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The Role of Prototypes and Frameworks for Structuring Explorations by *Research Through Design*

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1 Introduction

The relation between design and research is rapidly maturing. For one, research methods have become an accepted, even standard, part of design practice and (academic) design education. But equally important, there is a growing number of researchers who have a background in design, and who make active use of their design skills in research projects. This paper is based on a series of design research PhD projects, carried out over the past decade at StudioLab (then called “ID-StudioLab”) in Delft University of Technology in which designing played a prominent part in the research.

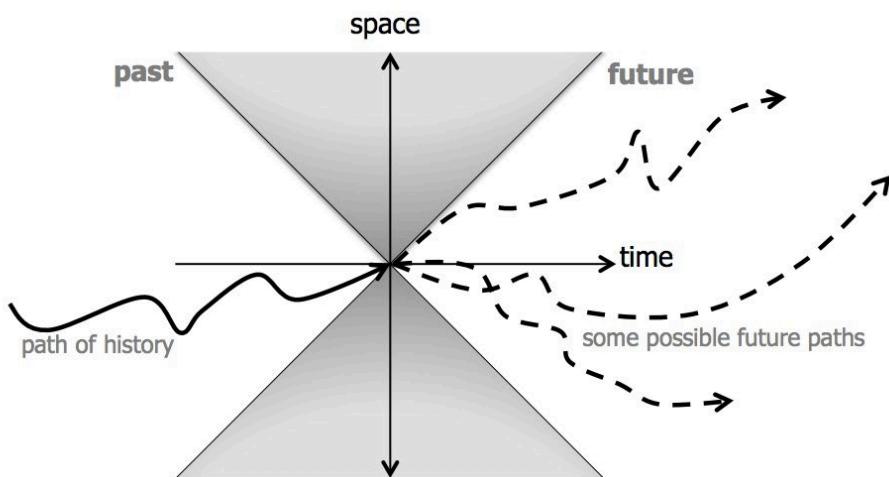
The goal of this paper is to describe how, in each project, a series of studies achieved a coherent unity, as is needed for a PhD thesis. Within established disciplines, this unity is often achieved by starting from extant theory, identifying open questions, and investigating those with empirical methods. In design research, the unity can also be achieved by a commitment to achieving an improvement in the phenomenon under study, where either a designed prototype or a flexibly-defined framework provided the central focus of the work, and a more constructivist research approach is followed. The principles of this may hold for other disciplines as well, especially exploratory engineering research, but as yet there is limited guidance for it in the research methods literature. We indicate how the prototype and framework served as a conduit to guide the project, and provided a base for disseminating findings and continuation in later projects.

2 Research and design – a tension

Research and design share similarities, yet are at odds with each other (Cross 1982; Archer 1995). On the one hand, both show an iterative development leading to an increase, either in understandings or a number of solutions. On the other hand, much research is aimed at understanding the past or present (with the hope of putting that knowledge to good use later), whereas design is aimed at constructing a possible future (that may not exist yet). This difference is visualized in Figure#1. In research projects, it is reflected in the outcomes, with research typically yielding knowledge about the present (and possibly speculation toward possible applications in the future)

and design typically leads to concrete solutions for specific situations (and possibly indication of broader applications), and broad, multi-faceted, explorations of a large variety of aspects and factors. Also, the difference is reflected in the type of questions that are asked. In our experience, designers are eager to ask “how to do ...?”, whereas scientific handbooks direct the researcher to ask “what is ...?” or “is it so that ...?”. Designer’s questions are often an expression of a goal, rather than a claim about a single or universal state of affairs.

With the advent of a new generation of researchers, namely researchers with a basic training in design methods, and a mindset that is future- and solution-oriented, we see new types of research being done.



Figure#1 A space-time diagram depicting past (a single path) and future (a set of possible futures). Designers, more than classically trained researchers, aim to find or create possible (desirable) futures, rather than precisely understand past or present for its own sake.

This tension between research and design is similar to the apparent contrast between basic and applied research. Stokes (1997) pointed out that the accepted paradigm of viewing research distinguished fundamental (a.k.a. “generalizable”, “basic”) and applied (or rather “application-oriented”) research are opposites on a single dimension. The idea was that on one extreme, basic science (exemplified by Niels Bohr, the father of Quantum Mechanics) sought generic knowledge and truth, on the other extreme applied research (exemplified by inventor-entrepreneur Thomas Edison) sought only direct, practical application and use. There was a variety of types of research inbetween these extremes, but attention to generalizability always went at the expense of attention to application, and vice versa. Over the past half century this view has dominated popular thinking about research, and that of policy-makers and many scientists themselves.

Against this, Stokes argued that generalizability and application can actually go together very well, and exemplified this with the example of Louis Pasteur, whose work both brought applied results in the form of vaccines, and who founded the field of microbiology. In this type of research, which Stokes labels “Pasteur’s Quadrant”, both generalizability and applicability are valued. This double attention: to

generalisation and application, to past and future, to understanding and solution, seems to fit very well the promise of designers doing research projects (see Note#1).

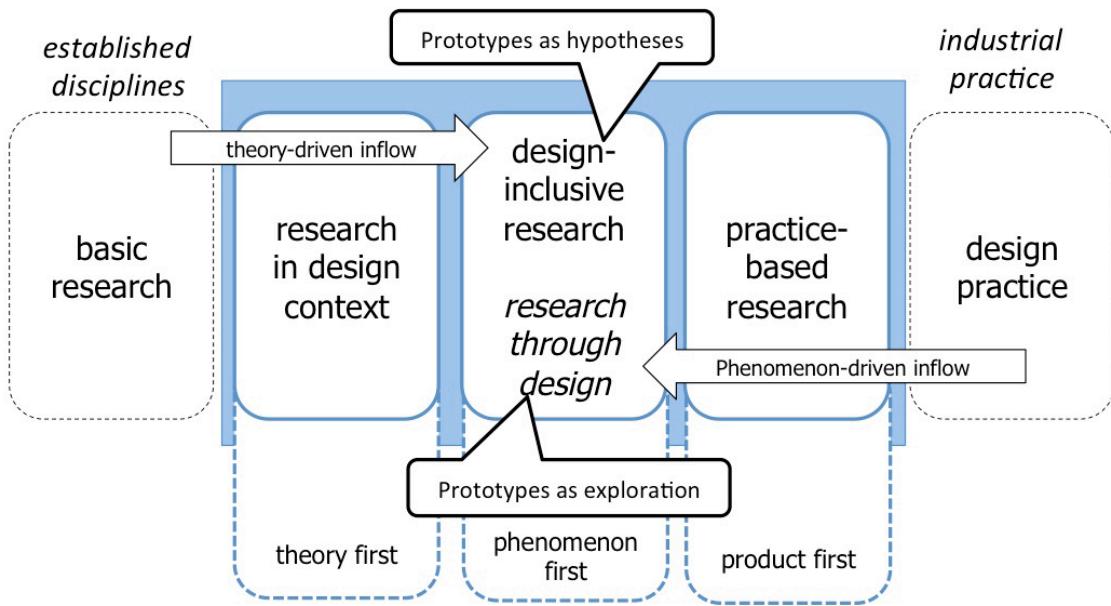
3 Design as a part of research – a historical reflection

The role that design skills, and design actions, can have in research has recently received growing attention. In this the prototype, and instantiation of the designed idea, has taken central stage. Zimmerman et al (2007) emphasized that designers create new, not-yet-existing, states of affairs, open up those new states for empirical investigation; Stappers (2007) indicated that “the act of designing” itself is the locus where new ideas get constructed by confronting technology, theory, and phenomenon (that what happens in the world), and many of these confrontations take place before the prototype has matured into a testable thing. Koskinen et al. (2011) draw attention to the constructive rather than analytic aspects that design can bring to research, Krogh and Koskinen (2020) point at the meandering form of designerly explorations, and Redstrom (2017) frames designerly research activities as programmes consisting of multiple, smaller, explorations.

To clarify the position of research through design, it is helpful to briefly sketch the historical development of design research at the Faculty of Industrial Design Engineering (IDE) of Delft University of Technology from the viewpoint of the first author. This development can be viewed from the survey that Horvath (2007) made of types of research at the Faculty, on the basis of 100 PhD theses. Horvath noted that, regarding the methods used, design research was wedged in between basic research conducted in established disciplines such as physics or psychology, and design practice in industry (Figure#2). Horvath found he could classify the PhD projects at IDE in three types:

- (i) research in design context (using methods of basic research, but applying these to design content),
- (ii) practice-based design (reflecting on design projects, and drawing generalizations from that experience), and between these two
- (iii) design-inclusive research, in which design actions form a necessary ingredient of research.

It is in this middle field that research-through-design fits in, but not necessarily filling that whole field.



Figure#2 Types of research (based on Horvath [2007]).

This middle field took shape around the late 90s, early 00s. Before that, most (PhD) researchers at IDE had had their research training from other disciplines (physics, engineering, psychology). They published in their “home journals”, and tried to make their research relevant for designers by using design activities or designed products as objects of study. The first author distinctly remembers how satisfied he and his colleagues were that “design students are so useful for making good stimuli for psychological experiments”. Not only could they produce stimulus material of high aesthetic quality, but often the stimulus material thus produced required the researchers to reconsider their experiment, as it brought out new perspectives on the research question.

As this development continued, the design step evolved in importance and complexity, but most often as a modular step within classic experimental method. In this approach, designing is seen as the art of making a stimulus (prototype) that instantiates the hypothesis that was generated from theory. This move, labeled the “theory driven inflow” from Basic Research to Design-Inclusive Research involved a change of object of study, and heightened designerly attention to operationalizing a hypothesis into stimulus materials, but the scientific-thinking and design-doing can be maintained as separate activities. And often, these are carried out by different people (see Note#2).

At the same time, a second development happened, driven from the opposite side, labeled “discovery-driven” or “phenomenon-driven inflow” in Figure#2. This featured designers exploring a new phenomenon by primarily going in and doing it, observing and reflecting as they went along, and in the interaction surveying which literature from which disciplines helps to understand, frame, and improve the prototype. It is this latter type we label “research through design” (see Note#3). The difference between research through design and practice-based research lies in the goal of the work that is carried out: in the latter, the goal of a project was a product,

and insight was a spin-off, while in the former, the goal of the work is to gain knowledge by exploring a phenomenon, even if a product might result as a side effect (Horvath 2007).

The difference in the middle column, between top and bottom, lies in the role of designing, and the place of theory and phenomenon. In design-inclusive research, the design action is a necessary step between hypothesis and stimulus, but one which is separate from knowledge generation: one person (the researcher) might generate the hypothesis and test it with the stimulus using the regular methods of experimental research, whereas another person (the designer) might design the stimulus, given the hypothesis as a given set of constraints. In research through design, the design action is essential to the knowledge generation, and carried out by the designer-researcher him- or herself (or in the case of a research team, distributed over the team members). Where the former can be seen as theory-driven and hypothesis-testing, the latter is phenomenon-driven, and most often explorative in nature.

In this chapter we focus on discovery-driven research using Research through Design, because in these we have seen the strength of doing design *as a part of* doing research (Stappers 2007), whereas in the theory-driven research, design can serve the needs of, rather than drive, theory.

One notion that helps bridge the divide is the notion of middle level of abstraction (Höök and Löwgren 2012; Löwgren 2013). This view indicates that inbetween the concrete level of material artifacts and the abstract level of published theories there is a middle level (or levels) of knowledge carriers which are neither ultimate particulars (Stolterman 2008) or generalized, abstracted, principles, but carry “a bit of both”, and may fulfill an essential role in connecting them. Examples of this are patterns, guidelines, strong concepts, prototypes, and frameworks. These middle level carriers have an actionability to convey, instantiate, and apply knowledge in design practice (Rutkowska, Lamas, and Sleeswijk Visser 2019).

In the remainder of this chapter we focus on prototypes and frameworks. The former of these is connected strongly to the artifacts in empirical reality under study. The latter supports the organization of knowledge from empirical findings toward higher interpretation and generalization, without committing from the start to a single theoretical perspective.

4 Research through design: the role of prototype

As mentioned above, we use the term research through design to indicate studies in which knowledge is generated on a phenomenon by conducting a design action, drawing in support knowledge from different disciplines, and reflecting on both the design action and an evaluation of the design result in practice. Moreover, we look at PhD research projects, which consist of a coherent series of such studies, exploring a phenomenon, and simultaneously yielding both generalizable knowledge and practical application.

To avoid losing our readers (and ourselves) in abstraction, we look at two examples of such PhD research projects. In this section one guided by a research prototype, in the next section one guided by a framework.

Ianus Keller's PhD project identified the phenomenon under study as "the way designers use informal collections of visual material that they keep as part of their professional practice". Our research group at the time was working on interaction design and creativity, and moving from "creating cool visions of design tools for 2050" to developing tools and techniques to help design practice in the short term (Stappers et al. 2007). Ianus' work started with a review of theory, one of technology, and a contextual study of how designers use visual materials in their current practice, which at that time was undergoing vehement changes as computers were becoming the basic design tools for manipulating images, but not yet useful enough for managing them. From this threefold exploration, the phenomenon was bounded more sharply to "how do designers keep their collection of visual materials they use for inspiration and information in design processes, and how can this be improved". Next step was to "get our hands dirty and our feet in the mud" by developing a prototype of a tool that would bring this improvement'. The tool was called *Cabinet*, short for "Cabinet of curiosities", after the 19th Century's collections that wealthy amateur scientists kept for information and inspiration.

In this project, the technological possibilities and the design practitioners' immediate needs were important in demarcating the boundaries of the prototype that could be realized, and thereby constrained the questions posed in the research. The initial literature review (see Figure#3) had indicated a number of areas of knowledge that might be valuable to frame the phenomenon under study, among them library science and database theory (understanding collections), media theory (visual materials), design processes, and creativity (the purposes for which the collections were kept). On the basis of the feasibility for prototyping, some of these areas were placed outside the frame. For instance, database theory was discarded, as we estimated that a realistic prototype would have to be made from the users' own collections in intense visual interactions, and most database theory dealt with typically large collections of a symbolic nature. What you can study helps to frame the phenomenon.

The research progressed through a number of stages: after exploration, the prototype was developed and during its development it was continuously tested with members of the StudioLab research community as test subjects and critical participants. After several iterations and improvements, the prototype was deemed "fit for duty" and set out at design offices in practice for four week practice trials. Also in this last phase, there were expectations ("they use it for storing and organizing", "they use it in presentations and for random inspiration"), but not in the form of hypotheses to be tested. The "how" was more important than the "what". The results of the studies were formalized and published in journals and conferences, but we noticed another factor in forming our growing insight: the importance of repeatedly presenting the prototype to different audiences. Throughout the project, versions of the prototype were shown to people who visited the lab (see Figure#4). Some of these were researchers in our field, some had different research backgrounds, some were design practitioners, students, other colleagues or family. Having to explain the prototype, its goals, technical principles, and examples of how it worked, each time for a different audience, played an important role in gaining insight, and gave interesting feedback and connections from different perspectives. Not only on the level of the study ("could I also animate the pictures for use in a presentation") but also at the level of research method: many people asked when the product would be available, mistaking the research prototype for a product under development rather than a tool for

generating insight. This illustrates the boundary between practice-based research and research through design as described in section#3 above.

The series of prototypes anchored the focus of the research, and determined the scope. What was or was not possible to “bring to life” with the prototype was a de facto framing of the phenomenon under study. Elsewhere, the roles of prototypes was summarized as:

Prototypes are unfinished, and open for experimentation; they are

- a way to experience a future situation,
- a way to connect abstract theories to experience,
- a carrier for (interdisciplinary) discussions,
- a prop to carry activities and tell stories,
- a landmark for reference in the process of a project.

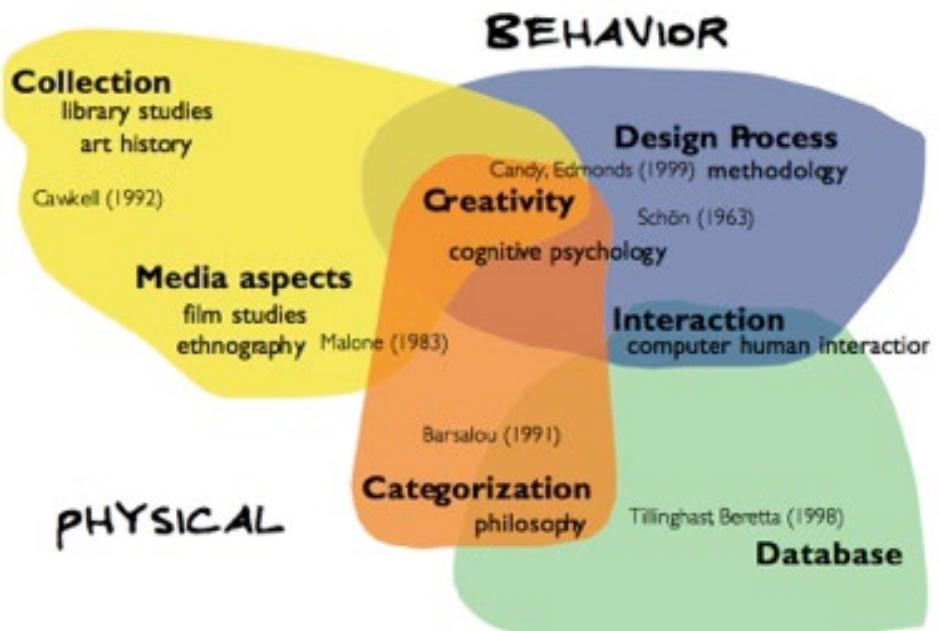
Prototypes force the researcher to confront theory, confront the world, they evoke discussion and reflection, change the world, and can be used to test a theory.

(Stappers 2014)

Note that the last item “to test a theory” fits the Design Inclusive Research type of hypothesis-testing evaluative research (see section#3), whereas the others are more generative, explorative, and descriptive in nature.

Lessons drawn from this project were

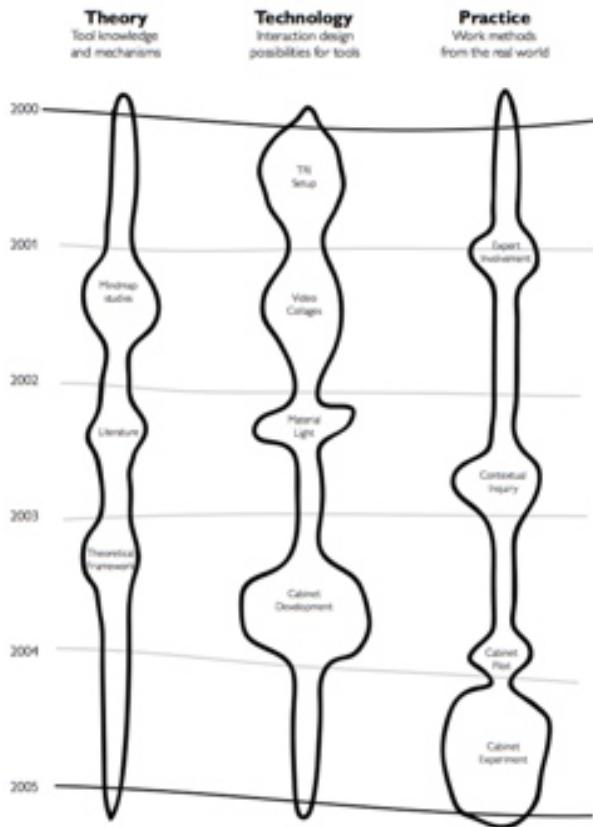
- your prototyping ability constrains the phenomenon that you can study.
- Multiple theoretical perspectives come into view, some proving more applicable, or generative, than others (Figure#3).
- not only the phenomenon, but also the qualities of the prototype constrain the areas of theory that can be brought in
- during the process, the emphasis shifted repeatedly between theory, technology and practice (Figure#5). These occurred side-by-side, entangled, rather than in the logical succession that is suggested by the template structure of journal articles. Many insights and decisions are made that never get reported; some of these can be picked up by others, because the prototype embodies them, and they (happen to) recognize the principles at work; but many insights evaporate as we do not have the means to capture them sufficiently, or cannot reach an audience that can work with this, often partial, knowledge.
- knowledge can come on different levels simultaneously, e.g., how the technology works (e.g., making images interactive), how the prototype is used (the phenomenon under study), how the research is conducted (by placing the prototype in everyday work conditions). On each of those levels, knowledge was generated.



Figure#3: Various domains of theory were considered as perspectives for *Cabinet* (from Keller [2005]).



Figure#4: Demonstrating working prototypes to visiting academics and practitioners (and getting feedback) contributed to developing the framing for *Cabinet* (from Keller [2005]).



Figure#5: the co-development timelines of theory, technology (prototype), and interactions with practice during the project (from Keller [2005]).

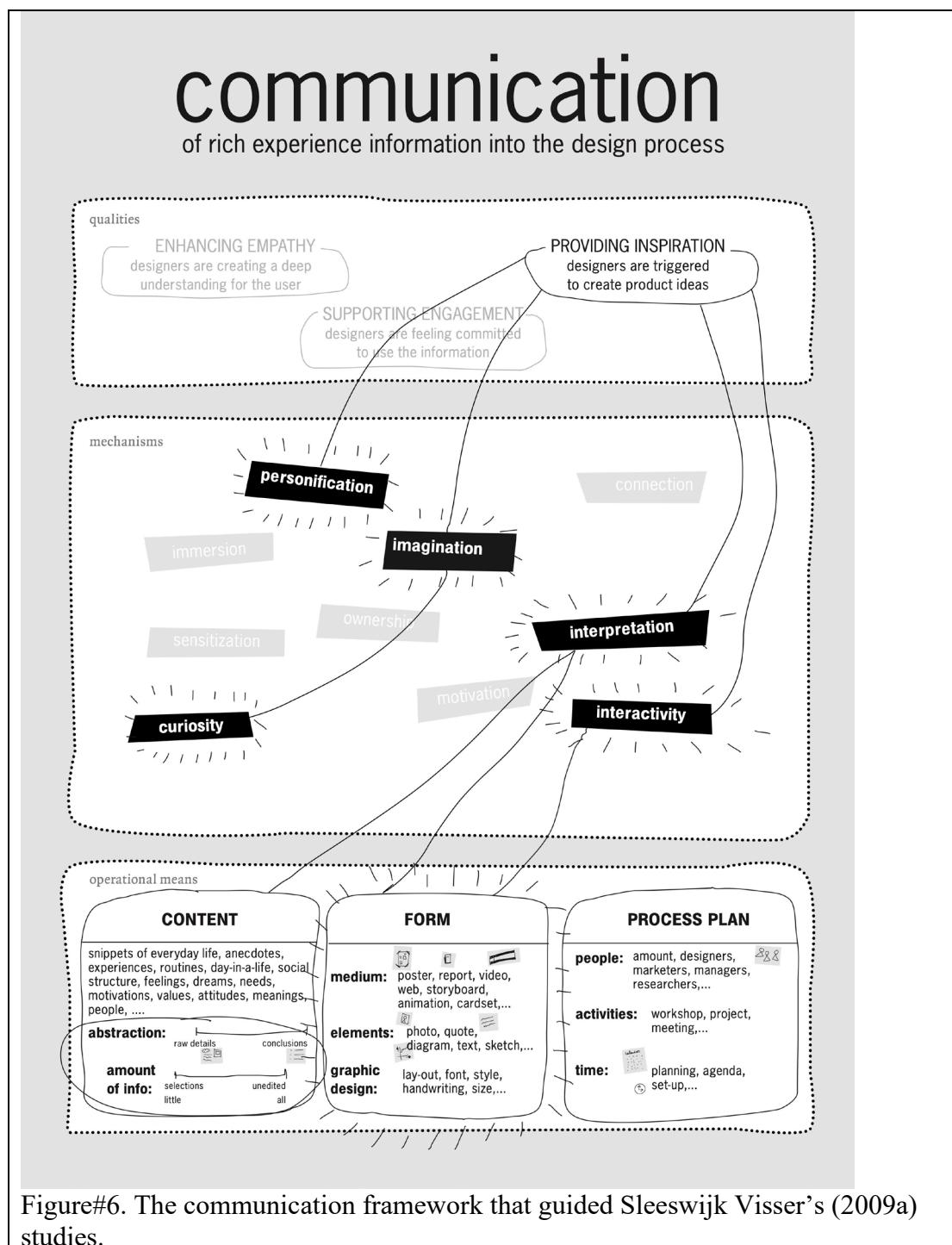
5 Research through design: the role of frameworks

In the case described above, the phenomenon, operationalized and bounded by the envisaged prototype, served to guide the different steps in the research. In this second case, a conceptual framework, built on both an initial hands-on exploration of the phenomenon, and a broad search for promising theoretical constructs, that might provided that guidance.

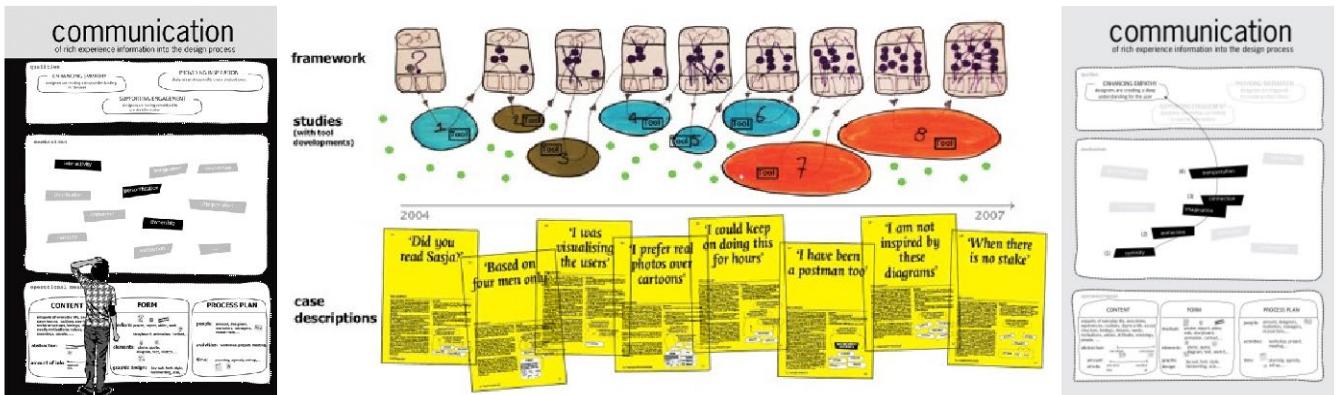
Before starting her PhD project, Froukje Sleeswijk Visser had worked on the contextmapping method of user research (Sleeswijk Visser et al. 2005). In her experience with using the method in industrial practice, she noted that a bottleneck of applying user research in industrial practice lay in communicating the research findings in a way that the design teams could use. For that reason, she chose to aim her PhD research activities toward improving that communication, and conduct the research through a series of case studies in industrial practice. Doing the research in industrial practice was done primarily to increase relevance: it served to get realistic data, but also to guide the research questions toward knowledge that would be applicable in practice in the short term. As with Keller's *Cabinet* prototype, we expected that our ability to handle the technology (graphic design, formats for interactive workshops and company-wide websites) would form an important part of the knowledge that we could generate. But in this case, a research framework (Figure#6) was developed to guide the series of field studies along the trajectory shown in Figure#7.

communication

of rich experience information into the design process



Figure#6. The communication framework that guided Sleeswijk Visser's (2009a) studies.



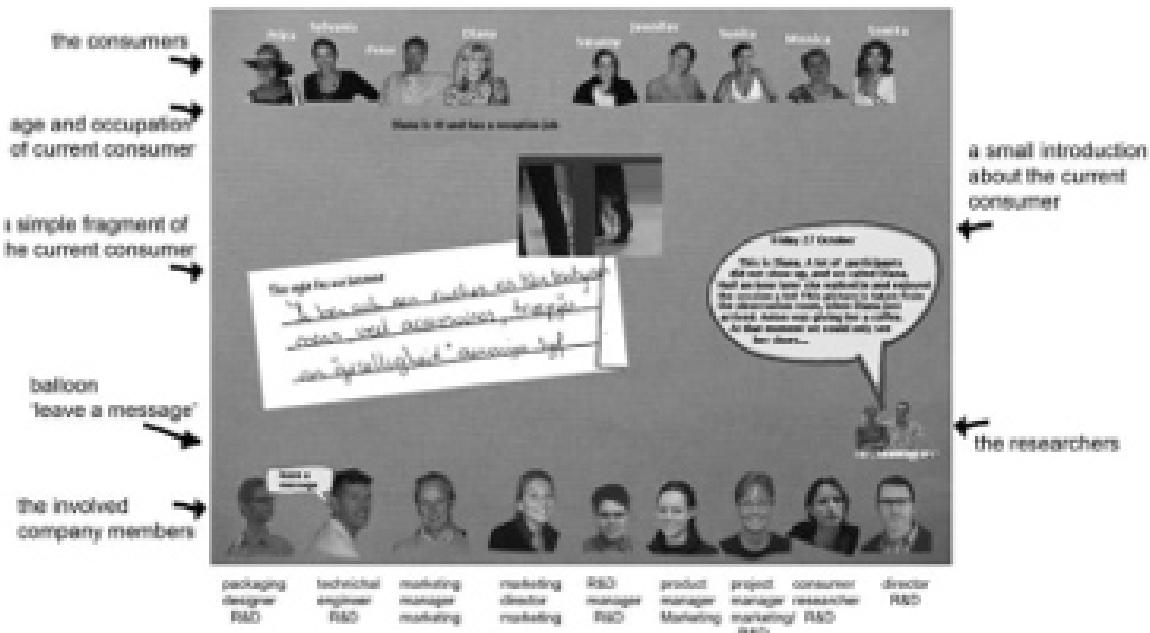
Figure#7: the communication framework was used both to guide a series of case studies with prototypes of communication tools, and connect the insights coming out of these (from Sleeswijk Visser [2009a]).

The framework of Figure#6 contained means, ends, and mechanisms. At the top of the framework are communication goals, derived from experience with the contextmapping method (top level), then psychological factors which were expected to play a part (middle level), and concrete communication content, forms, and process plans (bottom level). Figure#7 presents the fieldwork through eight case studies, sandwiched between an initial framing which showed the three levels, and a filled-in frame in which the levels were filled in, and in which a number of relations between the levels were discussed. The sprinkling of dots among the studies represents numerous small interactions, discussions, and informal observations that contributed to the framework.

Whereas with Keller the physical prototype served to guide the research by determining what phenomena it could “bring to life”, with Sleeswijk Visser there were several smaller prototypes, and filling the framework guided the approach in the separate studies. In most of the studies user research was done with the contextmapping method, and new methods were explored to share the findings with the product development team. Some studies addressed working formats for presentations of findings, collaborative ways of using findings to generate and develop ideas, and ways to use internet technology to involve different parts of a company in the data analysis, findings generation, and concept development stages (prototypes are shown “in action” in Figures#8 and#9; for more details, see Sleeswijk Visser[2009a]).



Figure#8: Physical prototype during a user insights communication workshop (from Sleeswijk Visser [2009a]).



Figure#9: web-based prototype for communicating insights from consumers (bottom row) to design team, explicitly depicting researchers, participants and recipients as individual people (top row). (from Sleeswijk Visser [2009a]).

The framework helped to “fill the holes” set out at the beginning. It helped distinguish which design actions were part of the core of the research (aspects of communication), and which were spin-offs (specific findings about user groups, ways of analyzing user research data to produce insights for communication), and pay attention to the three levels of abstraction (communication goals, psychological mechanisms and design parameters) and their relations.

And again, the methods under development were intensively demonstrated and explained to audiences in courses, masterclasses, and workshops, especially to design students and design practitioners keen on learning contextmapping and its application. Having to explain the communication methods to these audiences helped to strengthen the framework and the connections within it. And again there was a difficult hurdle in communicating what “the research” was about, because the term “research” appeared on two levels: (1) “research about user experiences” and (2) “research about how to best communicate findings from (1)” (see Note#4).

Sleeswijk Visser (2009b) compared her research approach to existing approaches in art and design and in the social sciences, notably Practice-led Research (Nimkulrat 2007), Action Research (Avison et al. 1999) and Grounded Theory (Glaser and Strauss 1967). With each of these approaches has similarities to research through design as described here, but none of them fits exactly. For instance, practice-led research stresses the communicative value of the designed object as a carrier of knowledge (in this project communication tools and techniques were the designed objects); action research provided methodological support in the way it accommodates end-user involvement, but whereas action research focuses on

iteratively improving a concrete situated practice in one organization, the research through design studies did not focus on a single organization, but each study served to explore a part of the frame. Finally, grounded theory provided support in developing insights bottom-up from the phenomenon, rather than having to commit on beforehand to one specific theoretical perspective. It “embraces the openness of the researcher in relation to the phenomenon and provides room for the research’s interpretation as part of the data collection”.

Sleeswijk Visser concludes that the framework guided the research journey as “a process of discovery, rather than evaluation”. The structure of the thesis, as shown in Figure#5, shows how the framework supported this. On the one hand it provided a set of “holes to be filled through exploration”, on the other it allowed the author to separate the rich description of the case studies from the description of the general findings in the framework. The framework, as it were, served as a meta-level leading the reasoning through the sequence of individual grounded cases studies. The framework also allowed her to position the tools that were developed for the cases into a coherent whole. Because many of these tools were copied and modified in practice, the framework could serve for practitioners as a way to find back the rationale and evidence behind the tools.

6 Discussion: connections and spin-offs

In the two sections above we outlined how both prototypes and frameworks can help guide explorative research. Prototypes through giving a physical instantiation of a phenomenon, frameworks by placing a phenomenon in a conceptual perspective. In the examples, both these means were present, albeit with an emphasis on the prototype (Keller) and framework (Sleeswijk Visser). Both give direction to the research, help to focus attention and to demarcate the boundaries of interest. Both give rise to concrete experiences, connect to possible applications, and fit well into the practices, cognitive repertoire of design skills.

One important thing of the framing, both through prototype and framework, is that the phenomenon under study is clearly marked, and spin-offs can be given a place. As Keller (2005) stressed in evaluating the *Cabinet* project, serendipity plays a large role in engaging with the world in a designerly manner: Regularly there are findings which are clearly valuable, but do not fit the question in a particular study. What should be done with these? If the findings are sufficiently interesting and complete, the framework may be adjusted, or a spin-off publication may be produced, e.g. on research methods, or promising side-effects. But most of the spin-off insights that come about while doing design as a part of doing research get lost, the “evaporate” again as the project continues. Here, both prototypes and framework can help, by giving a place where these insights can be anchored, either in concrete experiences (with prototypes), or future promising conceptual areas for exploration (frameworks). At StudioLab itself we noted such follow-ups, where sparks generated from one project were kindled into fires for another. Daniel Saakes (2011) further developed projecting material qualities over physical objects, building on playful explorations during the development of *Cabinet*, Carolien Postma (2012), Helma van Rijn (2012), Christine de Lille (2014) and Chen Hao (2019) further developed methods of designing with user research extending the contextmapping method, and several others are currently further extending these findings, even though the above-mentioned projects were not part of, say one larger, planned project (see Note#5).

This shows how progress in design research is not just furthered by published theories, but that prototypes and frameworks help to channel the view on phenomena, and serve as “an institutional memory” as communication between researchers as well. On the other hand, it can also show that the field of design research is as yet not mature, and progresses still more through series of cross-pollinating single explorations, rather than through an academic research agenda with grand theories and questions. Other scientific fields, such as biology and physics, have also gone through such phases some centuries ago, as the cabinets of curiosities illustrated.

7 Conclusion

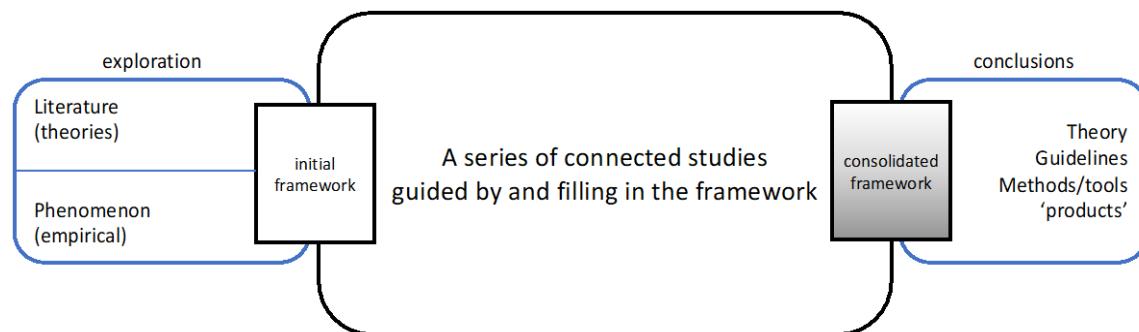
More than many other types of research, research through design is in need of structuring its approaches. Where most other types of research can fall back on theory-driven paradigms and the basic scientific method, research through design has the promise of using the design action as a knowledge-generating, formative ingredient. As long as design is a modular step between precisely-formulated hypothesis and material stimulus, research is “business as usual”. But if the design action is to bring its value as a knowledge-generating step in itself, i.e., not the result alone, but also the reflection on the design decisions in the process bring value, then the act of designing is not an outsourceable job, and we need ways of sharing insights gained from design action. The field is gradually coming to grips with this type of relation between design and research (e.g. Brandt and Binder 2007; Koskinen et al. 2011; Wensveen and Matthews 2014; Höök & Löwgren 2012; Sleeswijk Visser 2018).

Doing so is not easy. Not for nothing are the early phases of design referred to as “the fuzzy front end”, as it depends on ideation, creativity, reflection, making, trying, and association rather than linear logical argumentation. Also, design research is lending, adopting, and adapting approaches and methods from humanities, social sciences, and engineering, and combining these is not trivial. Stappers and Giaccardi (2017) conclude their literature review by stating “I do RtD” does not indicate a method, given the variety of work performed under that label. Yet new work is done. Boon et al (2020) propose to develop a description in terms of “genres of RtD”, Ricci et al (2020) embed RtD in co-design, and Sleeswijk Visser (2018) frames different roles to channel the contributions of collaborating actors to both the research (knowledge outcomes) and design (impact outcomes).

But there is also hope in history of science, art, and engineering “before design”. Connecting, in Stokes’ terms, “an eye for generalization” to “an eye for application” is not without precedent. Many of the breakthroughs in the history of science have been made by people who were dealing with practical, applied issues: Both Newton and Huygens were working on clocks for navigation at the time that they developed their theories, the Wright Brothers developed methods and principles of measuring, and ways of reframing the problem of flight on levels from aerodynamics to human control, as well as constructing a heavier-than-air flying machine. Their scientific worth was not just that they developed a theory that had design applications, but that they conducted design-relevant explorations from which they drew lessons that went far beyond the single clock or airplane.

The traditional methods of science has not been without criticism from philosophers and historians of science. Feyerabend (1975) argued that no single method could suffice to explain scientific development in the past, and Harré (2002) showed the huge variety of ways in which the great breakthroughs in our understanding have taken place. This is not to downplay the value of thorough validated experimental studies based on theory, but to point at the fact that our academic publishing culture has often emphasized the testing and proof of new ideas, but regarded the generation of those ideas as unexplainable, magical, or non-interesting. But this is the area in which design research can probably be strongest: showing that something is *possible* (rather than necessary) where that was not obvious before (e.g., putting a man on the moon) constitutes knowledge that is already of value, i.e., an existence proof. The state of that prior belief (whether we could put a man on the moon) determines if that

existence proof is sufficiently useful, or whether we must prove that we can put every man on the moon, or how many successful moonlandings are needed to convince us that “we can”. As always, the need for evidence depends on the purpose for which we will use the knowledge.



Figure#10. Frameworks and the tension between generalization (theory, top) and application (practical results, bottom).

Within explorative research, finding such possibilities that were not obvious before, is key. There, having a framework for one's efforts, e.g., a PhD research project, helps connect the phenomenon to what we know about it, where we see connections to other pieces of knowledge, and where we see holes in that knowledge that we can fill. The framework should be based on an exploration of both the phenomenon and theoretical lenses, both on first-hand experience and second-hand knowledge (Figure#10). Optimally, these two sides are explored side-by-side, not in sequence. Either order can introduce bias. A theory-first exploration may prejudice the researcher to not discover the blind spots in his or her view of the phenomenon, whereas a fully phenomenon-first exploration may prematurely lock him or her into an operational mode of picking at details. The framework is formulated at a larger scale than the individual studies contained in it. It helps to direct development of interventions and prototypes, to separate and distinguish findings and spin-offs. And it provides a perspective for fitting findings to relevant disciplinary areas of literature. We believe that this has at least pragmatic uses in conducting a (larger) exploratory research project, whether in design research or elsewhere, but especially projects invoking design skills as part of the research method.

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Notes:

Note#1: the discussion here is simplified to make a point. Several authors have discussed how scientific work is complex and does not fit a single mold; see, e.g., the appendices of Stappers and Giaccardi (2017).

Note#2: there is a longer tradition of designers and artists working with researchers as collaborators with separate roles, such as creating visualisations and other communication means to reach a non-specialist public, constructing provocative

installations or scenarios based on the researchers' theory (Driver, Peralta, & Moultrie, 2011). In this chapter, we focus on designers who themselves are the main researcher and who employ design actions as core part of the research (Research through Design).

Note#3: The term “Research through Design” was introduced by Frayling in a seminal speech at the Royal College of Arts (Frayling 1993). He distinguished three types of relations between design and research, where the role of design was that of object of study (Research **on** Design), beneficiary of the research insights (Research **for** Design) and part of the method of study (Research **through** Design). In the past decade, the latter term has been picked up in design research community, especially HCI (Stappers and Giaccardi 2017).

Note#4: In a Research through Design project, knowledge is generated at different levels, which can lead to confusion. For example, when the objective of the research is to develop a new design tool, and the method involves using prototypes of that tool or method in a design project, a single actor can be both user (of a research method), designer (of the new design tool), and researcher (evaluating the tool, and a product designed with the aid of this tool). The difficulty of separating these roles and levels of research, design, and use is discussed in Stappers and Sleeswijk Visser (2014).

Note#5: At many universities, PhD theses are used internally for evaluation but not disseminated. In the Netherlands (and elsewhere), PhD theses are publicly published books, some of them influential, read, and cited because they (can) convey more details of individual studies in journal articles, and a coherent perspective over several studies and articles from a 4-year research project.

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