Research ThroughDesign: What Does it Mean for a Design Artefact to be Developed in the Scientific Context?

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The use of design artefacts in research is a debatable topic which raises important questions about the different approaches to design research and legitimate ways of knowledge production. Research through design normally involves construction of a design artefact, which is at the core of the research process. This paper will outline some characteristics of artefacts that come out of such research practices, seeking to form a base for understanding the nature of research design artefacts and their evaluation.

We will examine the process of translation from the research question into the design brief, into the prototype, back to the question, back to the prototype; until the design artefact is fit as a tool for research; or is (temporarily) discarded. The artefacts produced in this way do not necessarily serve a utilitarian purpose, but provide an explicit feedback about their use and the experience they invoke. In terms of design, they are like code with a lot of debugging print statements. They possibly never leave the studio and when they do, different levels of independence from the studio setting can be identified.

Keywords*: design research, prototype, artefact, evaluation*

How does design generate (design) knowledge?

Design research extends onto several distinct research practices, whose common thread is the interest in and the use of design thinking to achieve scientific results. From design history and theory, through the research in advancement of practice, to the use of design artefacts as source of data, these different approaches outline a growing field under the general name of design research.

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We can trace the beginnings or design research to the post World War II reconstruction period and particularly the boom of mass production and mass markets. From standardisation to diversification, design practice was increasingly coupled with research. This research was, at first, aimed at optimisation of design processes and results but it gradually unfolded in different directions. The results of these directions contributed to different intellectual niches. Initiallythe focus was on knowledge in the area of design problems, methods and processes relevant to improvement of the practice. More recently, design research turned towards perception of our environment and general acting-in-the world. Thus design research does not necessarily generate knowledge which is useful only in terms of design practice. While the focus of historical, theoretical and procedural research is indeed on the practice of (commercial) design; there is a growing body of research which addresses more general problems of experience and social interaction.Concerned with questions critical for politics and society at large, this movement has the potential to engender 'new forms of knowledge' (Rendell 2005) using non-reductionist design principles to arrive at unexpected insights. We could conclude that the further away research scope is from the practice of design, the more contribution it makes to general knowledge.

Origins and approaches

When speaking of 'design research' it is generally unclear whether it implies research *into* design, research *through*, research *by*or research *for* design. These categories, borrowed from Christopher Frayling's discussion on research in design and art (Frayling 1993) are not mutually exclusive, but look for legitimacy in different fields.

While we are familiar with historical and theoretical research about design, the practice has had a more complicated relationship with research. In the 1960's Herbert Simon argued for a scientific legitimacy of design research by introducing a distinction on two types of sciences - the natural sciences (science as we knew it) and the sciences of the artificial (research activity centred around man-made artefacts) (Simon 1996). While natural sciences kept an objective view of natural phenomena which they treated analytically, sciences of the artificial are characterised by synthesis and the ambition to intervene in the way things are, changing existing situations into preferred ones(Simon 1996, p. 111). By separating artificial from natural sciences Simon creates space for a hierarchical interpretation of

'scientificity' in these approaches while setting the outcomes of design research close to the practice.

Frayling's view is a little different. He argues for recognition of design research as a professional practice, or as he puts it 'research with big R'. Nevertheless, something in his typology leaves us with a taste of hierarchy of importance or contemporaneity which favours cognitive tradition in fine art as an under-explored strategy that deserves attention. Frayling identifies research *through* design with the degree by studio project (awarded for example at RCA), characterised by research (results) obtained*through* the activities of art, craft or design. On the other hand, he tries to distinguish Research *for* arts and design from research written with a small 'r', leading simply to the production of an artwork or design piece. Frayling's writing is more of a call for a debate than a set of guidelines for research *for* design. Nevertheless, researches have picked up on Frayling's discussion and a certain meaning of his initial call established over time. Note a shift in meanings - what for Frayling was research *for* design is considered research *through* design (Koskinen et al. 2011), and vice versa.

The purpose of design research

The lack of concrete framework and evaluation criteria remains. There is a general agreement on the importance of this type of research amongst design research professionals. For example, a study conducted by Zimmerman and colleagues showed research *into* design as the most commonly mentioned type of design research, but it was 'this other approach' that is considered the most true to the nature of design practice(Zimmerman et al. 2010). The compatibility with design practice is a valuable incentive for dedicating more work to explicating the role of artefacts in design research.

In the beginnings of design research studies, we find in Simon's writings a well established idea that the purpose of design research is to improve design practice, with the focus on design process. Simon describes contemporary design knowledge as intellectually soft, intuitive, informal, and cook-booky(Simon 1996, p. 112). He distinguishes scientific from what he calls 'professional knowledge' (knowledge of *doing* something, as opposed to knowledge *about* something) and states that engineering disciplines (design isto be found amongst them) have mainly focused on sharing practical skills. Thus the need to make design theory explicit in order to teach a science of design (Simon 1996, p. 114)

Nigel Cross saw the opportunity to employ design research in the area of practice too. According to him, design research focuses on the study of principles, practices and procedures of design in order to contribute to the improvement of design practice (Cross 1984).

In their recent publications, Kroes and Dorst also agree on the utilitarian function of design research for design practice. Kroes describes design research as normative and process oriented (Kroes 2002). He makes a clear cut between scientific and design research, the former driven by logical positivism and product oriented (with empirical claims, laws, theories and explanations as their outcome, typically). Conversely, the centring on the process conforms to the improvement of design practice as the set outcome of research. The focus of design research is on the design process itself, thus the outcome is knowledge in the area of this process.

Zimmerman offers a more open interpretation of the way design research can lead to design theory (Zimmerman et al. 2010). He recognises two types of theory that can come out of design research: theory *on* design and theory *for* design.

A multitude of literature in design studies repeatedly confirms the idea that designers' research is a doctrine about the design process and design process only. Rarely does it talk about a design practice that can be employed together with critical thinking in order to generate new knowledge outside of the discipline.

Both research *for* and *through* design are based on practice and both produce design artefacts for research, but they need to be distinguished. When making the distinction, the first thing to consider is the purpose or the desired outcome of the research. According to Zimmerman, theory is rarely the main focus of design research and it comes out of it as a by-product (Zimmerman et al. 2010); it is implicit or emergent from reflection. However, theory that comes out of research *for* design is focused on improving the design practice, thus its focus resides in the field it explores. Research *through* design is suitable to explore more general societal or philosophical problems which cannot be easily reduced. Thus research *through* design has potentially a more general theoretical outreach.

With reference to the two types of theory, research *for* design produces theory *for* design; research *into* design produces theory *on* design; research *through* design can contribute to both. According to Frayling, part of the problem lies in the perception of research as an activity. Research with a big 'R' has a pre-defined research question, whose subject or object exists outside of the person doing the research, leading to discussable, shareable

knowledge. As opposed to the research with a small 'r', which is a part of (art-)making process, research with big 'R' is a profession, a professional practice. The view expressed here is an attempt to distinguish design research from research normally undertaken in the first steps of designing process. This should not imply that making is incompatible with research but it helps identify the two distinct objectives for research to be undertaken: design knowledge and theory or insights into phenomena that could hardly be discussed otherwise.

Largely because of a lack of strong theory to guide practice but also the confusion around the purposes of research *through* and research *for* design, a new term was defined by Koskinen et al, in a book titled "Design Research Through Practice" (Koskinen et al. 2011). Constructive design research is a type of contemporary design research, aimed particularly at framing the experience of integrating the fields of design and research. Practically, constructive design approach means something was built within the research process and put to use for research purposes. The approach is impure, experimental and based on contemporary theoretical frameworks that involve phenomenology, pragmatic psychology, research of emotions and experience.

We will refer to a research practice that uses design artefacts and or theoretical observations to come up with guidelines or frameworks which improve the practice as 'research *for* design'. On the other side, 'research *through* design' is an umbrella term encompassing approaches where the production of artefacts is explicitly driven by a research question.

The role of design artefacts in research process

With the difference in approaches demonstrated above, the discussion on function and character of the artefact coming out of research activities will take similar directions. When the purpose is generating guidelines and the focus is on the process of design (research *for* design), the artefact produced can be a found design object, as well as an object created over the course of research. "*Given* an airplane, or *given* a bird, we can analyse them by the methods of natural science without any particular attention to purpose or adaptation" (Simon 1996, p. 6) However, when the process of design is an integral part of research, the artefact is not *given*. It is primarily conceived in accordance to the research scope and question. In this approach, the design artefact is used as a *source of data* for analysis and generalisation, and not as an external object to theorise about. If process

and design object are inextricably linked (Kroes 2002), then the design artefact created within research *through* design or constructive design research, is understood in the light of its subject.

The (r)evolving role of design artefacts

Before going into more detail about the nature of design artefacts produced in the context of research, let us look once more into the different views of design artefacts in design research literature.

From the distinction on 'natural' and 'artificial' as mutually exclusive metaphysical categories, Simon develops his argument of equally valid research subjects - nature and artefact(Simon 1996). Artefactis an 'interface' between the inner and the outer environments, the former defined as its inner organisation and substance, the latter as the surroundings in which it operates.Following on this, Kroes investigates "the dual nature of design artefacts", considering their functional (input) and structural (output) properties(Kroes 2002). It implies a dual conceptualisation in design practice. Designers are professionally trained to bridge this gap and to address both aspects.

Hooker and Farrell argue that design and science do not produce metaphysically distinct types of things (Farrell and Hooker 2012). They criticise the interpretation of the Simon-Kroes model which implies a significant difference in the way design and science come up with artefacts. It is true that scientists do not produce natural world with their investigations, while designers do produce artificial objects, which is at root of this disjunctive discourse. However, both designers and scientists produce artificial things - while the former 'synthesise' design solutions, the latter come up with e.g. technology.

Following Simon's notion of the 'interface' we can look at design research artefacts as interfaces between the research question (outer environment) and the mechanisms it uses to give insights into phenomena (inner environment). Nevertheless, the separation on 'analytic' and 'synthetic' sciences does not help understand either of them, as both mental processes are part of research *through* design. If we keep the division on the 'analytic' and 'synthetic' in the discussion on research artefacts, we are facing the same problem identified above - there are either two distinctive sciences, or there is science and design practice, at two ends of professionalism. Either way, they belong to intellectually distant paradigms and are unable to communicate. What we propose instead is to recognize a tradition of an integrative approach to research which includes producing

design artefacts as part of research activity. How can we design 'analytically'?

From research question to design artefact

The process of developing and presenting experiments in the field of design for the purpose of scientific research is characterised by several distinctive qualities. It is less utilitarian and more conceptual; it usually involves several phases of refinement; it is aimed at a particular audience, interested in research process rather than the artefact's usability.

In order to better understand this process, we will look into examples of design artefacts that were produced in the context and for the purpose of research. How are research questions translated into design briefs? Furthermore, how are these translated into tangible design products? We will particularly focus on a research project that came out of an inquiry into perception of shifting infrastructures, developed in the framework of SINLAB research laboratory.

SINLAB was an experimental laboratory based at EPFL (ÉcolePolytechniqueFédérale de Lausanne), physically residing in La Manufacture, HETSR (Haute École de théâtre de Suisse romande). It was situated at the intersection of performing arts, architecture, science, engineering and philosophy(Sinlab 2012). It was conceived as a place for collaboration of doctoral and post-doctoral researchers with stage designers, theatre directors and choreographers who came in as artists in residence.

The following discussion will detail one research process in the laboratory, or the transformation from a research question into the design brief and then intodifferent prototypes. We will cover design and research decisions made along the way. Finally, we will evaluate this process from a research and from a design perspective. The research project described was chosen because of a clear yet changing research question it addressed; the diversity of prototypes and levels of 'finishedness' involved; and because of personal familiarity with the project development that came from involvement in all of its phases.

The research context

SINLAB's intellectual tradition is to be found closer to philosophy and performance studies than to design. The successive iterations of work were meant to feed into the common knowledge base, while attempting to answer three main research questions which revolved around time and

space perception, man-machine relations and *intermediality*in the stage context.

In order to address the first research question on transformation of perception and experience of time and space, a project titled "Moving wall" was devised. The project was imagined as a reflection on the idea of reconfigurable spaces. It was to serve as an *experience catalyst*(Badura 2013), hinting at new types of constellations in relation between humans and (cultural) infrastructures. These infrastructures are seen as shifting and changing, reflecting the perceived instability of contemporary life. As opposed to them, walls are seen as a symbolic order representing the concept of the solid as such and standing for stability, permanence and safety. But walls do at the same time signify shelter and prison; while they provide safety they also inhibit and isolate movement, perception, connection. The idea of the moving wall was thus devised to 'attack' this opposition of permanent vs. temporary, stable vs. changeable, passive vs. (inter)active.

The design development was focused on the intersection of aesthetics and technological development. We envisioned producing a complex interactive installation made of brick-like units that seemingly belong to a flat wall surface but are able to move and respond to external impulses.

An early stage prototype was built and tested in the lab environment. It demonstrated basic interaction principles using scrap materials and simple controls. The prototype performed sufficiently well as a demonstration of a tectonic effect of estranging our surroundings with unexpected interaction. However, it didn't go much further at that than the work already done in this field (Huang and Waldvogel 2005).

With this in mind, some of us set on exploring other paths towards a tangible experience of instable infrastructures and reconfigurable spaces. The work that followed concentrated on the experience of activity within the wireless network infrastructural layer. It focused particularly on answering the question: "How does the awareness of insensible infrastructures affect our experience of space?"

For this project, three prototypes were produced and presented to the public in different settings. The presentations were points of collecting data from observations on user behaviour, channelled discussion and quantitative data on network usage.

The first prototype was a cubical structure that reacted to the activity of one wireless network by changing its height. Visitors could cause the space to slightly 'shrink' or 'grow' by using more or less Internet traffic. The second

prototype introduced more complexity, offering interaction with four wireless networks that were the most active in the space. The shape was also more complex, having four peak-deformations on a flat surface of stretchable fabric. Two variations of this prototype were tested: a scaled model with peaks coming up with activity; a full-scale installation with the peaks coming down and oppressing the users, when they generated traffic. Both were tested in the lab space and in a public setting, at a research symposium (the scaled model) and with a general audience (real-life installation).
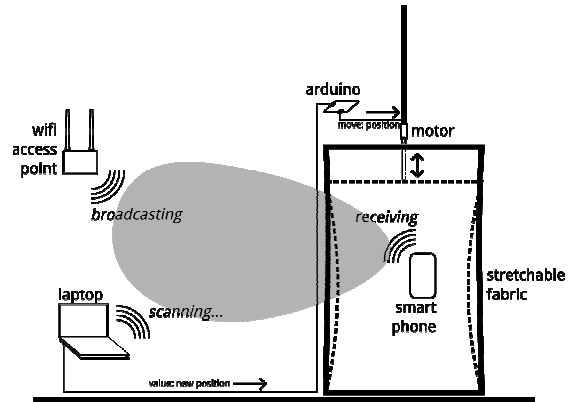

Figure 1. RKNFG interaction scheme. Laptop scanning the activity of the wireless network and controlling the height of the cubicle.
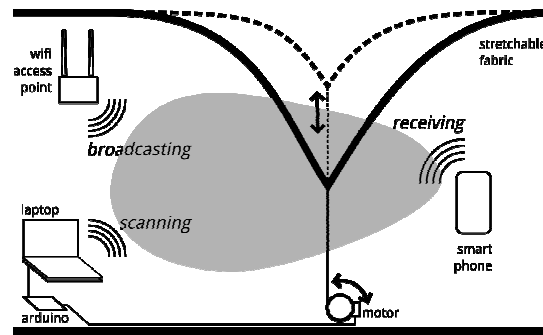

Figure 2. Quadricone interaction scheme. The peaks stretch with an increase in traffic; the users can interact directly with the space

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With open wireless networks available in the space, there was a clear feedback between the use of a network and the intensity of deformation of the stretchable fabric. However, when networks were not available, users could not make much sense of (inter)actions. They were not able to interact with the installation on an intuitive level, and kept perceiving it as a visualisation instead of a dynamically changing entity they could play with. The question of 'data arbitrary art' was also raised as the translation of wireless network traffic into four peaks (without a geo-spatial reference) seemed arbitrary. The discussion often drifted onto particular design decisions instead of focusing on the experience. Nevertheless, these prototypes gave insight into new participatory possibilities: an interaction between digital data, physical structures and human actions.

Further design research involved a development of more complex language of reactions and a more realistic image of the activity within the wireless layer. On the structural side the setup was made lighter and more universal. RBG LED lights were chosen to perform changes in the activity with colour and movement. The colour of the light was perceived on the bodies of two performers who were at the same time interacting with the system. Data acquisition was also improved - a mobile application was used to acquire data on both EDGE/3G and Wi-Fi traffic.
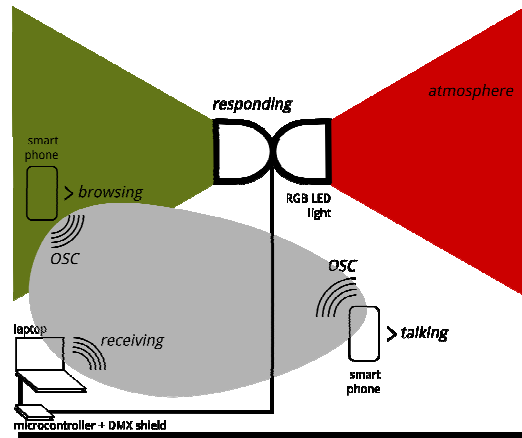

Figure 3.Connect or Not Interaction scheme. Lights respond to the activity of wireless networks created by the users (using an Android application)

The third prototype 'Connect or Not' offered an atmospheric experience of wireless communication, rendering the presence and the intensity of

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traffic (both GSM and WiFi) into an *interactant*. The interaction is manifested in the dynamic behaviour of lights (change of position, colour, flickering). It was closer to a performative tool, its design more contained. However, interaction with it was rather consuming as one had to focus on normally peripheral activities to a social event (sending SMSs, calling people or uploading images to social networks) to cause a reaction of the system, and then was too busy interacting to be able to enjoy it.

Evaluation of design artefacts

In their research into culturally embedded computing, a group at Cornell University concluded that the perceived context of an artefact (in this case an interactive display) strongly determines its experience. "When people approached the display as a tool for improving awareness of affect, they were somewhat frustrated with not being able to match input to output. However, when people approached the display as art, they were more comfortable" (Sengers et al. 2004, p. 18). The interpretation of displayed interaction was ambiguous and frustrating when understanding the output was the goal; when simply playing with it, people were more comfortable with the openness to interpretation they encountered. Thus expectations play an important role in the experience and evaluation of research artefacts.

Zimmerman reflects on projects that come out of research through design "not in terms of outcome, but instead in terms of characteristics of each project that made them ripe for knowledge development" (Zimmerman et al. 2010). How do we evaluate this 'ripeness'? To which extent does the artefact need to 'work' or satisfy its functional, aesthetical and ethical preconditions in order to be considered successful? Or to be useful for research? Research designs have to allow for interesting behaviours and unexpected features to become prominent research topics (like in the case of Breazeal' Kismet or Sengers Influencing machine (Sengers et al. 2004)). We have seen in the example of the Moving Wall that transformed into the Quadricone research, how such approach makes it hard to write up a 'design brief' which will fit the research and leave enough space for failures to become features. As Höök and colleagues found out in a series of design studies, "to be seduced by the interaction required a very tightly designed, flawless loop" (Höök 2008). This was not the case with SINLAB prototypes as they required a lot of assistance from researchers'

side to achieve interaction. The unsmooth feedback loop made the discussion always centre on the way it works and not on the experience.

Design artefacts produced in the context of research, particularly in the case of SINLAB prototypes, are addressing a particular research question and contributing to understanding of the phenomenon under observation. It is therefore not always appropriate to evaluate them through usability standards. They are developed into tangible objects or systems, which cannot hide behind theoretical abstractions. When they are successful, they reveal relationships, provoke reactions and criticise the incontestable.

Koskinen, Zimmerman, Binder, Redstrom and Wensveen find that "Research sets some requirements for prototypes at odds with doing good design"(Koskinen et al. 2011, p. 61). For them, a successful research design artefact helps clear up most important competing explanations.

The objective of the work described in this text was not improvement of design practice, though it couldhave been one of its results. Instead, as demonstrated above, research conducted within the SINLAB framework is inclined to allowing new insights in the constitution and perception of environments.It does so through construction of settings which foster tangible experience and facilitate discussion about the phenomenon under observation(Sempere and Savic 2013). These settings serve as *experience catalysts* (Badura 2012, 2013), seeking to catalyse a particular sensation or experience which can be discussed in the realm of design and architecture studies.

With the experience from the abovementioned and many more projects developed in research context, we could conclude that the success of a design artefact can be measured by the level of ambiguity and the focus on experience instead of design itself. When the discussion moves from design decisions onto the experience of the artefact, we can consider it 'ripe' enough to answer some of the research questions.

Conclusion

We have covered some general notions of design research, setting the ground for a study of design artefacts in research context. We saw what are the differences between three prominent approaches to design research; namely research *about*design, research *for* and research *through* design. Although there is no general consensus in literature about the precise meaning of these terms, there is a developing practice which contributes to establishment of a more solid meaning of research*for* and

research*through*design. There is more room for reflection on the broader nature of design, and its relation to other disciplines then when Buchanan wrote his text on design thinking (Buchanan 1992) and there are numerous articles and books written on the subject.

Design artefacts produced in research context are also more numerous. We can find such diverse examples ranging from explorations into a Japanese technique of fusing metal (Seago and Dunne 1999), mixed media cultural probes (Gaver et al. 1999), to interactive visual interfaces (Sengers et al. 2004, Huang and Waldvogel 2005, Fatah et al. 2008), tangible interfaces and objects (Dunne and Raby 2001, Sengers et al. 2004, Arnall et al. 2013). From this it is evident that artefacts produced in research context do not necessarily serve a utilitarian purpose, but provide an explicit feedback about their use and the experience they provide. In terms of design, they are like code with a lot of debugging print statements. The process of design is the furthest from linear and is usually characterised by decisions changing along the way.

Research *through* design is giving agency to artefacts. Researchers are not the only ones who influence the analysis process; their artefacts open unexpected doors too. More examples are needed in order for researchers to be able to compare each other's' approaches and results. This is not done with the expectation that results from prior efforts would be exactly replicated, as is the case in natural sciences (Zimmerman et al. 2010). It is rather to establish a rational base for evaluation of design artefacts in research context.

Research *through* design implies a certain type of interdisciplinarity. The research itself typically takes place at institutions which bring together researchers of different backgrounds and which designers have little control over (Koskinen et al. 2011). This does not infer that there needs to be a strong 'single-disciplinarity' amongst its protagonists. Rather, they are likely to possess interdisciplinary skills themselves, bringing their 'world views' closer and allowing for a collaboration which facilitates mutual inspiration. As Koskinen and colleagues conclude, "constructive design researchers need methodological and theoretical flexibility" in order to be successful in such environments.

The outcome of research design practice does not appear as a final product, if it ever does, before it has been repeatedly demonstrated to different expert audiences. We could say that it gets many opportunities to attain its purpose for research, more than a commercially designed product

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would. Design research artefacts are rather understandable and open to interpretations by the non-design audience (Sengers et al. 2004). This opens the door to both practice of designing them and the research itself to be shared with larger audiences.

Can research give birth to independently valid, stand-alone design artefacts? From the examples we have seen and numerous articles on similar artefacts (particularly the fact general audience has not heard of most of them) we could conclude that the different aesthetic and usability expectations allow design research artefacts more freedom in both directions. With this freedom comes an opposite trend of acceptance by the general audience.Besides a few notable examples of research design artefacts that blur the results with a high quality of design (Koskinen et al. 2011) , it is evident that research design artefacts rarely become commercial products. They are both unaffordable by corporations and nonessential to general audience. However, their reproducibility cannot be used as an argument against their validity for research, as they offer a unique way of dealing with complexand unorthodox research questions.

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