

Constructive design research

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A close-up portrait of Prof. dr. ir. Stephan Wensveen, a man with short, slightly messy brown hair and a full beard, smiling gently. He is wearing a grey jacket over a dark green t-shirt. The background is a soft, out-of-focus mix of pink and blue.

Prof.dr.ir. Stephan Wensveen
October 19, 2018

INAUGURAL LECTURE

Constructive Design Research

TU/e

EINDHOVEN
UNIVERSITY OF
TECHNOLOGY

DEPARTMENT OF INDUSTRIAL DESIGN

INAUGURAL LECTURE PROF.DR.IR. STEPHAN WENSVEEN

Constructive Design Research

Presented on October 19, 2018
at Eindhoven University of Technology

Towards the end of my PhD research, my mentor Kees Overbeeke asked me to inspire my doing of design research with my competence in surfing and skateboarding. At that point, I didn't succeed, perhaps refused to even try. Now, with a distance in time, and a distance from decent waves I will try.

Designing Freedom

My brother and I started with windsurfing, which, in a way can be compared to engineering with its focus on the right squared meters of sail, the mechanics of rigging sail, boom, mast and optimizing your course in relation to the changing winds on the small lake in Delft. At a certain point we discovered surfing, riding waves with just a small board, enjoying the freedom of less material, a more counter culture to windsurfing, and a better means of personal expression for us, both in and out of the water. In skateboarding I found physical expression, a creativity to use the streets as a canvas for expression, somewhat anti-establishment and an experienced notion of what I later was taught are 'affordances', where street curbs afford grinding for skilled skaters. In the down time we read surf and skate magazines and were slowly being influenced by values and images coming from California. This influence went deeper.

The recent exhibition 'California. Designing Freedom' by the London Design Museum [McGuirk and McGetrick, 2017] makes clear how I, you and design have been influenced and shaped by the values, the images and the products that came out of California. I will use the five themes from that exhibition to show how I have been influenced, and how these values direct my thinking and doing, as a person, a designer-researcher, a teacher, and a Director of Education.

GO WHERE YOU WANT: TOOLS OF MOVEMENT AND ESCAPE

The exhibition shows the typical technologically-assisted freedom that came out of California, from the miniaturized digital calculator in 1972, the first laptops in the 80's, the iPod and iPhone, to Google Maps and self-driving cars.

In 2001, the very first iPod came out, and I was amazed by its design, the smooth interaction with the scroll wheel and the integration with the music service iTunes. More than the material and interaction qualities, the iPod gave me the freedom to go where I wanted to go, which meant I could still live in surf town Scheveningen and musically enjoy, or survive, the 2 hour commute and take on the new job at the TU in Eindhoven.

SEE WHAT YOU WANT: TOOLS OF PERCEPTION AND FANTASY

In the 70's I was too young to have been under the influence of the Californian tool of perception called "LSD", and I am too old to wear Snapchat spectacles, but I have been to Disneyland.

In the 1980's I have played many video games of Space Invaders and Frogger on my friend's Atari. Frogger featured in one of my most famous academic articles, Interaction Frogger [Wensveen et al. 2004]. This article presented a theoretical and intellectual tool of perception and imagination for interaction designers; a framework to support designers in an analysis and synthesis of how perception and action can be mapped using feedback, and the newly introduced notion of feedforward.

SAY WHAT YOU WANT: TOOLS OF SELF-EXPRESSION AND REBELLION

The examples of the exhibition mostly show the rebellious nature of the graphic design that came out California, using the latest tool of the Apple Mac exploring new graphic languages or by giving a visual form to black power, freedom of speech and human rights.

I have always been fond of magazines for its mix of text and images. My brother and wife are graphic designers, and graphic design was a strong inspiration in my early years. We were amazed by the work of surfer-turned-graphic-designer David Carson for Transworld Skateboarding in the 80's, Surfer Magazine, Beach Culture, and Raygun in the 90's.

As a design researcher, my rebellious nature was aroused when I joined the design research group of Kees Overbeeke, Caroline Hummels and Tom Djajadiningrat in 1998, feeling we needed liberation from the established approaches of design research that for me lacked total relevance. The titles, or parts of titles of our papers showed this rebellious side: "Augmenting fun and beauty: a pamphlet" [Djajadiningrat et al. 2000]; "Forget about Ease of Use!" [Overbeeke et al. 2002], "Push me, Shove me" [Wensveen et al. 2002], "Touch me, hit me" [Wensveen et al. 2000]; and "But how, Donald, tell us how" [Djajadiningrat et al. 2002] where we

challenged the great Donald Norman with novel notions of inherent feedback and feedforward. These papers have been referenced by hundreds, and the papers downloaded by almost 10.000 design students, practitioners and researchers.

In my PhD research for affective computing I designed a research artefact to explore and demonstrate how *freedom of interaction*, leads to freedom of expression from which the artefact could predict someone's emotional state.

MAKE WHAT YOU WANT: TOOLS OF PRODUCTION AND SELF-RELIANCE

The pioneering spirit of California has been shown first by making the military-industrial tools of computing available for the individual, allowing for desktop publishing and later on it shows in the DIY and Maker movement, design thinking or biohacking. As Brendan McGetrick, the curator states, "design works best when it makes elite tools accessible to all" [McGuirk and McGetrick, 2017].

I must admit, that I have never been a real maker myself, and my family can tell you that I'd rather take things apart, than put things together. However, I have fully supported the makers in the department and therefore in 2006 co-initiated the /d.search-labs. The /d.search-labs aimed to use the power of design to strengthen the integration of the three parts of the 'Knowledge Triangle': design education, scientific research and societal innovation in the context of the multi-disciplinary field of Ambient Intelligence. The prototyping facilities and activities gave our department the resources to rely on its own tools to produce research prototypes and evaluate them in a controlled home domain context, a lab dedicated to producing knowledge for design research, education and innovation.

In 2008 student work (Peeters, 2009; Bouwstra et al. 2009) showed us that we wanted to integrate electronics and textiles, but had little means to make these prototypes. Therefore we initiated the Wearable Senses lab, where we focused on designing close-to-the-body interactions, specifically designs that incorporate wearable sensors, smart textiles or were designed and produced using algorithms and parametric design. The lab includes prototyping and manufacturing capabilities for the creation of apparel, accessories and jewelry, that integrate technology on an inherent level. Beyond industrial sewing, over-lock and heat press machines, the Wearable Senses Lab is equipped with knitting, weaving, tufting, vinyl cutting, 3D-printing and embroidery machines.

The integration of the expertise of diverse people from academia, industry and the arts, their prototyping tools, the material outcomes and the final concepts, create an energy that visitors feel, and want to be part of. Therefore WS has developed a strong network of industry partners (regional, national, and international) and in this way receives support on different levels from both the textile and the electronics world. These professionals have an important role in proposing design briefs and coaching for students to ensure that the projects have a level of societal relevance. Finally, industry collaborates with WS on the realization and dissemination of projects developed by students and researchers. This energy of innovation, creativity, aesthetics and a general sense of quality and passion created a community that feels like an emerging multidisciplinary culture. In the past ten years, the Wearable Senses lab has become more than a tool of prototype production and self-reliance, it became a tool of collaboration and community.

JOIN WHO YOU WANT: TOOLS OF COLLABORATION AND COMMUNITY

California has brought forward many countercultures for collaboration. From the early hippie communes, the efforts of Douglas Englebart for a collaborative computing environment, Stewart Brand's Whole Earth Catalogue and The Well, to Wired magazine and the social communities of Facebook.

Community "...becoming ever more oneself in the company of others. It's something where you are both more individualistic and more collaborative." [McGuirk and McGetrick, 2017].

Design studios and research labs are more than places to do work, they are tools of collaboration and community. As a design researcher, I have enjoyed sharing with, and caring for three internationally renowned design research groups based on interdisciplinary collaboration and community, i.e., the Delft ID-StudioLab (lead by Kees Overbeeke, Pieter Jan Stappers, Paul Hekkert & David Keyson), the community of Industrial Design at the TU/e and the Sønderborg Participatory Innovation Research centre (lead by Jacob Buur).

The values above have also been implemented as part of the education at Industrial Design. After year 1, students have the freedom to join the educational squad they want and they gain more and more freedom to self-direct their development to become the design engineer they want to be. In the Bachelor

year 3 and Master year 2 they can go where they want to go. This individual freedom has limits as it does take place in the company of others, in the social-cultural setting of the TU/e and the larger community of Industrial Design. This is a diverse community, and that is good, as the world outside is a diverse community. And as the Director of Education in Industrial Design I stress the importance of the multidisciplinary communities of diverse individuals with senior and junior employees, people, partners and guests, working side by side in squads, Innovation Spaces, design studios, and research labs. The world needs engineers that can deal with this complexity and collaboration.

I live and work in Europe and don't surf that often anymore, so enough with my celebration of California, there should also be critique. I agree with Justin McGuirk "one cannot celebrate the influence of California on design without acknowledging what, especially from a European perspective, is its dark side. Disruptive platforms, from Uber and Airbnb to Facebook, empower the individual at the expense of traditional forms of labour, media and society." [McGuirk and McGetrick, 2017, p15]. And even closer to industrial design is the deep irony of what the Californian counterculture has become: "...beautiful handheld devices that make us free and empowered, but they connect us very directly to corporate identities with agendas very much of their own." [McGuirk and McGetrick, 2017, p.199].

I will return to this later.

To critique is to care is to construct

'Metaphors suck' [in: Djajadiningrat et al. 2000] was my first contribution to design research, as one of the ten slogans we put forward as critiques of the established approaches to interaction design, design research and the interactive products that came out on the market. The titles were often criticizing, with its disapproving nature to draw attention, but the actual critique was based on a more detailed analysis.

Both designers and researchers are no strangers to critique, and regularly make detailed analysis and assessments. The goals of design critiques are multiple; gain understanding of the design, improve the design or the argumentation for the design, or abandon the current design and explore and construct alternatives. It is especially that last goal that we have pursued over time, and what for me should be the aim of Constructive Design Research; a critical approach towards design, technology and society, in order to care for design, technology and society.

"The critic is not the one who debunks, but the one who assembles. The critic is not the one who lifts the rugs from under the feet of the naïve believers, but the one who offers the participants arenas in which to gather. The critic is [...] the one for whom, if something is constructed, then it means it is fragile and thus in great need of care and caution." (Latour 2004, p246)

Actions speak louder than words. Latour is a philosopher, I am a designer, and therefore my arguments and care are not only expressed in words, but also in design actions. Our critique of constructions is expressed through new design constructions, tools and frameworks; an active generation of knowledge and constructive critique.

Design Research & Critique

I will now discuss some of our early critiques of established approaches, the alternatives that were constructed, and the impact of these constructions on design research and practice.

I am trained as an Industrial Design Engineer from Delft University of Technology, where I was educated in the ergonomics, business aspects, the construction and production, and the formgiving of the appearance. After my studies and the realisation that I would never be a full time surfer, nor had interest in becoming a practising industrial designer, I joined the research group of Kees Overbeeke. This group had a different theoretical basis, found in ecological psychology and Gibson's theory of affordances, perception and action. Around that same time, the latest technological opportunities moved traditional industrial design towards the new area of interaction design, the design of interactive products. The group, the theory, and the new area triggered my curiosity, and I slowly realised I wanted to become an interaction design researcher.

Research for the area of interaction design came from Human Computer Interaction with a strong focus on cognitive psychology, and the industrial design of these new products focussed on the use of semantics, metaphors for use, and aesthetically pleasing layouts of screens, icons and push buttons. This over-emphasis on the rational and cognitive approach to the design of interactive products didn't match our thinking and doing and became the aim for many of the critiques. We felt that the established approach only respected the cognitive competence of a person (user or designer), while ignoring their perceptual-motor, emotional and social competences.

Instead of the cognitive approach we advocated a direct approach [Djajadiningrat et al. 2004], where physical actions, affordances and effectivities, feedback and feedforward lead to tangible interaction. In, what is now known as an annotated portfolio we showcased and annotated several prototypes for concepts, i.e., a video recorder, a digital camera, a programmable thermostat and an alarm clock, each illustrative for a unique design lesson to exemplify different aspects of our general perceptual-motor driven approach.

This critique has had an academic impact as it is a highly cited and downloaded paper. The impact on practice is less clear. Some of the lessons might show in the specific details of products that are successful on the market, however the acceptance of tangible interaction beyond academia remains limited to game- and musical interfaces.

In the early 2000's the **established approach** to detect emotions for affective computing came from MIT and was based on the sensing of physiological parameters, heart rate variability, blood pressure, skin conductivity. We **critiqued** this monitoring approach which could be understood from an engineering and cognitive approach, but not from our designerly approach, as it didn't show much respect for the human users and their bodily and emotional skills.

As an **alternative approach** we suggested design principles coming from tangible interaction and offering 'freedom of interaction' to invite users to have the freedom to express their emotion to products in such a way that the product could recognize this expression. It was hypothesized that the alarm clock we **constructed** based on those design principles, would be able to detect a person's affective state and level of urgency from the expressive interaction to set the alarm time. This hypothesis was tested through several controlled experiments where the person's affective state was induced by movie clips validated for emotional valence and arousal. We found statistically significant relations between the dependent variables describing the expressive behaviour and the independent variables that describe the affective state of the persons. Although we hoped to

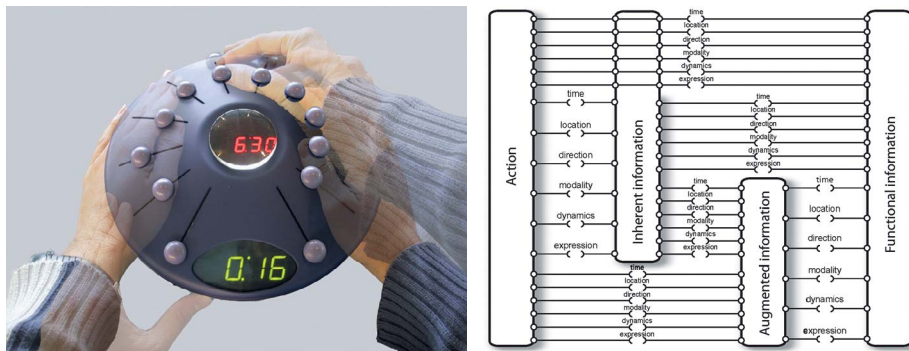


Figure 1. Two contributions of the research of Wensveen et al. (2002); the prototype of the alarm clock that allowed for freedom of interaction (left) and the theoretical Interaction Frogger Framework that resulted from the research (right).

find this relationship, some serendipitous findings also emerged in the analysis of the data. The results showed an unexpected relation where people in a positive affective state seemed to create more aesthetically pleasing patterns of balance and symmetry.

Impact: The project had a methodological impact on design research, as it was seen as a 'canonical example' of research through design by the interaction design community [Zimmerman et al. 2010]. More importantly, the research continued into a further development of the design principles beyond the alarm clock and the resulting 'Interaction Frogger' framework is now used in research, education and design practices around the world.

The **established approach** for aesthetics in industrial design was to focus on beauty of the physical appearance using semantics, visual metaphors or visually pleasing distribution of buttons, screens and dials. When products become more interactive, our **critique** was on the beautifully designed boxes that demanded 'ugly' interaction. We therefore proposed to strive for beauty in interaction. Philip Ross took this notion further and made the critical connection between beauty and values, stressing the relation between aesthetics and ethics for the design of intelligent products and systems [Ross, 2008]. He suggested a design process that was based on a pragmatist notion of aesthetics in order to design for aesthetics of interaction. He designed, **constructed** and validated an alternative product



Figure 2. Two contributions of the research of Philip Ross (2008); the interactive light fixture for aesthetics of interaction, in this case targeted at the Person Value of 'social power' (left) and the Perspectives Framework (right).

system, a static light fixture triggering different interactions on a sensory-motor and social level dedicated to relate to the Person value. The **impact** of this work can be seen in the established notion and importance of aesthetics of interaction in research and practice. The research prototype was further developed into the commercialized version Fonckel.

These, and other examples coming from Dutch universities of technology were not the only examples of academic design research that showed a critical attitude. Other efforts of critique on design, technology and design research could be seen. In the UK this was made very clear by Tony Dunne and Fiona Raby in (2001), who proposed Design Noir, a reference to Film Noir, as an alternative and critique on 'Hollywood' Design. Design Noir, or Critical Design makes use of design fiction and speculative design proposals to challenge assumptions, and the role that designed technologies play in everyday life. In the Nordic countries, design research often played a critical role in making sure that the introduction of new technologies was not pushed, but carried through the participation of all the people involved.

Although these critical efforts had different aims, they all shared an attitude of designerly liberation. A liberation from, and a counter culture toward the design research and innovation of that time, that was dominated by the scientific thinking and doing of non-designers. We were exploring and experimenting with ways to enable self-sufficient and designerly fulfilling design research and innovation. Partly a liberation from something, but more importantly the liberation to do something, or be something; a designer **and** a researcher.

Constructive Design Research

Design has become an academic field, with design research being offered by many contributing disciplines and from multiple viewpoints. In 1993 Frayling made the distinction between 'research for art and design', 'research into art and design', and 'research through art and design'. The first two forms rely on research and the traditions from disciplines, other than design. In research through design (RtD) it is the design process that becomes the research process and knowledge is generated and communicated through the designed artefact. The first two forms look more at past or present aspects, and research 'what is'. Research through Design is forward orientated, and researches 'what could be'. RtD imagines what could be and constructs this future, in order to critically investigate the outcomes and the consequences.

Originating in the art schools, in the early 2000's research through design was being explored and practiced within the context of Human Computer Interaction (for a larger overview of Research through Design: Stappers and Giaccardi 2017). So while there are hundreds of methods for design research, there only seemed to be a few methodologies. This was the fundamental observation, that lead Ilpo Koskinen to investigate the best practices of research through design practice, which resulted in the book: 'Design research through Practice. From the Lab, Field and Showroom [Koskinen et al, 2015]. The criteria for the best practice are simple: research has to be integrated and links theoretical thinking with studio work and doing actual designs. The second criterium is that research programmes have to be successful, with a community behind it.

The investigation brought forward the following three main approaches to research through design: Lab, Field and Showroom. The essence of the 'Lab' approach is characterized by a theoretically inspired design process and the designs can be seen as physical hypotheses. Systematic variations of the prototypes are tested in controlled lab experiments, using quantitative data and statistics to demonstrate causality. The aim is to come to generalizable design knowledge, frameworks and theory.

The essence of 'Field' is that design is investigated in its natural context of uncontrollable settings. It is based on design ethnography, driven by understanding, rather than causality, and a focus on how people create meaning with the new designs in their everyday environment. The aim is to generate situated knowledge and understanding.

In the 'Showroom' approach it is where research meets design and art. However, design can come closer to reality than art. Showroom is an umbrella term for critical and speculative design research, where the aim is to go beyond knowledge, and ask novel, uncomfortable, but relevant questions, rather than providing comforting answers. It is research and design for debate; where the task of design is to take drifts and detours from established practices.

The origin and emergence of the three methodological approaches to research through design can be understood in their social-cultural context of design research. Lab approach emerged in the Netherlands out of universities of technology, where first tier money was used for fundamental design research, using a legitimate and established methodology of controlled experiments with quantitative data searching for causality and general knowledge. Field emerged out of a Scandinavian context where research of emergent technologies was rooted in a participatory context, and a US context of ethnographic practices for interaction design. Showroom emerged in the UK: rooted in a context of design and art schools.

The book introduced the new term of Constructive Design Research to avoid the difficulties around the existing term of research through design, to keep the discussion open, and to appreciate methodological and theoretical contribution next to the constructed contributions in artefacts.

The second key observation for Constructive Design Research was the relation between doing and thinking; the theoretical and philosophical background of research. Earlier attempts to turn design into science failed to attract much following. Design turned out not to be an abstract and general discipline, but particularistic and specific [reference Koskinen]. Therefore, constructive design researchers prefer to be inspired by what philosophers would call post-Cartesian thinking, e.g. ecological psychology, post-phenomenology, pragmatism, ethnomethodology or critical theory. These philosophies and their related theories can be inspiring, but their level of abstraction and the analytical nature is less practical for the synthetic and creative aspects of design. Designers are

not philosophers, nor theorists. Therefore the main contributions of constructive design should come from the exemplary designs and the bridging concepts [reference] or intermediate frameworks that connect the designs to the underlying theory and philosophy.

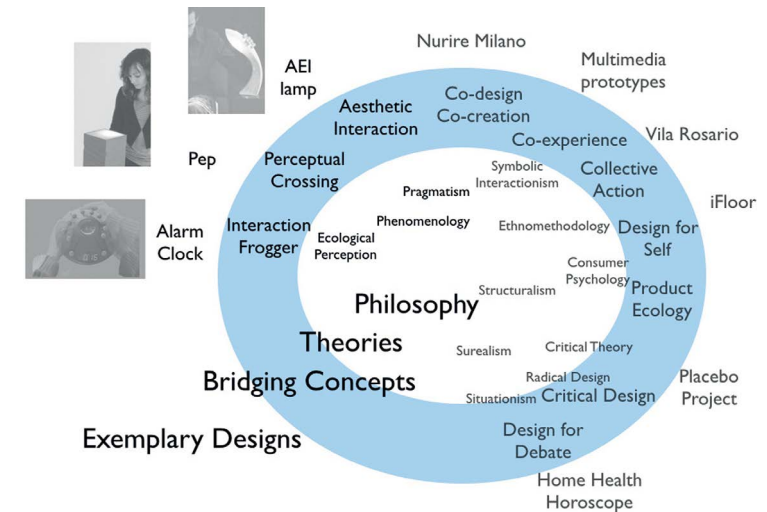


Figure 3. Overview of how the main contributions of Constructive Design Research, the exemplary designs, and the bridging concepts relate to the underlying theory and philosophies [adapted from Koskinen et al. 2015].

The third observation of the book came from the design research practice, and showed the things that are being designed to generate knowledge. Constructive design researchers work in studios, design labs and workshops and construct things. This is what they are held accountable to. These design 'things' ranged from moodboards, storyboards, sketches, drawings, and diagrams. We saw working prototypes, sometimes physical, sometimes virtual.

The design things, or prototypes can have different roles in constructive design research and the generation of knowledge. In Wensveen and Matthews (2015) we identified four roles. As an 'experimental component', prototypes (plus the design of the experimental conditions) act as a physical hypothesis that can be tested. This is very typical for the Lab approach. Examples are the aforementioned project of Wensveen, and Philip Ross.

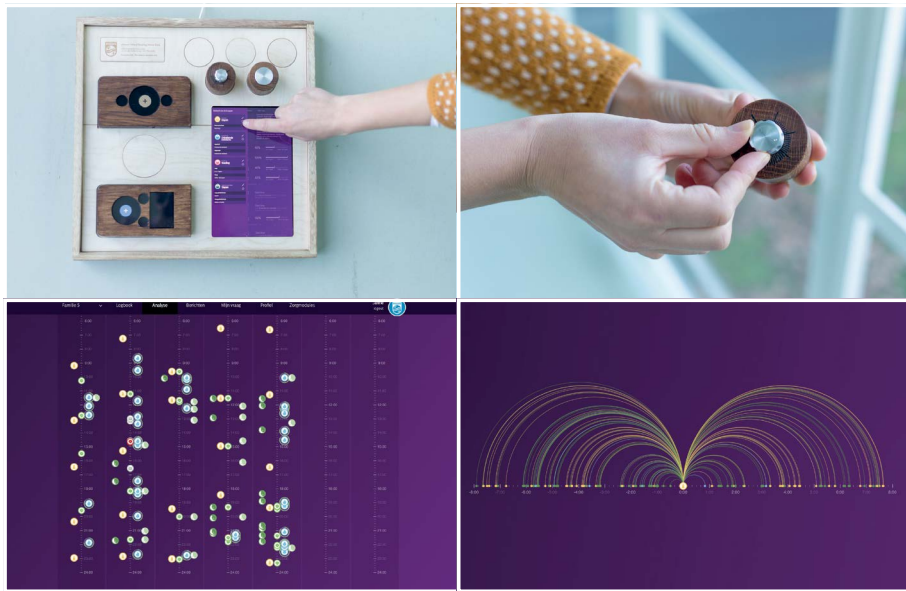


Figure 4. Data-enabled design: prototypes as ‘means of inquiry’ into the context of baby care [van Kollenburg et al. 2018].

Prototypes can also play a role as a ‘means of inquiry’, similar to a thermometer, to collect, record and measure phenomena. These prototypes are introduced and studied in use, collect data, quantitative (e.g. data logging) and/or in combination with qualitative data (e.g. interviews). They can become a means of inquiring into a context of use or of creating a situation or circumstance for the purposes of analysis: i.e. a way of generating new data for research reflection. A good recent example originates from the TU/e and Philips Design, which is called Data-Enabled Design. “Data-enabled design sets out to use data, from situated design experiments, as creative material to inspire and inform the design process from early stages. Through a combination of sensor data and qualitative methods, a detailed and nuanced understanding of context, behavior and related experiences is developed.” [van Kollenburg et al. 2018].

In the third role prototypes feature as conceptual arguments, designed as a ‘research archetype’ that illustrates or elaborates a new perspective about, for and/or through design, like the earlier mentioned examples for the ‘Direct approach’ towards tangible interaction. Another example comes from our Smart

Textile Services project, where we approached our research not from a topdown definition and description, but instead used a bottom-up approach. Collaboratively we designed, researched and realized with our partners from high-technology, textile, fashion, dementia caretakers, examples of ‘Smart Textile Services’. These prototypes served as discussion pieces and became archetypes for this new class of smart textile product-service systems [Figure 5].



Figure 5. Eleven ‘research archetypes’ to illustrate and embody a new class of product service systems: ‘Smart Textile Services’ [CRISP project, pictures by Wetzer & Berends.].

Furthermore, the *process of prototyping* can equally serve as a ‘*vehicle for inquiry*’ and a basis for experimentation with design practice. The PhD work of Martijn ten Bhomer (2016) is exemplary here, where he analyzed over 70 sessions, where 48 partners and over 30 prototypes were involved, to understand the role that prototyping and prototypes play in the realization of embodied smart textile services, the creation of a community, and the alignment of the stakeholders.

	Prototype as...			Prototyping as...
	Experimental Component	Means of Inquiry	Research Archetype	Vehicle for inquiry
	Role 1	Role 2	Role 3	Role 4
Purpose & Role	Test of specific hypotheses	Open-ended exploration	Illustration or demonstration	Driver for the research direction
	Systematic variations of prototype or context of use	Instrument to collect, record and measure phenomena	Physical embodiment of research concept, understanding or design research space	Research contribution is tied to the process of crafting the artifacts
Special considerations	Design of the experiment is equally crucial	Often combined with doing interviews	Critical perspective is equally crucial	Process is documented, analyzed and critically assessed.
Data	Primarily quantitative data (e.g. data logging, questionnaire)	Qualitative (e.g. interviews) and/or quantitative (e.g. data logging)	Designed artifacts that form the basis of critical analysis	Qualitative case study
Method of Analysis	Statistical analysis	Ethnographic analysis	Expository analysis	Case analysis
Type of research contribution	Empirical, Theoretical	Empirical	Conceptual, Methodological	Methodological

Table 1. Comparative overview of the characteristics of the different roles that prototypes, and prototyping have played in design research [adapted from Wensveen and Matthews, 2015].

The book on Constructive Design Research has been helpful for designers to become, and realize they can become, established practitioners of research. Other evidence for the established practice of research through design are the academic communities, such as the Research through Design conference, to be held in the Netherlands in 2019 and the ‘what makes a good CHI design paper’ discussion at the Human Computer Interaction design community [Gaver and Höök, 2017]. The Dutch science foundation NWO recently launched a program, Research through

Design and RtD and is also entering commercial practices in companies such as Afdeling Buitengewone Zaken, Buro Moeilijke Dingen, Superflux and Tellart. Our own department of Industrial Design has built a very strong reputation for doing research through design, recognized in our recent research accreditation and rated with ‘very good’ to ‘excellent’. In our education we now have the compulsory Master course Constructive Design Research (CDR), and established the track of CDR to prepare our students for successful careers as design researchers. They are in high demand by design research centres around the world.

I am very content with this impact, but I also care for the development of research through design. Therefore it is time for me to critique the established approaches, and suggest a next challenge.

Research through (Design & Realization)

My personal critical look of our own Lab examples, but also many others, reveal that most academic examples of RtD seem to stay within the limits of one challenge, one designer, one set of users, and one, perhaps two iterative cycles of design and research. The generated fundamental knowledge is published and referenced in high quality conferences and journals, and then disseminated foremost through academic teaching. With this dissemination, the influence on the wider practice of design is slow, more in terms of 10 years. As a consequence the impact of RtD on society remains limited to the fuzzy front end and slow in its dispersion. So, while the academic quality of the Lab approach has been established, the societal relevance and impact of research through design could be improved.

I, too came to that observation after the third cycle of Lab research (Wensveen, Ross, Deckers). While each new cycle was purer in its Lab essence, we did manage to include cycles of realization and valorization. With Philip Ross, the valorization happened in the years after the PhD, when he further developed the research prototype into the commercialized version Fonckel. Eva Deckers managed to disseminate and further validate the knowledge from her research with student projects and valorized the knowledge with an industrial partner; all documented in her PhD thesis [Deckers, 2013]. Both of them were awarded with a Cum Laude. In both projects, realization came after, or late in the project. An external validation of the knowledge beyond the Lab, and beyond the one prototype, the one designer, and the one stage of design was difficult to include in the Lab approach.

Next, I describe a research project where we included multiple designers, contexts, cycles and prototypes to go beyond research through design; research through design and realization.

SMART TEXTILE SERVICES

Smart Textile Services (STS) was a collaborative project within the Creative Industries Scientific Program (CRISP). The project created an 'inspirational test-bed': a platform of methods, tools, materials, creativity and collaboration between multiple partners, with many prototypes through which the creative industries explored the opportunities and challenges of joining their expertise towards designing smart textile product service systems.

GROWTH PLAN

The methodological driver for STS was found in the infrastructuring approach of the 'Growth Plan' that was based on earlier projects within Ambient Intelligence system design [Ross and Tomico, 2009], and the strong ID attitude towards prototyping and Research-through-Design. The Growth Plan consists of three stages, Incubation, Nursery, and Adoption. With each new stage, control is lost and complexity added. Each new stage goes deeper into realization and external validation.

In the **Incubation stage** (M2-M12) designerly creativity is mixed with explorative innovation and conceptual or theoretical curiosity. Initial use cases, academic theories and existing state-of-the-art technologies function as an inspirational material for the exploration of the design research space. Designers use techniques such as future scenarios in combination with rapid prototyping to create quick iterations of application prototypes. These outcomes are evaluated through design critiques within their local context. This leads to demonstrators for conceptual contributions, and exemplars of preliminary requirements to direct new technology developments for the adjacent stages. At the end of this stage, the project partners jointly create the methods and tools to determine success criteria for the concepts.

Successful concepts then go to the second stage. This **Nursery stage** (M13-M24) is characterised by 'scaling up and stepping out' to build credibility within a larger, yet still protected, environment. This environment now adds partners of partners (e.g. lead users, suppliers, other researchers) and protected manufacturing and testing facilities (e.g. Design Factories, Data Labs, Field Labs). The initial demonstrators are scaled up from the one-off to multiple copies, and tested with

multiple participants to understand the consequences for the entire infrastructure of the ecosystem. Tests of the demonstrators are conducted by means of organizational fit for the industry partners, and empirical research for the academic partners, allowing the fine-tuning of the new practices, data collection and technologies to the specifics of the context.

The **Adoption stage** (M25-M36) is characterized by the creation of academic, societal and economic adoption of the demonstrators by wider audiences. In this phase, the demonstrators are developed so that they can be incorporated and realized in existing practices of the partners. The industry stakeholders involved can adopt the concepts and start caring for economic value outside the Nursery environment. In this stage, the final criteria for success are researched and determined.

The project concludes with the **End stage** (M37-M48). The consortium activities in this stage support documentation and dissemination for various audiences, ranging from the general public to academia, funders, investors and companies. Time is dedicated for the PhDs to document their research in their PhD theses.

The infrastructuring approach of the Growth Plan and the dedicated 'orchestration' of project leader Oscar Tomico successfully aligned the expertise and expectations of all partners involved. The final portfolio of STS contained eleven design projects targeting multiple user groups, such as fashion designers, parents and children, and dementia patients, their partners and therapists. Four of the eleven concepts went through multiple iterations: TexTales, Vigour, Tactile Dialogues and Vibing. These iterations went well beyond fuzzy front-end, actually following the full growth plan, from initial incubation via nursery into adoption, introducing the new class of smart textile product service systems and a better understanding of their consequences.

The academic contributions were conceptual, empirical or methodological and brought forward new knowledge regarding *crafting communities for service design* [Baggerman, 2013], *craft and sustainability qualities for STS* [Kuusk, 2016], and *the role of prototypes for embodied STS* [ten Bhömer, 2016]. As part of the larger CRISP program, STS prominently contributed to the leading insights for designing product service systems, i.e. 'Orchestration', 'Embracing Complexity', 'Designing Relationships' and 'Creating Value [CRISP, 2015]'. STS generated several societal and economic contributions, from industrial innovations and innovative business models; a renewed outlook on the innovative potential of the Dutch textile

industry; and the potential for cross-over collaboration between service providers, technology and textile partners.

Finally, the reputation of the project sparked new research projects: an NWO project 'Crafting Wearables' together with Radboud University which already started during the project, the European funded ETN Marie Skłodowska-Curie project called ArclnTex with 15 PhD's across Europe, and the recent STW project on Ultra-Personalized Products and Services which we do in a 3TU context (Delft, Eindhoven, Twente). Our reputation was also noticed by the Dutch Ministry of Education, Science and Culture when our team was invited to dress the Minister for Prinsjesdag 2015 in a parametric designed dress and 3d printed shoes [Nachtigall, 2018].

STS went well beyond the earlier Research-through-Design paradigm of one design-one designer-one context which, to be honest, is also due to the resources within the project. STS also demonstrated that innovations in smart textiles and wearable technologies become more accessible. Therefore we now need a critical inquiry into the everyday aspects of living with these systems to gain knowledge on how people create meaning in their everyday context.

The following example [Mackey, 2017] has less resources, and started within the one-designer-one-challenge paradigm. With less partners, and the right choices and attitude Angella Mackey quickly went beyond the '...through design' paradigm, beyond speculation and into realization to critically study the adoption of novel designs in everyday life. In her study of the future technology of 'dynamic fabric' the designer-researcher Angella Mackey wore a "greenscreen garment" every day for seven months. Part of the system is a chroma-key smartphone application, with which she photographed the garment and digitally composited multiple digital colors, patterns and videos upon it. The fashion expressions were uploaded to her Instagram and so situated within a digital social ecosystem.

The study discovered and explored themes of 'Multiple Garments in One Garment', 'Aesthetic Extensions beyond the Garment' and 'Control of Personal Style'. "Even though these thematic outcomes are still speculative -offering visions for what could be if dynamic fabric existed in everyday dress - the genuine social contexts that they draw from puts a different kind of value to the perspective." [Mackey, 2017].

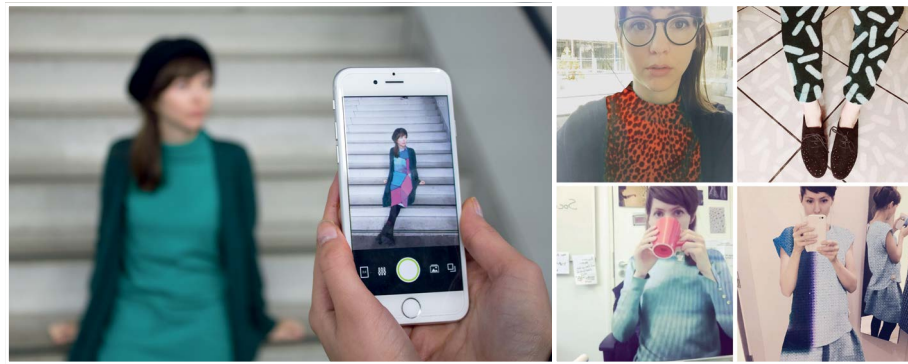


Figure 6. Demonstration of smartphone application for Greenscreen Dress (left) and the Instagram expressions (right) [Mackey et al., 2017]

I appreciate this research, as these valuable insights on the meaning of technology in everyday life could not have been gained from a Lab approach, nor from a superficial Field approach within limited time. I also appreciate that it is critical and goes beyond Showroom, or speculative design. In her own words: "Where speculative design aims to provide or uncover a critique on themes like human behaviour or interactions with technology, Greenscreen Dress critiques the speculations themselves - challenging them by attempting to answer Would I really consume less clothes?, Will I really want a dress that can be entirely transformed by digital content? Or how would I actually choose what to wear?"

Both examples, Smart Textile Services and the Greenscreen Dress demonstrate that research through design can, and in my opinion should move beyond the initial early stages of design, and instead research the consequences of design beyond design. "Research through Design and Realisation".

Aesthetics of Intelligence

For the next wave that I want to ride, I return to aesthetics. Aesthetics, as a critical reflection of how people create, use, enjoy or dislike design has always been fundamental to understanding how designed technology affects people's emotions, beliefs and even their attitude towards life. The term 'aesthetic' can also refer to a set of principles underlying the design.

Just consider the smart phone in your pocket, or the car you want to own. Design, including the aesthetics, is what makes technology useful, accessible and meaningful to ordinary people. Without designers shaping for the human experience of a product, technology would not make it to market and into the everyday lives of people.

On the other side, design and aesthetics depend on technology, as each advancement in technology offers and requires new opportunities for aesthetics. Industrial designers have always explored the relationship between the latest production technologies and the appearance of products. In the last twenty years, industrial design has gone through a paradigmatic shift from aesthetics of appearance, primarily visual, towards an aesthetics of interaction with a multi-modal experience. This shift, co-developed by us since 2000, was made possible and even necessary with the advancements in technology, from new materials and production technologies towards computation and information technologies.

A recent and relevant advancement of technology is Artificial Intelligence (AI) as for the next twenty years machine learning, data science, and neural networking will be increasingly relevant for the design of everyday products, services and systems. At first, this relevance will become apparent through new or enhanced functionalities for the Internet of Things. We already experienced AI for our online activities, e.g. detecting email spam, but now this intelligence is also manifested in everyday products, such as cars, voice-controlled home-assistants, or smart thermostats. In the future, when the functionalities and usability of artificial intelligence are adopted and accepted, users will demand more personally meaningful and rewarding experiences of these intelligent products. They will be looking for more aesthetic experiences.

To prepare for that future, and to be able to design for aesthetic experiences, designers will need to understand the technology at a level that it can be explored and controlled in the design process. The introduction of the TU/e bachelor course Data Analytics for Engineers, and other elective courses and projects should provide a basis for designers from where they can further explore the technology and start using ‘intelligence’ as a design material. The opportunity of the technology, the education of the designers, the availability and collaboration with experts and the societal demand for meaningful experiences of intelligence make the area of Aesthetics of Intelligence a relevant research challenge:

How can the ongoing technological developments in the area of (artificial) intelligence lead to an ‘aesthetics of intelligence’ that can be influenced by designers, and valued by people in everyday use?

As a departure we align the definition of aesthetics of intelligence in analogy with the Pragmatist understanding of aesthetics of interaction [Ross et al. 2010]. This should lead to four principles: Aesthetics of Intelligence (1) has practical use next to intrinsic value, (2) has social-cultural and ethical dimensions, (3) has satisfying dynamic form, and (4) actively involves people’s bodily, cognitive, emotional and social intelligence.

Aesthetics, as a set of principles underlying the design, has three important aspects: it is competitive, cultural and critical. A distinct aesthetics of the design (appearance, interaction or intelligence) can give a **competitive advantage** when all other companies have mastered the engineering and achieve similar product functionality and usability. Again consider the choice for your smartphone, or the car. That decision was also highly influenced by the fit between your personal values and the aesthetic principles underlying the design.

With these personal values, aesthetics has a strong **social-cultural perspective** and therefore can, and even should align with different social cultural settings in order to be formed, interpreted and appreciated by people in everyday use. A European perspective on data and intelligence is therefore different from a US or Chinese perspective. I can try to make my argument in words, but lets use examples: Just look at Stewart II by designer Felix Ros. It is a haptic interface designed for a self-driving car. It is a concept that allows for a haptic dialogue between car and driver drawing on notions of inherent and functional feedforward and expressive action of the user. His objective is “to design a haptic language that enables intuitive communication between man and machine” [Ros, 2017].



Figure 7. Stewart II, a future concept that allows for a haptic dialogue between an intelligent self-driving car and driver [Ros, 2017]

Now imagine how such a system will behave in a German, Italian, American or Chinese car.

Aesthetics, as a **critical reflection** also has an ethical perspective, where it can question assumptions of these new technologies through poetic dispositions and foreground the ethical considerations of intelligence. An example is the ‘Me, myself and AI’ project by Luke Noothout [2018] who proposes a critical alternative to the readymade services, trained by the gigantic and obscured AI data sets of large corporations. Instead, he argues for a more democratized Artificial Intelligence, and how with accessible technology, our everyday lives could be enriched with little AI’s trained by us (figure 8).



Figure 8. ‘Artificial Intelligence Training Lab’ by Luke Noothout & Bureau Moelilijke Dingen. Photo by Paul van Beek.

To realize aesthetics of intelligence we are introducing a fourth aspect with the letter C, that of **Collaboration**. This new area requires extensive collaboration between multiple disciplines and will benefit from involving multiple cultures. Within the TU/e, the research challenge of Aesthetics of Intelligence fits both the cross-research themes of 'Human-centered Systems & Environments' and 'Data-driven Intelligent Systems' and needs fundamental design research by creating Aesthetics of Intelligence in these systems, and evaluating these creations. The topic is also well suited for a European funded project, supported by different cultural perspectives and creating European competitive advantages for the next realm of intelligent product service systems.

Another example that shows how meaningful relations between aesthetics of appearance, interaction and intelligence can be realised is Ripple Thermostat by Anke van Oosterhout [2018]. Ripple Thermostat is a research project investigating the interaction with an intelligent thermostat using force feedback, and shape change to provide feedforward. Ripple is an interface designed to control interaction with an intelligent thermostat. As systems become more intelligent and adaptive, communication with them becomes more complex. This interface aims to teach the user better energy-saving habits. The shape change allows for intelligibility of the underlying intelligence and is used to reflect the activity of the thermostat throughout the day when the system is controlling the temperature.

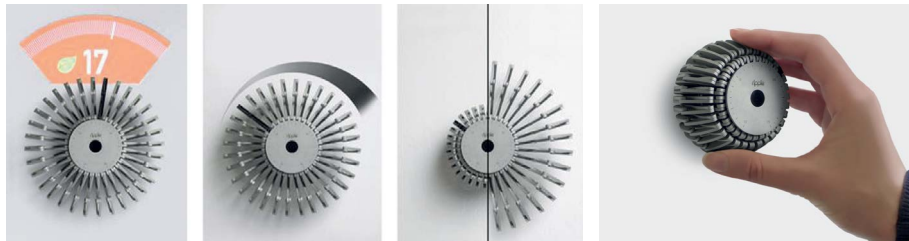


Figure 9. Ripple Thermostat by Anke van Oosterhout [2018], a research project investigating the interaction with an intelligent thermostat using force feedback, and shape change to provide feedforward.

I show these examples as potential conceptual archetypes of how an aesthetics of intelligence can be shaped and experienced in the everyday. They can serve as discussion pieces for a critical inquiry into their dynamic form and the practical use in the moment, and intrinsic value over time. With these examples we can assess the active involvement of people's bodily, cognitive, emotional and social intelligence, and the social-cultural and ethical dimensions when these products and services form a larger system.

One more thing...

In my invitation, I promised to discuss one more thing. One more thing was the famous introduction of Steve Jobs, casually announcing the next big innovation coming from California. With Steve Jobs, I share the same etymology of our first name, and a strong belief in the power of design. I don't know whether he surfed. I am not Steve Jobs. I am using the freedom of this inaugural lecture to announce my 'One more thing...'

Vision of the Future Everyday

Perhaps the earliest example of a large-scale research of the future through designing for that future was the Philips Design project 'Vision of the Future' [Philips Design, 1996]. This project started in 1995 and designed the future of 2005, 10 years ahead in time. Vision of the future was launched in 1996 with a book, films and an exhibition in the Evoluon. It consisted of many future scenarios showcased through product- and interaction designs for the personal, domestic, public and mobile domain. These scenarios integrated social-cultural trends, such as sociability, exploration and connectivity, with emerging technologies of that time, some being developed at Philips Research Labs, e.g. telecommunication, miniaturisation, light-emitting polymer screens, software agents and virtual reality.

I had just graduated as an Industrial Design Engineer and remember the boldness of the project, the aesthetics of the designs and the imaginative ideas to understand the future of design in bridging technology with social-cultural trends. While successful in 'predicting' the future, and showing Philips Design as a visionary design agency, the project and its successors were not without critique. "A few years later an internal study by McKinsey showed that 60% of the concepts were realized, of which only a small number by Philips, which indicated that the ideas were good, but putting them into practice was difficult." [Gardien, 2015]. This critique is understandable, as corporate and commercial adoption is essential for a large multinational.

I would like to make a simple analogy and dream about an ambitious proposal. If we see the Eindhoven University of Technology as the Philips Research of today, then the visionary role of Philips Design might be played by the department and communities of Industrial Design. Then maybe, in the year 2020, twenty five years after the original Vision of the Future, the TU/e department of Industrial Design designs for the future of 2030. Let's call this project Vision of the Future 2030 and show it in a book, augmented and virtual experiences and a physical exhibition in the Evoluon and the Atlas building.

Like the original project, it will consist of multiple future scenarios for the personal, domestic, public and mobile domain. The striking aesthetics of appearance, and the first explorations of an aesthetics of interaction for 2005 are in 2030 enriched

with an *aesthetics of intelligence*. The *Growth Plan* will align the expertise and expectations of all partners involved in the multidisciplinary effort, that combines the emerging social-cultural trends, with the latest emerging technologies, some being developed at TU/e. This time, commercial criteria are less important. Academic adoption is ensured through Lab, Field and Showroom approaches.

I expect that this Vision of the Future 2030 shows what it means to be human with technology, what it means to design freedom with technology, and from technology, what it means for design to share and care for society, the world and the people that live it.

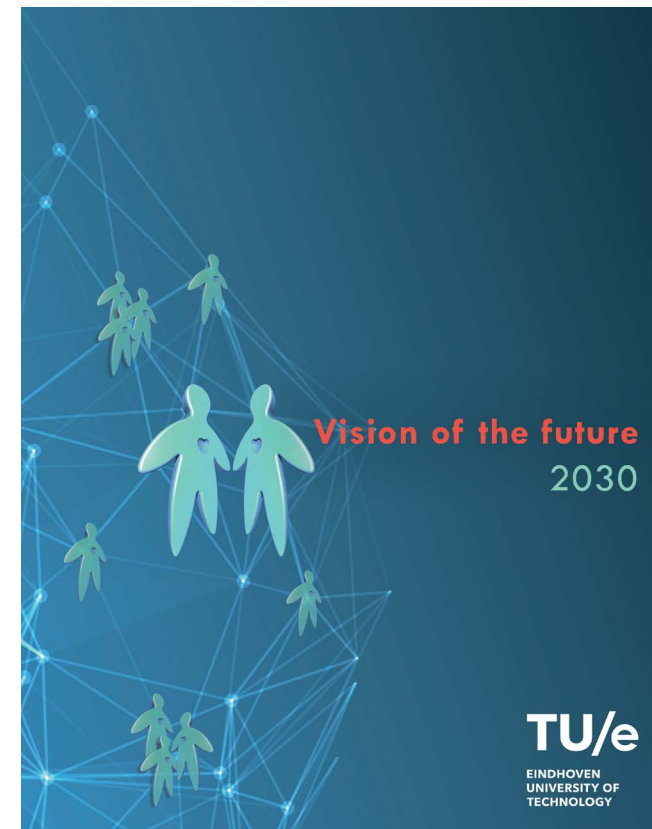


Figure 10. Potential cover for the book 'Vision of the future 2030' by Suzanne Hania (adapted from Philips Design, 1996).

One more and final thing

This final thing should also be the first thing, as people come first. I want to thank the people that cared for me and shared with me, the people that gave me freedom and the people that gave me critique.

Kees Overbeeke passed away seven years ago. He has been “mijn baasje”, an inspiring and critical mentor, a proud promoter, and a friend. Kees don't surf. However, he showed me the line up, taught me how to paddle, and pushed me into my first academic waves. Kees, I am on the stage. With so much pleasure I remember those first sessions, and I want to thank Tom, Caroline, and Joep, who were there with me, and still are.

I could join who I wanted to join, and I have been very fortunate to join many great design research communities, I want to thank all the members from the ID StudioLab in Delft, SPIRE in Denmark, especially Jacob, Ben and Laurens and in Eindhoven DI, /d.search-labs, and DQI. I want to thank my current Future Everyday group, the larger community of Industrial Design and look forward to collaborate on exciting topics. This lecture is also an invitation to collaborate more with the larger TU/e community on education and research, towards TU/e2030 and beyond. I have special appreciation to all the great champs and friends from Wearable Senses and the CRISP project. You have shown how quality attracts quality. Oscar, you are quality and have exceeded the dreams for our CRISP project, as you have been an amazing orchestrator for the project, an embracer of complexity, and a friend to me.

I want to thank all the people in the department of Industrial Design, from the early pioneers with their bold dreams, to the current explorers of the new frontiers. We have survived some pretty gnarly waves, with probably more to come. Let's enjoy riding them.

I want to thank my past and current PhD students, Julian, Philip, Eva, Bram, Martijn, Kristi, Shadi, Pauline, Troy and Angella for many inspiring sessions, and for giving me the belief and the results that we can experiment within research through design. Thank you, to my current and past Bachelor and Master students, you give

me energy and hope for the future. By now you understand that with my critique I have cared for you. Now, I want you to be critical to us, because you care.

I would like to thank the former and the current Board of Industrial Design and the Executive Board of Eindhoven University of Technology for placing their confidence in me for this appointment.

I wouldn't be standing here, if it wasn't for the people that supported my career at transitional moments: Loe Feijs for welcoming me at the TU/eindhoven while finishing my PhD for Delft, Jeu Schouten and Sabine van Gent for giving me the freedom to go where I wanted to go after i finished the PhD, Ilpo Koskinen for giving me stages to climb on and Jacob Buur for providing a fresh view on appreciation and participation, Aarnout Brombacher for welcoming me back to Eindhoven and Ron Wakkary and Lin-Lin Chen for making waves when I needed them.

As Director of Education, I want to thank my former, current and new colleagues in ID Education that care so much for the department, the staff, the students and me. You are such a good team. The more experienced I become in this new role, the more respect I have for Miguel Bruns, the former Director of Education, who managed to align our old educational system with the new TU/e system. We are still who we are, but now with more opportunities to extend our community of collaboration and to show the value of design for technology.

Finally, to the people I love so dearly, my friends and family. Thank you mum for showing me how to care and share. Jij ook pap, and for being critical. Ik heb het van jullie. My sister Sandra, and my brother Kasper, from the early days on the Windglider and the beaches around the world to here. Dank jullie wel.

Sem en Reeve, ik hou van jullie en ben trots op jullie, en ik hoop jullie nu ook een beetje op mij. Pappa is nu ook een baasje, en een beetje beroemd.

Suus, je bent de liefde van mijn leven, en alhoewel ik nu professor ben, I will always be your surfer boy.

Ik heb gezegd.

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Curriculum Vitae

Prof.dr.ir. Stephan Wensveen was appointed full professor of 'Constructive Design Research in Smart Products, Services and Systems' in the Department of Industrial Design at Eindhoven University of Technology (TU/e) on May 1, 2017.

Stephan A.G. Wensveen received his MSc degree in 1995, and his PhD in Industrial Design Engineering from TUDelft in 2005. In 1998 he joined the research group of Kees Overbeeke and in 2002 they moved to the excitingly new department of Industrial Design at TU/e. In 2011 he expanded his horizon on multi-disciplinary design and Participatory Innovation when he joined the SPIRe group of Jacob Buur at the University of Southern Denmark. He has been back in Eindhoven since 2013. His initial research was on the relationship between emotions, expressivity and interaction design through which he helped introduce notions of 'aesthetics of interaction', 'feedforward' and 'interaction frogger', and he is co-responsible for canonical examples of Research through Design. He is interested in using the power of design to integrate research, education and innovation, which he demonstrated for the /d.search-labs, the Wearable Senses lab and a large nationally funded project on Smart Textile Product Services (CRISP). He is co-author of the book 'Design Research through Practice', which introduced the notion of Constructive Design Research.

Prof. Wensveen is a regular associate chair for the Computer Human Interaction (CHI) and Designing Interactive Systems (DIS) conferences and editor for the International Journal Of Design. He is currently Program Director for the education of the department of Industrial Design.

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