusual for other personal technologies. Drones navigate the skies, but also occasionally collapse into the sea or crash into remote obstacles. This unique capacity causes encounters with more than just humans – similarly to what we have already seen with other robots in the wild such as lawnmowers and vacuum cleaners. From birds to sea creatures, the stakeholders in the development of drones goes beyond just human-drone interaction. In HCI, the attention given to these more-than-human actors and the entangled nature of being human, i.e. how natural phenomena and other beings need to be taken into consideration in research, is in definite growth [52], [53], [197], [312], and HRI will certainly follow. Within design research, an important approach is critical design [189]–[194], focusing on critical and societal implications rather than simply applications. It already has a history of use within HRI, serving for example to promote children's critical thinking [313]. This approach connects to art and there are examples of drones being developed outside of academic research for the purpose of provoking discussion [199], [200]. This type of work opens up for situated and innovative understandings of drones, which definitely plays a role in expanding the perspectives included in HDI.

Figure 1.11: The fourth Designerly Perspective on Human-Drone Interaction: Drones are Framed by Law. The icons show how legal frameworks will often play a role on what is prohibited or allowed, generating a frame surrounding the possible research in HDI, while simultaneously bringing the need for further transdisciplinary research.

1.4.5 Drones are Framed by Law

Because drones already exist in many shapes and forms in society, a legal framework is in place. Such frameworks are in constant change, however, and often struggling to keep up with the technical development. However, the fact that laws have

an impact on the design of drones is nearly absent from the research. A clear example is how many drones are purposely designed to weigh less than 250 grams. This is constraint led by international legislation requiring specific licences to fly robots heavier than 250 grams. Legislation and public opinion go hand in hand, and drones potentially carry their fair share of negative attitudes due to, among others, military associations [6]. It is noteworthy that there are helpful user-centred surveys within HDI exploring users' existing perceptions of drones and their attitude towards possible applications [5], [210]–[214]. In these surveys, a nuanced perspective of drones is offered, with space for negative impressions on the technology, and the opportunity to poise critical questions on the use of drones in society and which design values should be considered. It is necessary for researchers in HDI to incorporate these user-centred perspectives into their design work by acknowledging the non-positivist stance often seen in society.

As exemplified by Ljungblad, Yemao, Baytaş *et al.* [3], probing professional drone pilots raises issues which research could otherwise ignore. In this interview study, many issues with legal grounding are lifted. To move beyond interviews, researchers should consider engaging in more designerly ways through applied design work with other participants. One particularly helpful approach for creating connections between different stakeholders is participatory design. This approach is already present in HDI. Wojciechowska, Hamidi, Lucero *et al.* [274] ran a co-design study with experts from sub-Saharan countries. Similarly, Agrawal, Abraham, Burger *et al.* [234] presented a particularly interesting example where they engaged with emergency responders in a series of sessions constructing scenarios grounded in real-life challenges. As opinions and laws are in constant change, through engaging in a participatory manner with people, researchers tap into the serendipitous encounters with opinions and laws. I suggest that participatory design with applied design tasks involving a diversity of participants is a strong resource for HDI, purposely involving participants with informed negative attitudes towards drones, with broad knowledge of the applied legal frameworks in different countries, along with those with deep technical knowledge of the technology.

Chapter 2

Designerly Views of Drones

Tackling the social aspects of drones is a massive endeavour. When I first approached this project, I planned to design drone probes (those initial intentions can be found in a short abstract [314]) to be sent into other people's homes, following an accepted way of producing knowledge in HCI. However, I first needed to orient myself with the technology at hand. This thesis weaves the story of my first encounters with drones as a research material, and how that process generated unexpected implications. Along with Desjardins and Key [137], I viewed my first-person research as a stepping stone for the rest of my work: *"Although the use of first-person research is not new it is often one of the stories left out – perhaps because it is sometimes seen as preparatory work for upcoming RtD researchers activities. Instead, we argue that the knowledge produced in moments of 'getting up to speed' is as relevant and insightful as what will come next. We challenge RtD as well as other practitioners to recognize and validate these first-hand knowledges as much as participant knowledge during both formal and informal dissemination"* [137, p.2144]. Following this call, I have dedicated the first year and a half of my PhD to formally disseminate these first engagements not as background work, but as research on their own. These encounters took the form of autoethnography and research through design probe-making. Both of them are seen here as a type of design deployment.

As Gaver notes: *"Deploying our designs allows us both to discover the questions we should ask about their use, and some of the answers to those questions."* [315, p.17]. Assessing design through deployment is not led by hypothesis, but is rather motivated by the need to find a plurality of experiences. It is precisely through multiple accounts – often from the fringes rather than the central tendency – that the most inspiring design spaces are formulated. *"Given that designs can be appreciated from a number of different perspectives, and that different people may find different ways to engage and make meaning with them – or fail to do so – multiple, inconsistent and even incompatible accounts may all be equally true"* [315, p.17]. The aim here for me is therefore not to contribute to a converging view of social drones, but rather to diffract the possible relationships and notions surrounding them. Diffraction as a way of thinking is used as a metaphor by many theorists such as Barad [66]. But to not get lost in theorising, I stand on the approach proposed by Sanches, Howell, Tsaknaki *et al.*[316], which builds on Schön's reflection-in-action, and proposes diffraction-in-action as a way to engage with 'lived data'. Sanches, Howell, Tsaknaki *et al.* offer three guiding principles for engaging with lived data out of their own design projects: (a) *"engaging with data*

can be an open-ended and undefined process. Resisting the impulse for actionable insights early on, design researchers can surface more nuanced or alternative meanings of data", (b) *"difractively engaging data in a slow, long-term process and resisting the impulse for efficiency, can help surface, articulate, and explore practices around data"* and (c) *"designers can hold space for messy, ambiguous data that requires active interpretation, resisting the impulse for clean and tidy data. This shifts the goal from designing to provide expedient insights with data toward designing for a process of balancing open interpretation with scaffolding interpretation"* [316, p.2]. These principles are essential to my results. In my work, I have used minimal interventions (autoethnography and minimal concept-driven RtD) to provoke waves of diffraction – and the data resulting often shows the qualities mentioned above. Said diffraction is essential to the notion of re-framing as presented in my research goal.

This is the point in the thesis where I report on the answer to the research questions previously presented. I will therefore resist the urge to point out that design knowledge does very poorly at answering research questions, as it tends to generate more. As Redström puts it: *"In design, we seem to feel a similar urge, as when we struggle to formulate a research question to guide and define the purpose of design experimentation, or as when we for some reason still encourage students to account for theory first in their theses, even when we know the work unfolded the other way around"* [41, p.103]. At the end of this degree, I find myself with more questions rather than any answers – and that is precisely as it should be. We return to the stated goal and research questions:

G: Re-framing human-drone interaction research through a designerly lens.

RQ1: How might ethnographic methods and narratives ground design knowledge in human-drone interaction?

RQ2: How might visual and concept-driven approaches inform human-drone interaction design?

To aid the navigation of the questions in combination with the methodology and designerly perspectives presented above, and how they contributed to the appended publications, I offer a diagram that puts all these terms together (Figure 2.1).

Through the HDI literature review presented above in Section 1.3, I attempted to identify which design knowledge and methodology is already present in the field. The aim here was to navigate the stated goal. In the following sections I present the papers that compose this dissertation, each of them exploring a small point of view towards Human-Drone Interaction. Each publication is an important piece in a picture that is *not converging to a better definition of social drones, or even attempting to give concise guidelines on how drones should be developed.* Rather, they present narratives that question the grounding and assumptions surrounding the design of drones. Design knowledge thrives in a plurality of perspectives, in intricate narratives, and sometimes in tiny insights. In this work, I have experimented with combinations of methods, impressions, and expressions of design knowledge in connection to drones, but also to many other agents in the sociotechnical systems/assemblages surrounding the technology. There are two different tracks simultaneously followed. Both have in common a combination of

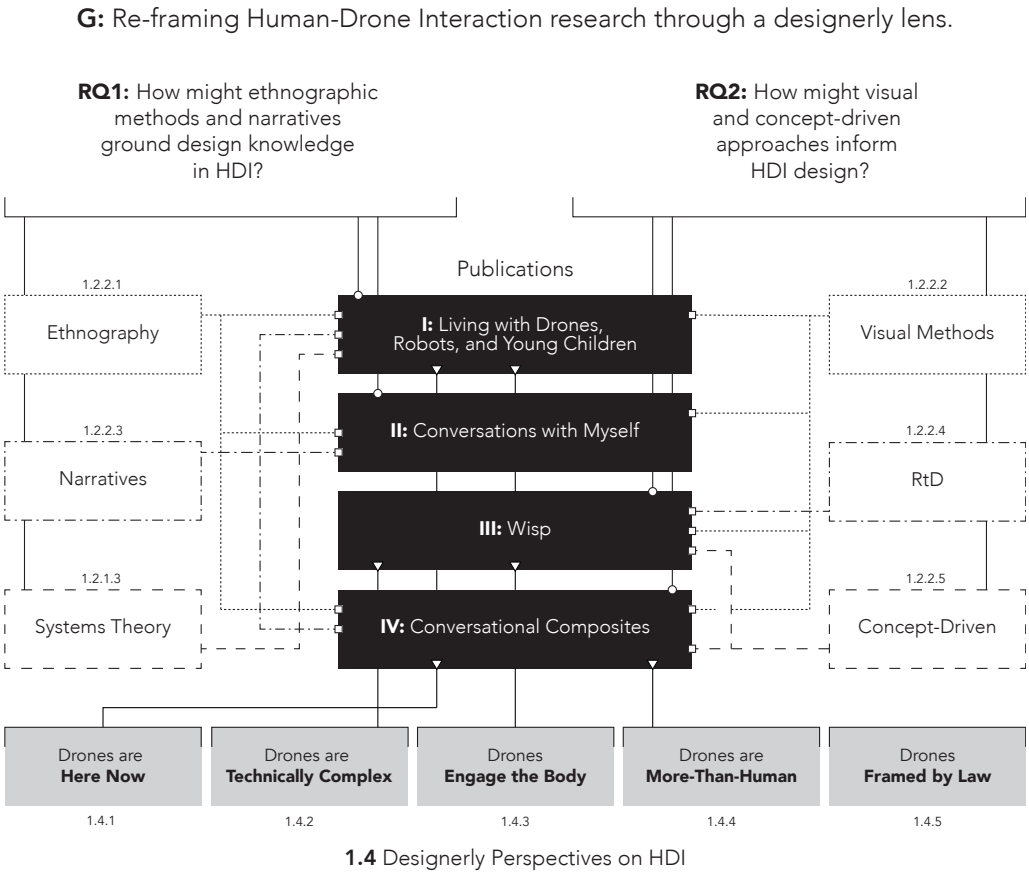


Figure 2.1: Diagram representing the goal of the research along with the research questions, as well as how the publications relate to them. Connected to each paper there is a list of methods with their section number, as well as the set of Designerly Perspectives on HDI.

techniques and theories that find ways to surface the importance of first-person perspectives in a convincing manner, as well as to argue for the value of combining design approaches and theories in HDI.

I argue that a designerly way of approaching research is critical to re-framing HDI. There are several ways of achieving a more reflective and design oriented research practice, and one central gap is, as pointed out by previous research [317], [318], the unrecognised importance of design epistemology within HRI. When knowledge from the design process is not expected in publications, important situated, reflective, nuanced, and critical knowledge on user needs and context can be missed. This type of design knowledge may point towards otherwise missed aspects or important questions and circumstances, which can support other researchers within the same domain to take a more holistic perspective. In the work presented here, I have shown how some of the applied designerly approaches surfaced critical knowledge for HDI. A pluralistic reporting of design work in research could be promoted by varying publication formats, for example through the inclusion of forms of visual knowledge. I exemplify how visual knowledge pertaining HDI can be expressed in publications. For example, page limitations currently discourage the inclusion of images. Many of the methods suggested above rely on visual format, for example, ethnography is often documented through still and moving pictures. Blevis [319] stresses the importance of photography in

HCI research, and to that end uses a photograph of a drone flying over a crowd watching a performance. He presents the combination of text and image as an example that demonstrates how *"a carefully produced editorial record of a specific instance of a disruptive technology is design knowledge"* [319, p.987].

To explore the first research question I used autoethnography and sketching to build my own understanding of drones. These are described in Section 2.1 and Section 2.2. I have – of course – not explored all ethnographic methods available. But I can confidently say, for example through my autoethnography, that these methods are appropriate to HDI, and resulted in knowledge that is not only designerly by nature, but both generative and critical. The results of these two papers are narratives and images, together painting a non-positivist picture of drones. The design opportunities surfaced in these two papers stay away from prescribing action or dreaming application worlds for drones – the type of results that would make researchers critically question their work rather than justify it. They show value in grounding design knowledge as having a definitive place and importance in re-framing HDI.

To tackle the second question, I applied RtD in combination with concept-driven design research programs as described in Section 2.3. These programs come with a set of assumptions, approaches, framings, and philosophies. I have – naturally – not tried all existing interaction design approaches and philosophies. I can however describe how they have been helpful in re-framing what role drones ought to (or not to) play in society. I also looked into how the design of drones could be analysed with attention to ambiguity through a novel visual approach to user data, as explained in Section 2.4. These approaches and philosophies were essential in inserting design values (ambiguity, critical thinking, etc) into HDI. Both of these tracks paved the way to the suggestions for future work explained in Section 3.

2.1 Living with Drones, Robots, and Young Children: Informing Research through Design with Autoethnography

Fringe phenomena and 'users', and in particular children, are difficult to study [320]. There are not only intricate ethical issues to be tackled, but it is also incredibly hard to engage field study participants in ways generate genuine insight [321]. These fringes also call for unusual ethnographic methods. In this paper, I consider the research gap in Child-Drone Interaction, as well as the gap in first-person methods in Human-Drone Interaction.

Problem

A simple search on Amazon for 'toy drone' generates thousands of results. The market for small flying robots is growing. For example, the DJI Ryze Tello[1], priced just under 100USD, is marketed as a tool for education. According to their website: *"We set out to build the most fun drone ever, and we came up with Tello: an impressive little drone for kids and adults that's a blast to fly and helps users learn about drones with coding education"*. The small drone, weighing only 80g, is said to work in many contexts: "Whether you're at a park, in the office, or hanging out at home, you can always take off and experience the world from exciting new perspectives". The website offers a big tagline stating: *"Relax! Tello's super safe"* (See Figure 2.2).

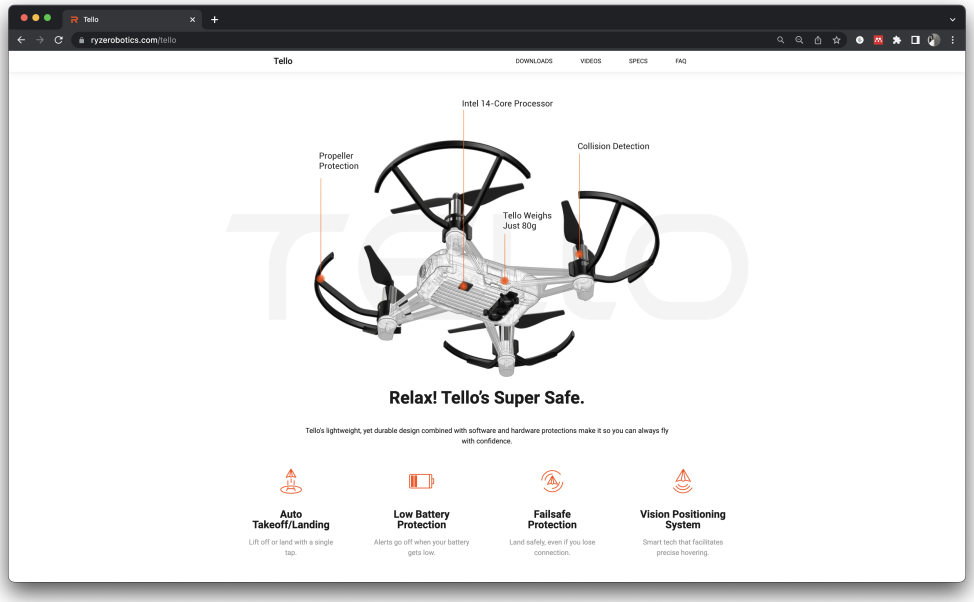


Figure 2.2: A screenshot of the Ryze Tello website showing the tagline "Relax! Tello's super safe. Tello's lightweight, yet durable design combined with software and hardware protections make it so you can always fly with confidence." https://www.ryzerobotics.com/tello captured on the 13th of December 2022.

When looking into the research field, the interactions between children and drones seem to be predominantly perceived as educational, connecting learning

[1] https://www.ryzerobotics.com/tello

goals with the activities the drones support such as racing, photography, or programming [298], [322], [323]. This is not surprising, as there is plenty of research with other robots leaning in the same direction. A variety of social robots such as Pepper and Nao, are currently being explored as tools or companions in education and critical thinking [e.g. 313], [324]–[327]. But children are encountering drones in their daily lives, outside of the educational framing. There is a lack of research in Child-Drone Interaction [206] which may be due to safety, ethical, and privacy regulations when considering children as users. A valuable research direction would be to include children as participants in most studies, including opinion surveys.

However, an utilitarian perspective does not cover the full spectrum of drone encounters. Methods that are not seeking to optimise are particularly helpful here. How can we study genuine and situated interactions between children and drones? What happens when a parent is driving a drone at home? There are many potential applications and dimensions of what drones may be. Through a literature review, Herdel, Yamin and Cauchard [217] present drones as 'helpful', 'amicable', 'functional', 'knowing', 'sensational', 'reliable', and 'unusual'. While the unusual category could fit a lot of drones, there is a gap in researching the 'creepy', the 'unreliable', the 'invading', the 'unsustainable', the 'unwanted' drone.

Methodology

At the time I started this study, I had planned other interventions with families and RtD probes. But before sending out drones to people's homes, I wanted to find my own understanding of what it would mean to incorporate this technology in a domestic setting. Studying children is definitely not without ethical issues, and I felt that I had better control of consent in my own home. I was both afraid and eager to learn about which troubles would surface.

The issue of studying child-drone interaction could be tackled in many ways. I chose to dive deep into an autoethnographic study, serving both a a first encounter for me with a longitudinal interaction with a drone, but also as a way to experience those interactions along with my two children (aged 6 and 3 at the time). Choosing autoethnography was only made possible to me because I was already a mother. But since I had the opportunity and my family was in agreement with it, I found it to be the method that could best translate in situated, intimate, and honest accounts of engagements with the technology.

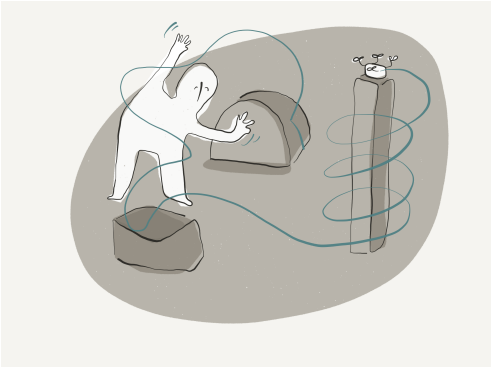
However, I did not want my small scale, statistically insignificant study to result in the alienation of a community that does not fully understand autoethnography. Therefore, for my own organisation and following Desjardins and Ball's call for inventiveness in autobiographical design, I decided to pair the autoethnography with a sociotechnical systems framework. This framing is well explained in the paper itself.

Contribution

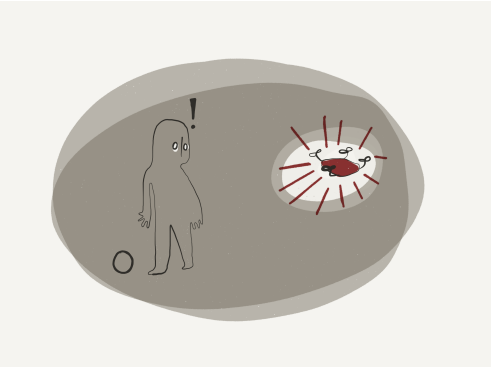
The year-long autoethnographic study generated a number of narratives which can be read in the original paper. This paper contributes with one of the first studies seen in research in Child-Drone Interaction. Here, I will dedicate this space to some of the ideas that were left out. The summary of the study takes the form of **design opportunities for Child-Drone Interaction Design**. As I describe in

((a)) Touch

((b)) Enactment in 3D Space



((c)) Directed Play in 3D Space

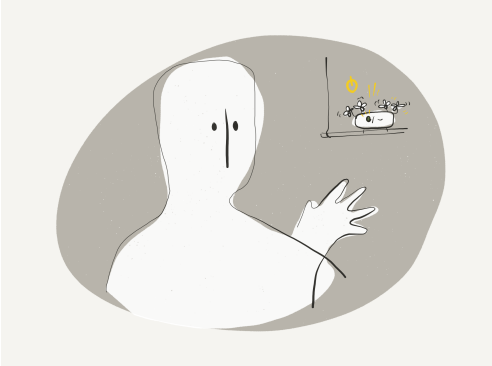


((d)) Wickedness and Attention

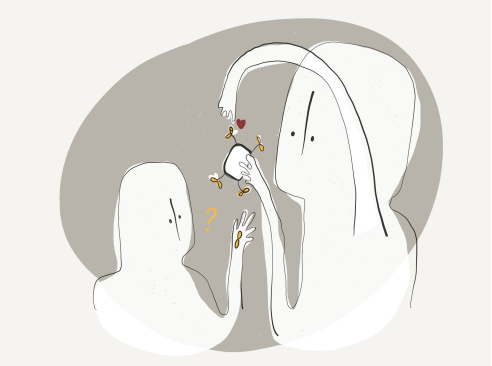
Figure 2.3: Four out of the Nine Opportunities for Child-Drone Interaction

the paper, these are not to be seen as guidelines, and have no prescriptive value. Rather, they should be used as ideas to challenge and problematise the interactions we design for – they are not implications for design [77], but problematisations in design. I made a set of illustrations, one for each challenge, which are not included in the publication. As I produced these images, the implications of the challenges became clearer to me, so I will dedicate this space to expanding on what can be read in the published paper. In Figure 2.4(a) the drone can be seen poised as a bird-like metaphor – that metaphor can be generative and inspiring [328] as to what types of idle actions a drone could embody. Birds are not either flying or dead. For example, in Figure 2.4(c), there is a reinforcement of the user-bystander dichotomy as it could be assumed – a user driving the drone in the foreground, while a bystander is shrinking faded into the background. I will discuss some issues with this dichotomy below, but I wonder why I decided to represent this opportunity as such. This illustration surfaced the damaging values that such a relationship could generatee.

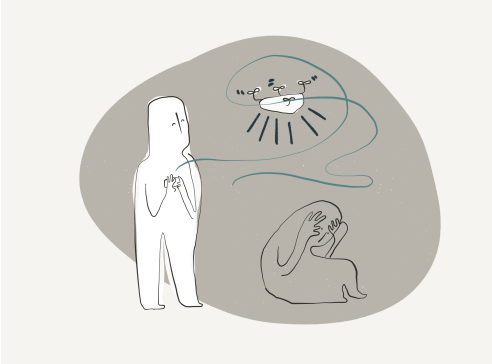
One important contribution of this paper is the **deconstruction of the user-bystander dichotomy in HDI**. For example Baytaş, Çay, Zhang *et al.* define social drones as *"applications where fully autonomous drones operate in spaces populated by human users or bystanders"* [205]. We are far from reaching fully autonomous drones, but even within the clearly visionary definition, there is a mention to users or bystanders. The choice of the word bystander comes with some assumptions such as perceptions of passivity which could derive from ideas such as the 'bystander effect'. Are we really placed as either users or bystanders in



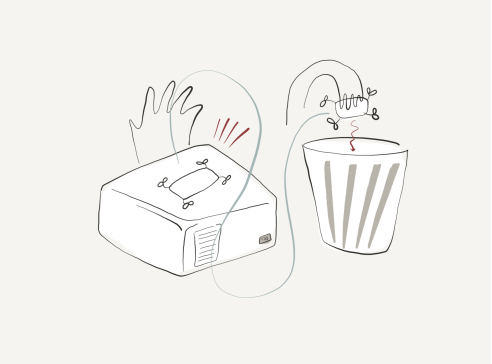
((a)) In-between States



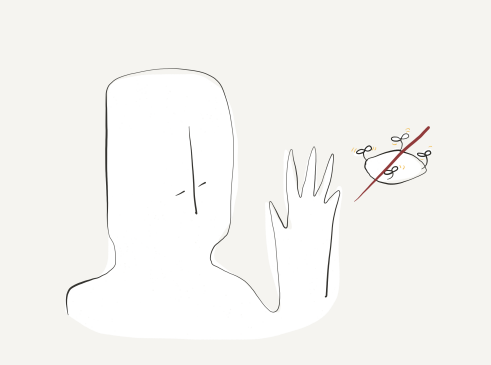
((b)) Difficult Ownership, Safety, and Right to Repair



((c)) Culture, Values, and Type of Play



((d)) Anticipated Experience and Death of the Drone



((e)) Unmaking

Figure 2.4: Five out of the Nine Opportunities for Child-Drone Interaction

interactions with drones? Or is it the way drones are designed that will eventually create bystanders? These questions could warrant a whole other PhD dissertation.

There is one detail I left out of the original paper which has to do with autonomy. At first, and without me noticing, the children were unaware that I was the one driving the drone. And not once did they act as bystanders. They tried actively either fully avoid the drone, or try to communicate with it. The user-bystander dichotomy was irrelevant in our interactions with the drones at home. As noted by Höök, Eriksson, Louise Juul Søndergaard *et al.*, our reasoning often uses dichotomies such as the one presented, but more dangerously, through our design processes, we tend to reinforce the patterns [177]. Moving away from dichotomies in design (in this case through soma design) should mean that our work should be grounded in experience rather than *"in preconceptions about how to divide the world into conceptual categories. On the other hand, those concepts are deeply ingrained in our whole ways of being and will be enacted and re-enacted in our design work, unless we are able to 'see' them, deconstruct them, attend to them, and thereby design in novels ways"* [177]. My autoethnography helped me clearly 'see' these concepts and seek to deconstruct them whenever possible. **It is a worthwhile research agenda to design drones that do not assign anyone the role of a bystander.**

A Post-Publication Reflection

This autoethnography in this paper was conducted while I was pregnant with our third child. I had considered the reason as to why I had suddenly decided this study was over one year after it started. But the reason was no other than the fact that he was born. When the paper was submitted I had not yet arrived at this conclusion – but it is quite interesting from a sociotechnical systems perspective. In the words of Kayany and Yelsma: *"Humans and technologies in households are interconnected as members or elements of the same system. When a new element is introduced to the system, the system goes through a process of integration that may result in the re-organization of roles, relationships and functions"* [329]. Indeed, the system was reshuffled and thrown into a state where a drone could not continue to fly indoors. We had a fragile baby to consider – hence it was no longer ethical for me to continue the study (see Figure 2.5 for an illustration of this).

This surfaced one of the true values of autoethnography. The study was long over, the narratives told, and yet insight was still generated. I wonder how often participants in studies care to, or are given the opportunity, to retell and re-frame their understandings. This change in the system is a type of micro-ethics which is necessary when doing research with children [81].

After my presentation of this paper at NordiCHI'2022, I was approached by a researcher. He said, in a friendly manner, *"you present this work so convincingly, it makes me wonder if I am taking my research too seriously"*. At the time I laughed and confirmed that he probably did so. But months later I still think often about this statement. Autoethnography is still widely perceived as 'not serious'. My attempt with this paper was precisely to find ways to make this method more approachable, and understood as indeed rigorous. The notion of the distance between research and researcher is visible in many forms. I take my research so seriously that I dedicated one year of my life documenting my interactions with my children, finally exposing them to the community in open access. Helms reflects precisely on some of these troubles, in her own research [101]. As she states *"I am*

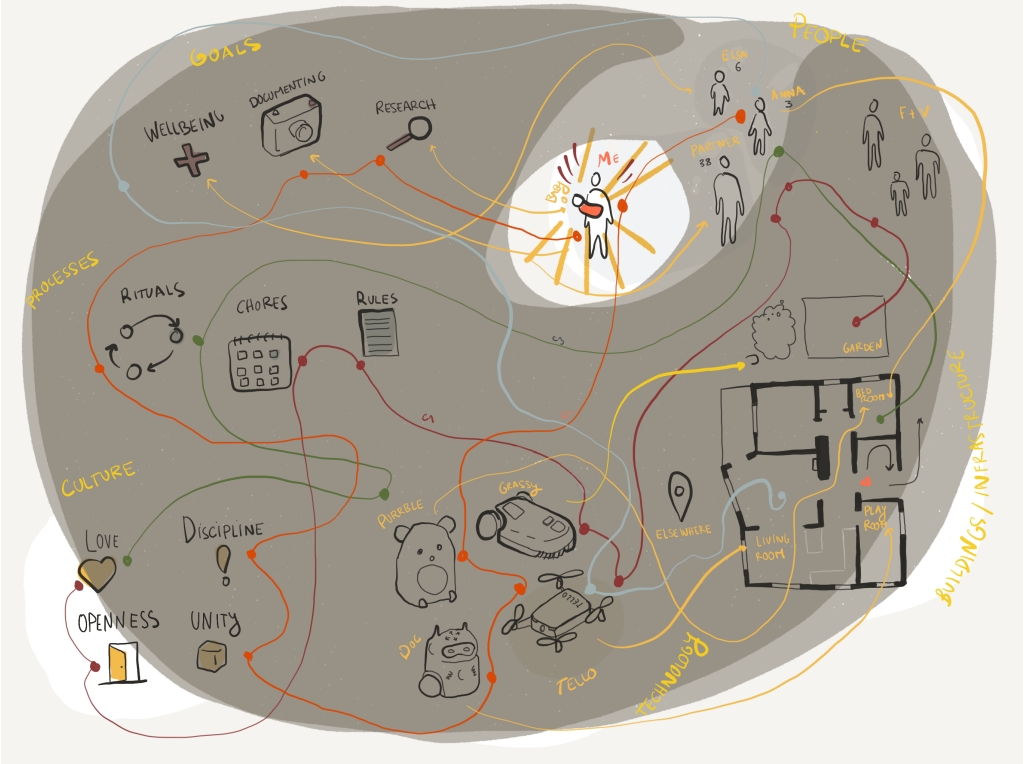


Figure 2.5: A new image of the sociotechnical system that is our family as described in the paper. Here, what matters is our new baby.

not in a position to speculate or fully understand the diverse possibilities of how my work might be misread, or even interpreted as intended within its full academic context, and still give rise to feelings of discomfort or harm for people external to my family. This might happen now or later. Yet as I reasoned for that publication and my child's potential later interpretations of it, I anticipate opportunities to discuss them in person with her" [101, p.9]. There is still a lot to be done in the HCI community in appreciating the intricacies of autoethnography.

2.2 Conversations with Myself: Sketching Workshop Experiences in Design Epistemology

Often – and particularly at the start of a career or education – we are expected to navigate complex social situations in a way that generates and supports what can be reproduced as useful knowledge or expressed as valuable experiences. At the start of my own PhD, I found it challenging to negotiate certain situations, colliding with difficulties in communicating my intentions, and finding my own path. A philosophical and theoretical framing of one's knowledge is essential to a career in academia, but finding a place and a standing relies on questioning more than just the solidity of one's methods.

Figure 2.6: A sketch of me, presenting a sketch of me presenting the pictorial at the venue.

Problem

The pictorial presented in this section covers ideas that go beyond a particular design problem, and are instead focused on a meta-reflection with relevance to HCI. Within the field, it is common to participate and organise workshops, either within research projects or as a part of conferences. As professionals in academia, we are often part or host workshops with educational or research purposes. While visual knowledge and methods are discussed in HCI (see Section 1.2.2.2), they are often neglected or less prioritised even when organising such events. As a budding researcher, I was invited to participant in a week long workshop to explore 'soma design' as a research approach, together with other researchers. The group was composed of an interdisciplinary mixture of academics, with varying levels of familiarity with the philosophy, and different seniority. As a result of participating

in this workshop, I summarised my graphic diary of the experience as a pictorial, discussing tensions in incorporating the presented philosophy, accommodating my tendency for visual methods as focusing and how they collided with notions of the body, and negotiations with drones as a design material.

Methodology

This pictorial represents a bridge to surface the value of visual methods as a fruitful approach to research. Rather than taking notes, my presence at the workshops was truly dedicated to being present and feeling, experiencing through my lived body. But my own background is an expression of a living necessity to sketch and perceive knowledge through illustration – through the dialogical nature of drawing [114], [118]. The work is grounded on an autoethnographic account of a workshop experience, documented through a graphic diary composed of sketches paired with narratives embedded in the paper's text but also through the use of ALT text (a digital accessibility tool for describing images).

Contribution

The contributions of provocative papers are difficult to pinpoint. It may take a long time before they can actually be recognised. Conversations with myself is a pictorial grounded on the assumption of sketches as a formulation of knowledge, an expression of lived data. The work presented both in sketching and in making sense of my own feelings during the workshop was essential to the development of my own path. As an expression of transparency, this pictorial is seminal to my approach to research. This insight is at least twofold:

First, the encounters I had with other people's designs and prototypes revealed unexpected dimensions of care; in the ways they unpacked them, presented them, handled them. Joseph La Delfa, another researcher working with similar drones as mine (see [253]), trusted me with assembling parts of the drones for his demo. He said: *"I hope you do not think I am too protective of my drones"*. But I did not think so – the way he had minutiose manner in which he unpacked each small drone, the way his hands moved, carefully putting together each piece, trying each interaction – all his mannerisms around the probes were inspiring to me. I had brought my own drones but they were so unfinished I was, at that point, embarrassed to even bring them out of the bag. I craved to find that relationship to a design probe myself, and I suspected this was a vision of the effect of an intricate combination of the 'soma design' framing and a dedicated process of research through design. These ritualistic gestures of preparation of the drones were reminiscent what I could observe online in hobby drone pilots, which further justified the necessity for the studies described as future work in this thesis.

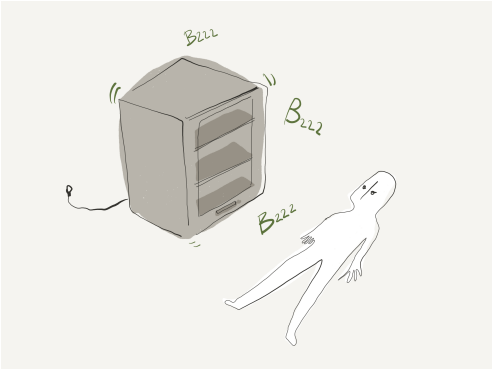
Second, I faced an important methodological insight. I had, at that point, already organised countless workshops with students, colleagues, or research participants. How often had I, however, organised for enough time and space for the workshop participants to engage through their own tools, facilitating conversations with themselves rather than just among them. During the 'soma design' workshop, I had neglected the importance of sketching for me – I avoided it because I saw it as a tool and technique that contradicted the somatic ways of knowing privileged. But as the week progressed I understood that that meant not talking to myself, and that I needed to advocate for sketching as a way of

focusing on my body, an activity in designerly ways of knowing, and I needed no other excuse than my own to stick to it. In the precise same way as others used verbal expression or written notes, I needed to sketch to make sense of the world. And as an inexperienced researcher, I needed the encouragement to take the time to myself, to take a break. I now remind others and myself to afford the time and space needed to support conversations with themselves in multiple ways and in the schedule of their workshops.

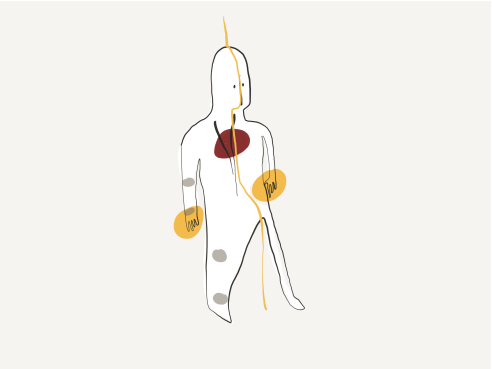
Curiously, some time after, I attended yet another course in 'soma design'. During the sessions planned, there was generous time and a safe space for reflection through whatever tools we found useful. We were encouraged to use that time to ourselves, rather than engage in conversations with others. I produced then some of the sketches that still represent most of what I find valuable in 'soma design' to my own work. Some of these images can be seen in Figure 2.7.

Being Human in Academia

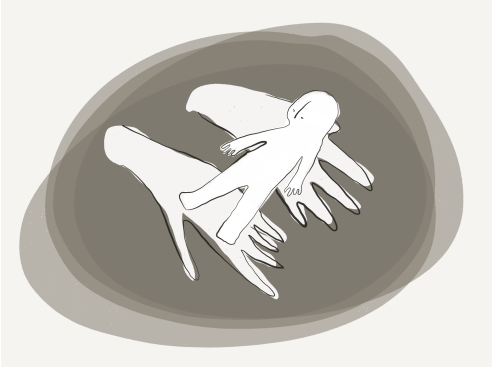
After presenting this pictorial at 15th ACM conference on Creativity & Cognition, I was approached by more than one researcher. It was my first time presenting a paper at a conference, so I did not know what to expect (see my opening slide in Figure 2.6). I was particularly tense since the pictorial was recognised with the Best Pictorial award. Perhaps I thought the narrative would not resonate with anyone in the audience, but the opposite happened – I was asked questions and given praise that related to the researcher's own struggles with their research topics and ways of knowing. Somehow, what was noteworthy, was that revealing a human side in research, making the difficulties with a workshop a real component of the research assembly visible, was enough to evoke insight. It is not that the knowledge in the pictorial was generalisable, or that my expressions of doubt and difficulties were universal, but rather that they were evocative enough to generate reflection through the visual and textual narrative presented (see section 1.2.2.3 on the importance of the use of narratives). This pictorial became therefore an expression of what I found rewarding in the field of academia – a possibility of artistic, autoethnographic, honest accounts of experiences as something of value in community making and in developing intentions of care when organising workshops. It became a gateway for me to be approached by other researchers navigating the same waters.



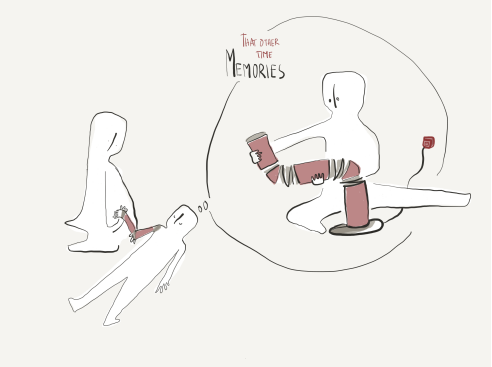
((a)) The machines in the room interrupt the focusing states.



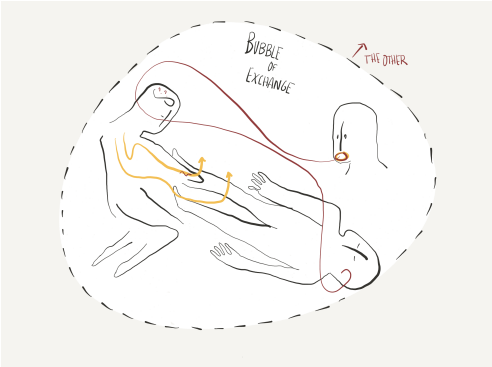
((b)) Doing a body map in another way, feeling out of balance.



((c)) Imagining myself in the care of others, as a probe, lying as a small animal on a giant's hands.



((d)) A Feldenkrais exercise in moving someone else's legs and arms.



((e)) In a Feldenkrais exercise, I felt as in a bubble with two others, through touch, sound, and breathing.

((f)) During an exercise, we explored notions of the other through touch in unfamiliar ways.

Figure 2.7: Sketches produced during a 'soma design' course.

2.3 Wisp: Drones as Companions for Breathing

Most research within human-drone interaction is connected to solving usability, efficiency, safety, and reliability issues, or dreaming of worlds with future useful applications. But there are also examples of the use of drones within art [199], [200] and well-being [253]. In this project, we shift the focus away from usability through exploring minimal somatic interactions with drones. We pay particular attention to using design philosophies to develop alternative interaction forms, specifically slow technology and soma design. These theories supported the research through design development of a provocative probe – *Wisp* – (a provotype [163]), by designing a micro-drone controlled by a human's breathing, creating space and opportunity for reflection and sense-making in the understanding of what drones are or ought to be.

Problem

As drones become commercially available, and applied in a variety of social contexts, the perceptions and ideas surrounding their use will be very different – as well as what (social) drones will be defined as. As noted by Johan Redström: *"These experiences of when a familiar category is (partially) redefined by a new design are individual and of course dependent on one's previous encounters with that category. While it is difficult to see a familiar thing we take for granted, like a camera, a bike, or a mobile phone, as a kind of ongoing and highly active 'definition' of what these things are to us, is there not a glimpse of this idea in the experience of something familiar being redefined through the introduction of a significant difference? 'So this is a camera,' 'I have never experienced biking like that before,' 'I would never have thought that phones would become this ,' and so on."* [41].

There is considerable work in HCI surveying current perceptions of drones through placing participants in contact with drones or images of drones – many of them with findings related to privacy issues, as well as the fear of damage or injury, and even which design aspects impact such perceptions [e.g. 246], [330], [331]. It is however, a worthwhile research endeavour to create platforms for discussion of what roles are desirable for drones, and for the design-led definition of what drones are to us. To that end, it is necessary at times to create defamiliarising experiences [151]. We could identify many ways of interacting with drones – focused on playfulness or precision of command. However, we decided to use breathing as an input mode, grounded on the conceptual idea of breathe as an accessible and primary mode of interacting with the world.

The *Wisp* project is presented in its first steps and slowness, further arguing for the need to share early steps in RtD processes. In this paper, we describe the steps from conceptual groundings to first informal evaluation, leaving space for alternative paths and an open discussion space for the HCI community, rather than presenting a 'finalised' design.

Methodology

The prominent research questions in this thesis are related to the design aspects of fringe applications (e.g. artistic uses, toys, etc.) involving the likelihood of more prevalent drone usage on a personal and commercial level. To engage in these issues, a situated methodology is necessary, in contact with both the

technology and participants over extended periods of time (as exemplified by my autoethnographic study [42]). In the case of this paper, we applied a 'research through design' (RtD) approach, by actually deploying probes in order to explore and research the experience of drones [155], [158], [164]. Using co-located robots in this context is important, as research shows significant differences in the perception of embodied robots versus tele-presential or simulated robots [332]. We recruited many designerly ways of researching, reporting on expert interviews, technical issues, first-person perspectives, and conceptual groundings. We make extensive use of visual media, showing photographs, diagrams, and sketches.

Contribution

This article describes the importance of a design research framing for human-drone interaction, as well as the benefits of developing drone concepts as prototypes of possible worlds. Through recruiting a critical posture in developing a minimal interaction with a drone, paired with a strong connection to concept-driven design, we offered an article that is dedicated to presenting designerly ways of thinking and re-imagining drones. Through our process, we report on the various steps of the design – presenting the rigorous description as a contribution in itself. For example, the results from the expert interviews can be re-used into other RtD projects. Through the informal pilot study we present, we generated a composite framework of soma design and slow technology, combining them into a generative tool for advancing somatic slow interactions. We present drones, through our work, as an intricate design material with aesthetic qualities evocative to the re-framing and re-definition of social robotics.

The next steps for this project are described in Section 3.2.

The Problem of Intermediate-Level Knowledge in Wisp

Left outside this paper is a seed for future work. It is remarkable that this publication became an example of how it is possible to deliver unfinished design artefacts as a vessel for knowledge and how preliminary and transitional results have a place in academic discourse. To tackle how these results can be developed and grasped, I see the need for further examples of intermediate-level design knowledge strongly grounded on understanding the artefact itself as a knowledge contribution. The design-oriented approached generated a large number of prototypes, which were valuable from a first-person perspective as an ongoing exploration on how drones can or should be designed, materialized through artefacts and narratives. This led me into a possible crossroads at this point: either develop an *ultimate particular* [31] to be studied in more detail as a product, or a collection of *instances* represented in an annotated portfolio and paired with strong concepts [165]. Both of these approaches presented some shortcomings, which resulted in a solution based on a strong emphasis on ambiguity as a resource [109] for interpretation and formulation of knowledge placed in a 'showroom' version of *Wisp*. *Wisp* is therefore a design abstraction of the first-person perspectives acquired through the project: a platform and interpretable portal towards further design-oriented knowledge and serves in on itself as the result of our research. When documenting *Wisp* we faced the following difficulties:

- Annotated portfolios [49], which have crystallised as the archetypal presentation of RtD intermediate-level knowledge, have come to emphasize the

products rather than process of design. They can, furthermore, be difficult to interpret even by other designers as they are static views of the instances without describing where the annotations come from. This creates issues for the communication of knowledge in the community (for more on annotated portfolios see section 1.2.2.2).

- Strong Concepts [165], could incorporate the process of design, but formulated to offer solutions to design spaces. While strong concepts are undeniably useful to the design community, they are demanding to formulate to guarantee their *contestable*, *defensible* and *substantive* dimensions. They rely on a multitude of different designs and neglect the presence of the designer themselves. This creates issues to designers intending to contribute in informal yet informative ways, and still leave space for ambiguity.

I argue that the finesse and characteristics of the 'showroom' opens for a different set of possible intermediate-level knowledge. The ability to summarise the knowledge gained throughout the process into an exhibition is in on itself an ambiguity-compatible way of presenting intermediate-level knowledge which can be interpreted and appropriated by designers and non-designers alike. Artefacts can at times afford the understanding of the design process – they are actual design decisions embedded in the ultimate particular that transpire the knowledge behind. For example, in the same way as an article refers to another one, so can a design refer to previous knowledge. Within architecture, a brutalist building can be recognised through the use of patterns (such as raw concrete, or a strict grid-based floor plan), but also through a combination of aesthetics that speak for themselves – at least to other architects.

2.4 Conversational Composites: A Method for Tangible Illustration Layering

In this pictorial, we present a method for conversations through visual techniques. We suggest the use of a combination of tangible and digital media as a platform for exchanging interpretations of narratives surrounding a given prompt. In this case, we used narratives of hobby drone pilots as the starting point.

Problem

Conversations held between researchers are often verbal or in written format. We tend to neglect other forms of communication – for example through visual tools such as photography and drawing. These forms of communication are, as described in Section 1.2.2.2, excellent at allowing for ambiguous thoughts to come into play in the dialogue [113], [114] rather than prioritising clarity at all costs. As mentioned by Yurman, the 'loose' nature of sketching is like a metaphor for an invitation.

At this point in the research, most of my work had taken the form of textual discourse. However, thankfully, when the pictorial presented in Section 2.2 was accepted at the ACM Creativity and Cognition conference in 2022, I took a look at which workshops would take place in the same conference – and found Yurman, Juul Søndergaard, Pierce *et al.*'s workshop entitled 'Venetian Drawing Conversations'. Their call for submissions included developing *"visual dialogues resulting from the merging of drawings created by different people"* [333]. They encouraged applications from researchers, scientists and creative practitioners working in or interested in areas such as:

- "Experimental design methods
- Drawing as research
- Research through design: artefacts as knowledge production
- Speculative and critical design
- Ambiguity and defamiliarization
- Visualizations as design methods
- Ideation and futuring techniques
- Aesthetic interactions" [333]

As a reminder – one of my research questions revolves around the relevance of designerly approaches to HDI. So this call was tailored to my interests. I suggested to my supervisor that we should put together a submission, finally having an excellent excuse to put into practice some of our artistic practice as part of our project. Sara has extensive practice in watercolour and other painting as a hobby. We decided to combine the two topics we most care about: ethnographic data and artistic/designerly approaches.

We were inspired by the idea of *exquisite corpse*, a playful technique invented by surrealists, where one image is collectively created in the folding of paper. In *exquisite corpse*, a group of people share the task of creating a human figure, and

each participant is assigned a fragment of the composition, starting for example at the head, and folding the piece of paper so that the next participant continues with the shoulders without having seen the previous drawing. At the end, the revealing of the whole picture is usually quite amusing, a mixture of ideas mashed together into one body. This game has been inspiring to other researchers in HCI [334]–[336].

Abstract novelty and amusement were not exactly our priority – we wanted to create a method that would allow for turntaking and still preserve some of the revelation elements of *exquisite corpse*.

So we needed a prompt. We decided to make use of an online forum we had been members of since the start of the project. We put together a simple anonymous questionnaire asking hobby drone pilots from the Swedish DJI drone owners Facebook group, prompting them to give us short stories from incidents they have had with their drones. Here are two examples of the prompts we ended up using:

> "It flew away. I used the app litchi and had created a route it would follow, but it never came back. It turned out that I did not think that the stated height is in relation to the starting point and when the ground rose, it came closer and closer to the ground and finally stopped in front of a large spruce and did not know where it would go. There it hovered until the batteries ran out. A resident in the area found it after 1 1/2 years and when I checked the film on the memory card it was clear what had happened."

> "I'm on my 5th drone. I have crashed three drones and that is of course due to the way I use the drone. My drone is a camera dolly and the best movie clip is when you drive backwards and sideways. Unfortunately, you do not see in the direction of travel either. I usually film my grandson, who engages in kite surfing and kite foiling, 2-3 m above the water is usually the best and safest, but sometimes you end up below 1 m and then there is a crisis."

Methodology

The pictorial describes a method of data analysis through the use of sketching and illustration: *Conversational Composites*. To be able to understand the potential of the method, we applied it as a conversation between me and my supervisor (Sara Ljungblad). Together with Miriam Sturdee, we developed a vision for this method as we move on from our experience and present it as a valuable tool for others. Therefore – we put considerate work into illustrating the process, opening up for alternative appropriations of the method.

Conversational Composites involves a back-and-forth exchange of sketches and drawings between multiple participants. It's unique because it focuses on the physical creation and modification of a composite piece, which allows for the traceability of each participant's perspectives and interpretations. The final product is made up of distinct layers, each with its own identity, but all contributing to the overall composite. This method can be used by any number of participants – as many as the number of layers. The process begins with a prompt, which serves as the starting point. These prompts can be research questions, requirements, stories,

photos of events, user quotes, diary entries, design artefacts, design guidelines, manifestos, and more. Once a suitable prompt for conversation has been selected, the next step is to determine the layers of the composite. It's important to consider the physical properties of the chosen media and techniques when defining each layer. For example, if translucent paper is being used, it may not be suitable to use watercolor as a technique. The method involves creating and exchanging each layer with the next participant. Each step should build upon the previous content and make use of the current layer's media and technique.

After completing their assigned layers, participants should annotate their work and reflect on any new insights that arose. It's suggested that participants read each other's annotations and discuss the composite as a whole, noting any changes or similarities between layers, and how each image was built upon, redrawn, ignored, or left unchanged. The method also allows for the examination of each layer on its own and the rearrangement of the layers to potentially uncover new meanings.

Contribution

Our method is an example of how visual tools can be generative for academic knowledge. Indeed – much of the relevance of designerly approaches in researching HDI comes from their ability in dealing with complex relationships and making visible what otherwise was invisible. Design research, as exemplified by *Conversational Composites*, thrives in the possibility of bringing a multitude of voices onto the discussion in multiple ways. In this pictorial, we presented a set of directions but most of all we noted how its use supported previously unexplored directions. For me, in particular, it made me question some of the future work I was planning.

The importance of more-than-human actors in HDI became more evident to me. Curiously, there was great value in discussing the resulting images with the other participants at the workshop. Their questions were generative to our work with drones, and indeed showed how incorporating designerly ways of knowing made us move forward in our HDI research. In the re-interpretation of the textual narratives given to us by actual hobby drone pilots, we expanded and rebuilt the stories. The new depictions conveyed other meanings – but more importantly, they became an excellent prompt for further discussion for the workshops this method was envisioned for. The pictorial offers the method to the HCI community in its raw form, although we propose a number of alternatives that can be put into place. We suggest that the technique may be used with other prompts and media. The final artefact generated through our method relies strongly on transparency and collaboration, while still affording a large variance in backgrounds and number of participants.

We envision *Conversational Composites* as a method that promotes interdisciplinary collaboration, helps to flatten hierarchies, and allows for design research discussions to occur in alternative forms that facilitate a deeper and more novel understanding. The inherent ambiguity and equal influence of each participant in this method creates a rich conversation that can be productive at levels beyond speech or text. The final step of this method involves analysing and discussing the composite, interpreting it through conversation. This allows the composite to be viewed as a whole and to mindfully consider which elements are visible through the layers and which fade into the background during this process. We plan on the continued use of our method, particularly when engaging in other ethnographies.

An Invitation

If you happen to be holding a physical copy of this thesis in your hands, I leave below a bespoke prompt with a sketch for you to continue drawing your thoughts at this point – is there a way you could use this method? I invite you to add slowly [185] to the conversation by putting your mark on this paper, and returning the copy to a shelf, or sending me a picture of your addition to my email. If you have done this, feel free to make a mark on the fore edge too! Perhaps others will join your conversation.

Chapter 3

Future Work

Did you arrive here without having read the previous chapters? That is fine. No – really – this is the most important chapter. A licentiate degree should be about where I am headed, and because I have learnt so much in the process of getting here, I would have redone everything in the appended publications. Are you reading this after I am done with my PhD? That is even better, you can check in how many ways this plan failed.

I could summarise the work in this thesis as follows: studying the design of social drones[1] is significantly more complicated than anticipated. Drones resist playful design explorations due to their technical complexity as we could see through the *Wisp* project. The engineering of drones is arguably still in its infancy – and so is their design. My work so far has leveraged what could be described as a design sensibility-driven approach, formulating encounters that happen in society as deeply relational. Drones are not only in the air, they take up our attention and create grounding notions that are relevant to what should be considered when designing and researching them.

Because the funding of this project is targeted towards AI[2], my own work goes hand-in-hand with the developments in automatisation. In fact, many commercial drones already incorporate advancements in AI. As pointed out in the literature review, the field of HCI seems to expect drones to quickly become autonomous, but the truth is that there are more than technological issues in this – to fully make a judgement on the risks of autonomous drones in order to create a valid legal framework for them will likely take decades. There is, however, considerate peril in the fast development of autonomous features and potential applications. The work so far does not focus on the development towards automation, but is oriented towards discussing the current relationships between humans, drones, and other actors. One of the questions posed within the project is whether or not the risks of using drones outweighs the benefits. This question can not possibly be answered by one researcher alone – rather, it needs a combination of multiple perspectives.

[1] It is unfortunate that I am still using this expression at this point. I am uninterested in further definitions of what a social drone is. In line with agential realism [66] none of my work relies on a demarcated understanding of what exactly a social drone is. Rather, a drone can be both social and something else at the same time, both of them being true. The whole drone can be social, or the way it moves. Its propellers can be agents of social interaction. And I would like to keep that open-endedness that way.

[2] https://wasp-hs.org/projects/the-rise-of-social-drones-a-constructive-design-research-agenda/

As shown by the autoethnography appended [42], there are complex relationships of care created by the presence of a drone. It is of the essence to keep making space for the role of designers as facilitators and champions of alternative values in Human-Drone Interaction. For me, a good dose of anti-technopositivism is necessary in any research conducted. Further ethnographic studies will continue to inform just how important designers are in this context.

Drones are an excellent technology for challenging the *status quo* of research within Human-Robot Interaction. I see them as the harbingers of more-than-human design knowledge into the field – where much of the focus could be unmaking the technology rather than developing it. The idea of drone concepts that pose problems (such as *Wisp*) is helpful in figuring out what is desirable or not – not only for humans, but for other actors.

There are two important frames for my work moving on: Bellacasa's matters of care [67], and Stolterman and Wiberg's notion of concept-driven design. My research in the following years will, informed by the work presented in this thesis, leap from first-person narratives towards representations of other's relationships to drones.

Bellacasa grounds her argumentation on Latour's notion of the negotiation between matters of fact and matters of concern [68], [337], stepping further into the discussion of what she names *matters of care* [67]. Informed by Haraway's call to *stay with the trouble* [28], Bellacasa *"raises the issue of how 'we' are contributing to the construction of the world. How does respect for concerns in the things we re-present encourage attention to the effects of our accounts on the composition of things?"* [67]

Hence, I propose the two tracks a a continuation of my previous work: ethnographies of care and concept-driven explorations of drones – both of these resulting in developing narratives and designs for the showroom.

3.1 Ethnographies of Care

After two years of researching drones, I have come in contact with many stories and examples of how they are used. I have throughout the years joined a number of online fora (for example on social media) and been particularly attentive to news about drones. In the combination of the stories I have heard, the reactions I have seen online, and my previous work in autoethnography [338], I have found that there are many dimensions of care transmitted in the interactions with drones. As already mentioned, drones challenge the notion of the user-bystander dichotomy, producing many layers of matters of concern (from safety to legal) but more importantly for my research, and creating worlds where neglect becomes evident.

One example of this is how drones often end up in accidents, either submerged or colliding with trees or even animals. Market leader DJI even offers an after-sales service curiously called 'DJI Care Refresh'[3] covering protection for collision, water damage, flyaway, and natural wear. This service offers, for a 1 year plan *"Two replacements in one year: Usable twice for damage, Usable once for flyaway"*. This is a quite significant service offering brand new drones at the cost of a replacement fee. But what happens to these drones that flyaway or are drowned in the sea. Our previous work [339] asked in an online forum for short stories of drone accidents. In these stories we could identify many dimensions of matters of care, from expressions

[3] https://www.dji.com/se/support/service/djicare-refresh

of worry for privacy, drones returned after many years thanks to the kindness and curiosity of the finders, and collisions with more-than-human agents.

Once, while scrolling a forum for DJI drone owners in Sweden, there was a post that caught my attention. There was an image in it: a submerged drone in an old lime quarry. The post was written by a group of divers and it read: *"During the morning today we found a Mavic 2 drone. The owner had filmed the quarry, but even themselves. Help us find the owner so they can find their drone back. Share share share."* The initial post gathered more than 120 shares. There were a number of comments, many with suggestions on how to track the owner through the SD card inside the drone. Some asked if there was no operator ID, as this is usually required in Sweden. Many pointed out, the propellers were gone, find it it suspicious. Some theorised that the drone was just dumped, while others thought perhaps a fish or crayfish had taken them. One week later, the diver's group posted a photo of the owner reunited with the drone. I can't help but be curious – what was the story? Who took the propellers? What happens to the drone now? Stories such as this one show the complexity of the sociotechnical assemblage surrounding that one drone. Because these robots are in the wild interacting with humans and more-than-human agents, they have become invaluable objects to research. This story surfaces many dimensions of care, which can not be neglected in research.

I propose therefore a series of studies, making use of online ethnography and participatory ethnography (See Section 1.2.2.1) with hobby drone drivers. I am interested in those that engage with commercial drones out of own volition and interest, either using or building them in their free time. This group of people include teachers using drones in their classroom, racers, repairers, you-tubers, and others that I do not yet know of. The aim is to gather many stories surrounding drones in order to preserve their complexity and making visible the labour of care associated with them, along with signs of neglect. Here, a variety of 'matters of care' should surface, giving voice to agents beyond the drone and the human, such as the crayfish at the bottom of the lime quarry.

3.2 Drone Concepts

Another thread in my work is centred on the development of minimal and experimental interactions with drones. The work with *Wisp* was a first step in this progressing idea [43]. Through concept-driven interaction design, I propose continuing the discussion on what roles drones ought to play in the world. Initially – the objective was to create probes that could be used in domestic contexts. However, through the work presented in this thesis, I have found that forcing the domestication of drones through design probes may be intensely undesirable [42]. Instead, exhibitions presents themselves as an excellent platform for discussing drone concepts and making advancements in (More-than-)Human-Drone Interaction.

Creating *Drone Concepts* (regardless if for the showroom or, for example, for online publications), brings issues pertaining the discussion on Intermediate-Level Knowledge as derived from Wisp and explained in Section 2.3. These concepts to be exhibited need to negotiate the need for interpretation of the design knowledge behind them while simultaneously being ambiguous enough to provoke – they need to afford discussion that contributes to the research aims and the theory surrounding the design of drones.

Within these concepts, I see space for the creation of actual interactive prototypes (as exemplified by *Wisp*), but also the development of critical designs and artworks that question and reveal the tensions of the real-world assemblages surrounding drones as discovered through the above suggested ethnographies of care. I propose therefore the development of critical signage, dioramas, posters, paintings, sculptures, and many other types of conceptual design and artistic artefacts. These contributions are to be developed as research-through-design, with continued rigorous documentation of their process.

3.3 Drones Stories and Concepts in The Showroom

The connection between these two (ethnographies and concepts) may at first be unclear, but they collide in the creation of artefact-oriented narratives and exhibition pieces. I propose that the first ethnographic studies result in pieces with drone-centred rich narratives, where the drone plays the hero (or the villain). For example, the drone that visited the bottom of the lime quarry is certainly no longer functional. Its shell could be turned into an exhibit, paired with a story of its life and those it has touched. The drone we have used at home with my children is definitely one of those pieces [42]. Similarly, *Wisp* [43] is a prototype designed to be experienced in order to question what an interaction with a drone is or may be. The development of the concepts mentioned above, such as signage for future worlds, comes together in visions and narratives to be discussed with a wider audience. Here, it is important to note that the notion of wider audience must be an inclusive one, reaching out to anyone, from children to disabled people, regardless of language or age. The aim of my research is to culminate in an accessible exhibition rich enough to make all visitors question and converse on the future of drones in our society, be that that they should thrive, or that they should be unmade.

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