Design Research Thinking – a Narrative Sketch

or: Elements of a Theory of Design Research

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Abstract. Design research foundations are controversial. There is the "scientific" path and the approach of a "designerly" theory of knowledge production, the latter being associated with the notion of "practice-led research" or "research through design". The question remains: how to substantiate the designerly claim in face of attempts to make design research a strictly scientific endeavour? We argue for a narrative way: a rich argument has to be designed on the basis of a transparent set of assumptions in order to create a flexible foundation. Relevant aspects have to be combined into a coherent story. We approach the task in the form of a design project; the theory is considered a designed artefact. The design process is a knowledge generating research process.

Keywords. Design; research; theory; foundations; effect system; narrative.

Introduction

The issue of foundations for design research is controversial. In simplified terms there is the "scientific" path and the attempt at developing a "designerly" theory of knowledge production, the latter being associated with the notion of "practice-led research" or "research through design", which have generated much interest in recent years. The question remains: how to substantiate the claim of this approach in face of attempts to make design research a strictly scientific endeavour? More explicitly:

How can design establish its own genuine research paradigm, independent from the sciences, the humanities and the arts, that is appropriate for dealing with purposeful change in complex, ill-defined real-world situations?

We argue that this should be done in a narrative way. A rich and comprehensible argument has to be designed on the basis of a transparent set of assumptions in order to create a flexible foundation through discourse. All relevant aspects have to be considered and combined into a coherent story. The following is an attempt to sketch this story. We approach the task in the form of a design project. That means the theory is considered a designed artefact. The design process is a knowledge generating research process. This becomes plausible if one replaces research or "inquiry" by "design" in Dewey´s (1986) pragmatist definition:

"Inquiry (design) is the transformation of an indeterminate situation into a unified whole through the controlled and directed determination of its constituent parts and relations."

Elements of a Theory of Design Research

The number of 10 constituent elements is a design decision to keep the model manageable, and, maybe for formal aesthetic reasons, too. See Jonas (1999) for this *form* of reflection. The issues are briefly sketched, for details see the references.

1. Teleology / purposes of design

Design thinking means the process of exploring futures, conceiving change on different levels of time, scale, abstraction, etc., initiating discourse and thus increasing the variety of choices. The pragmatic forward-orientation in time relates design to the "Sciences of the Artificial" (Simon 1969). Design is a basically teleological, projective activity aiming at specific purposes, which cannot be adapted to established scientific standards. Science normally avoids teleological arguments. Rosenblueth, Wiener and Bigelow (1943: 23) rehabilitated the concept of teleology, which

"... has been discredited chiefly because it was defined to imply a cause subsequent in time to a given effect. ... Since we consider purposefulness a concept necessary for the understanding of certain modes of behavior we suggest that a teleological study is useful if it avoids problems of causality and concerns itself merely with an investigation of purpose."

However, since design is knowledge-intensive and requires contributions from diverse scientific disciplines, it must be assured that scientific methods can be integrated into the designerly process. Glanville (1980) has been arguing that scientific research should be conceptualized as a subset of design, i.e. research is a restricted design act, rather than design being inadequate research.

What are potential purposes of design? Maybe the principal categories are the *aesthetic purpose* of creating beautiful forms (products), the *logical purpose* of creating functional fits between people and environments (process), and the *ethical purpose* of changing existing states into preferred ones (people).

2. Relation to human / social needs

Design is inseparably linked to needs, wishes and fears, which designate the purposes of design. Needs are changing in time, needs are different from place to place. Therefore the purposes of design are diverse:

We had and still have the situation of *need* (these problems can be resolved), with artefacts that can be called "solutions" to "problems" such as washing clothes, heating homes, transporting people, etc. Then we had and still have the situation of *need of need* (these problems re-occur frequently), with artefacts that create fits in communicative situations, that promise to give meaning, happiness, status, etc. and - even more important - serve as drivers for the production-consumption-cycle. We are increasingly facing the situation of *need of orientation* (these problems are unstable, solutions are transitory), with environments that make sense or do not. Products in a traditional sense are secondary for this kind of need. And we have the *need of what?*

Designers are not the born experts for human / social needs, which they sometimes claim. Why should they? This leads to a demand of research into needs, especially into designerly ways of exploring needs in real-world situations. Designers should never again take the bait to decide about people´s needs, as the modernists did. Nevertheless designers are *responsible* for what they are doing in their new role as scouts and facilitators for people.

3. Fluidity of form – context interfaces

Alexander says (1964: 15-19) *"The ultimate object of design is form."* and continues:

"... every design problem begins with an effort to achieve fitness between two entities: the form in question and its context. The form is the solution to the problem; the context defines the problem. In other words, when we speak of design, the real object of discussion is not the form alone, but the ensemble comprising the form and its context. ... we may even speak of culture itself as an ensemble in which the various fashions and artifacts which develop are slowly fitted to the rest.

… The form is a part of the world over which we have control, and which we decide to shape while leaving the rest of the world as it is. The context is that part of the world which puts demands on this form; anything in the world that makes demands of the form is context. ..."

What means form? Concepts only make sense in difference to their counter-concepts. Which are the potential, mostly implicit, counter-terms of form?

- *Form – Content* evokes the widespread artistic concept of an autonomous "opus", created by an "author" who is solely responsible to him/herself. Design (*Form*gestaltung) in this sense is useful art, at best, if the content provides a valuable function for some third party. Such a form – as a museum piece, for example - can hold eternal validity.
- *Form – Context* implies an *interface* between the *form* and a psychic, social, cultural, economic, ecological, etc. *environment*. Human-centered design aims at optimizing this interface; a difficult task since forms can lose their validity very quickly, if their environments change or if the ascribed meanings no longer correspond with those actually perceived.
- *Form – Medium* denotes an even more fluid configuration. In a hybrid medium of initially just loosely or uncoupled elements of any kind more stable *forms emerge temporarily*, similar to Latour´s (2005) collectives or Luhmann´s (1984) social systems: businesses, web-based communities, health-services, discourses, etc. Here the interfaces, or better transition zones, between form and medium are fuzzy, ephemeral, mainly self-organizing, only

partially controllable.

The third meaning of *form* is becoming more significant and means an enormous challenge for design. Concepts such as "author" or "opus" become meaningless.

4. Purposes of design research

In the sciences the purpose of research is knowledge generation in the respective field. So the primary distinction is not by different purpose, but by different subject matter. In design research, due to the relevance of people, process and products, we have an inseparable mix of purposes and subject matters. This becomes obvious in Archer´s (1981: 30) definition:

"Design Research … is systematic enquiry whose goal is knowledge of, or in, the embodiment of configuration, composition, structure, purpose, value and meaning in man – made things and systems."

Findeli´s (2008) very recent definition is very similar:

"Design research is a systematic search for and acquisition of knowledge related to general human ecology considered from a 'designerly way of thinking' (i.e. project-oriented) perspective."

A rough categorization of subject matters / purposes might be *understanding artefacts* (aesthetics) / the *design process* (logic) / the *human experience* (ethics) and *improving the design process* so that stakeholders´ needs are better matched. Understanding might be related to research ABOUT design, improving the process to research FOR design. The issue of improving the human condition THROUGH design is implicit here. This most advanced position implies that design is an epistemological process of its own: creating useful knowledge by means of design inquiry. Research THROUGH design demands special attention; sustainable models of this categorization are required. A reflection of researchers´ involvement in the design process seems to be promising in this respect.

5. Design (research) deals with whole systems

Holistic design theories of the past have either adopted a mechanistic view of systems as trivial machines, or they have used the "humanistic" concept of "man". Social systems were considered to be consisting of men as basic elements, equipped with, at least bounded rationality (Simon 1945). But there is no systems concept available, which encompasses this generalized construct of "man". Therefore we take "man" as the hybrid combination of a living, a mental, and diverse changing social systems (Luhmann 1984). What "man" is depends on *who* is *observing* and *how* and *when*.

The systemic dimension refers to the concept of *design as an interface discipline* (Alexander 1964, Simon 1969), which creates the interface between various organic and psychic and communicative systems by means of artefacts, which play a constitutive role in the creation of the social (Latour 2005). More precisely: Design is the agent / joker or parasite (Serres 1987), which creates temporary fits between the co-evolving systems of cultural evolution, namely: communications, consciousnesses, bodies, as autopoietic systems, plus artefacts, as allopoietic systems. Only artefacts in isolation are controllable, all other systems are of autopoietic nature. With respect to these closed autopoietic systems, *causality-gaps* have to be introduced, which are always present in different distinctness according to the specific design task.

Baecker (2000) has called design the expert discipline of dealing with not-knowing. Because of this systemic competence design research may turn out to be the paradigmatic model of research in a mode-2 context (Nowotny et. al. 2001).

6. Design (research) is an evolutionary process

Darwin´s theory is a theory of the emergence of forms and their change under external influence. Accidental variation is utilized for the creation of structures that persist under local conditions for a while. This applies on various levels, from the generation of biological forms to the overall socio-cultural process. The generalized evolutionary scheme of variation – selection – re-stabilization … is applicable to the development of social systems; here it will be applied to design. The three separate components of the evolutionary process create further causality splits:

- *Variation* is aiming at the creation of alternatives. This is no problem in design, because consciousnesses and communications provide abundant "creativity", which is essential for producing new potentialities, thus increasing the variety of selective options. This is the "timeless" artistic task, separated from any social or cultural or commercial context.
- *Selection* is aiming at the fit of alternatives into existing communicative structures, which are expectations (of expectations). This is a problem indeed, because structures are detectable, but not their future stability. To a certain degree, at least, design research can examine existing structures. Single aspects can be tackled by isolated approaches: organism - artefact gaps by means of ergonomics, consciousness - artefact gaps by means of cognitive ergonomics, communication - artefact gaps by means of market research, etc.
- *Re-stabilization* is aiming at the integration of selected alternatives into the system, eventually by modifying structures or creating new ones. There is hardly any predictability, because this is a question of long-term viability within communicative systems. Futures studies are dealing with evolving systems.

The complete design process comprises variation, selection and re-stabilization, whereas the *conscious* design process is just the variation part in the socio-cultural process (Jonas 2007). Designers intervene punctually and

temporarily in the endless evolutionary redesign process (Michl 2002). Most artefacts fail. In spite of this axiomatic unpredictability design (research) tries desperately to impact the selection- and re-stabilization phases.

7. Circular learning models describe the process

In epistemic terms design can be taken as a *learning process*, which is biologically grounded in the need of organisms to survive in an environment. The aim is not final "true" representation of some external reality, but rather a process of *(re-) construction* for the purpose of appropriate *(re-) action*. The biological evolution suggests similarities of the way the material world is structured and the way we think of it. Already Aristotle suspected, that the recognizability of the world must rely on this similarity between the "particles" of the world and those in our senses. Evolutionary epistemologists (Campbell 1974) argue, that the Kantian transcendental apriori has to be replaced by the assumption of an *evolutionary fit* between the objects and the subject of recognition.

Learning is conceived as a cybernetic cycle of acting and reflecting, aiming at a purpose. The circular design process models, as e.g. that of the Institute of Design Chicago (research —> analysis —> synthesis —> realization), seem to be adoptions of Kolb´s (1984) "learning cycles". The latter, in turn, seems to be derived from the very basic O.O.D.A. model of the USAF. If we combine the macro model of ANALYSIS —> PROJECTION —> SYNTHESIS (domains of knowing) and the micro model of research —> analysis —> synthesis —> realization (the learning phases) we obtain a hypercyclic *generic design process model* (Hugentobler, Jonas, Rahe 2004).

The question remains: How is the scientific hypothesis generated? How is the design concept created? Induction and deduction are accepted syllogisms in science and design, but they do not explain the creation of the new.

8. Abductive PROJECTION is the neglected link in the cycle

Which is the missing link between Simon´s states 1 and 2, between the inductive understanding and the deductive conclusion? The logical syllogisms of induction and deduction are obviously unable to explain the generation of new facts and artefacts. Innovation is about the creation of new stable objects or forms, of in-form-ation (Glanville 2008). This has often been neglected in design research.

Based on pragmatist concepts from Peirce (Davis 1972), Dewey (1986) and others we consider *abduction* to be the central mental and social "mechanism" of knowledge generation, applicable in everyday life, in the designerly as well as in the scientific process. Abduction combines the otherwise sterile syllogisms of induction (formulating a rule out of existing data or cases) and deduction (deriving special cases from rules) into a productive learning cycle. Without abductive reasoning at best "normal science" (Kuhn 1973) would be possible (March 1984):

"As Peirce writes: abduction, or as we have it production, 'is the only logical operation which introduces any new ideas; for induction does nothing but determine a value; and deduction merely evolves the necessary consequences of a pure hypothesis'. Thus, production creates, deduction predicts; induction evaluates."

Roozenburg (1993) differentiates between explanatory and innovative abduction and concludes that it is the latter, which should be taken as the 'paradigm' model of the crucial generative step in the design process:

"In explanatory abduction it is assumed that the rule (of the syllogism) is given as a premise; innovative abduction aims at finding new rules. …"

In designerly methodological terms we speak of ANALYSIS (the inductive phase), PROJECTION (the abductive phase) and SYNTHESIS (the deductive phase). Abduction is essential for bridging the logical gap: In science the gap is finally removed by means of a generalized logical construction, PROJECTION can remain a mystery. In design the gap is temporarily bridged; the art of PROJECTION is the essential task. And the further clarification of the abductive mechanisms of PROJECTION is crucial for the development of genuine designerly concepts of research and their spreading into other fields (Chow, Jonas 2008).

9. Appropriate models of design research

Friedman (2002) preaches the model of clinical / applied / basic research as a structure for design research on its different levels. One of his main objectives seems to be the preservation of a clear separation of design and design research: design is to remain a practice, design research is to become a scientific activity. Nevertheless new hybrid / integrative models are emerging that focus the "beauty of grey" between "mere" design and "proper" research and argue for a specific epistemological status of design research. A striking triadic pattern is showing up. A design-specific structure, albeit in different terminologies, of the research process is emerging in various "sciences of the artificial" (disciplines dealing with the transfer of existing states into preferred ones), such as design (Archer 1981, Nelson and Stolterman 2003, Jonas 2007), management (Weick 1969, Simon 1969), HCI (Fallman 2005, 2008). See table 1.

author	*steps / components of design research*		
Archer 1981	science	arts	design
Jones 1970	analysis	divergence	convergence
Simon / Weick (1969)	intelligence	design	choice
Nelson&Stolterman (2003)	the true	the ideal	the real
Jonas (2007)	Analysis	Projection	Synthesis
Fallman (2008)	Design Studies	Design Exploration	Design Practice

Table 1. Triadic concepts of knowing in design research, indicating a generic model of the designerly research process (see also Chow 2009).

The interpretation is still contentious. Is it a necessary sequence or a loose combination of different spheres of knowing? Fallman (2008) argues that the same tools are used in the 3 fields, but for different applications. Jonas argues that Research THROUGH Design means the integration of all 3 components. In any case the middle column seems to be the central design-specific component, where the 'designerly' competences are located.

10. Reflecting the researcher´s involvement

Any purposive process such as design has to reflect the observer´s involvement, i.e. his/her positions in relation to the designing / inquiring system; the move to *operational epistemology* (von Foerster 1981), or from C1 to C2 is unavoidable.

1st generation methodology, as mostly conceived, provides normative methods FOR the design process. This is a seemingly scientific attitude, which neglects the researcher´s involvement and the dynamic context of every design research task. One great merit of 1st generation methodology research in the 1960s is that generic process models have been considered in some depth. The notorious criticism of their rigidity is justifiable only if they are considered as normative standards. If this misunderstanding is overcome, then the benefits of the generic models become evident. The 2nd order cybernetic approach of reflecting observation modes (Glanville 1997) brings more clarity. It provides an explanatory basis for the concept of research FOR / ABOUT / THROUGH design, and reveals a new category. See table 2 (Chow, Jonas 2008).

It is the (INACCESSIBLE?) abduction step, which combines the logical syllogisms of induction (formulating a rule out of existing data – post-rationalization) and deduction (deriving special cases from rules – pre-rationalization) into a productive cycle with the potential of creating something new. We conclude that design research only makes sense, if all observation modes are taken into consideration. Otherwise, the process remains locked in sterile assumptions, which prevent the productive use and further dynamic development of methodology.

Observer position / Observer looking	Outside the design system 1st order cybernetics	Inside the design system 2nd order cybernetics
outwards	*research FOR design* research for process improvement, based on certain assumptions regarding the structure / nature / purpose of design	*research THROUGH design* involved / situated research aiming at pragmatic innovation and knowledge generation
inwards	*research ABOUT design* research aiming at knowledge generation about design as a mental / social phenomenon	*INACCESSIBLE* probably the essential mental / social "mechanism" of generating new ideas, the location of abductive reasoning

Table 2. Knowledge generation in design research, the concepts of research FOR / THROUGH / ABOUT design related to observer positions (Glanville 1997).

Relations, feedbacks and narratives

Actually these 10 issues cannot be linked linearly; they are in a complex relation. The effect system (fig. 1) has been designed by relating the issues using a cross-impact analysis (Serres 1991). The *form-context form*, which has been visually emphasized in the diagram, emerged during the process of reflecting the *systemic relations:*

- *Form* - the inner elements (red) that establish the kernel of the theory: the systemic (non-causal) and the evolutionary (unpredictable) character plus the circular dynamics are essential,
- *Context* - the outer elements (blue) describe the social, human and material environment, in which the theory has to function and the projective character of design and research,
- *Interface* – the links between form and context (green) by means of the fluidity of form/context and appropriate models of design research.

The inclusion of the form-context issue into the list of constituent issues and the final emergence of this concept in the system diagram turns out as a circular combination of pre- and post-rationalizing reflections (Chow, Jonas 2008). This way of confirming the model may appear trivial or at least unscientific, but it is an example of designerly reasoning in design research.

Feedback analysis reveals that we have established 27 positive cycles in the system. The longest one (1—> 4 —> 9 —> 10 —> 2 —> 8 —> 1) connects the outer *context* elements. Another one (5 —> 6 —> 7 —> 5) links the inner elements of the *form*. Each cycle allows the construction of various *narratives*. The starting point is arbitrary:

- *Form: the theoretical kernel.* (5) Design is about the improvement of real-life situations. That means that reality cannot be de-contextualized and split into manageable pieces as in scientific research, but has to be conceived as system. (6) If we agree that design deals not only with mechanistic (trivial) but mainly with autopoietic (non-trivial) systems, then we should resort to evolutionary epistemological approaches. (7) Evolutionary development on all levels of the living world can be modelled by circular feedback mechanisms, which (5) contribute to the emergence of new systemic structures...
- *Context: the environment of design research.* (1) If we agree that design should be conceived as a purposeful activity, not only aiming at the creation of artistic pieces, but at making the environment more convenient for people, then (4) this should imply that design research does not only aim at the creation of knowledge for its own sake, but also to contribute to the various external purposes of design. (9) This means that, beside the scientific models of research, we need models of the research process, which take this specific purposefulness into account. (10) Purposefulness implies that, other than in the sciences, human and social values, stakeholders´ interests, ethical criteria,

etc. have to be accepted as legitimate issues in a theory of design research. (2) Otherwise it is impossible to establish a proper relation to human and social needs today and in the future. (8) In order to bridge the gap to future improved states, PROJECTION has to be focussed. Abduction has to be made explicit and applicable in order to improve the process. (1) Thus design acquires the competence to act in a purposeful and responsible projective manner …

- *Interface: the link of form and context.* (3) The fluidity of the interface seems to be the essential theoretical aspect. (9) Appropriate models of design research are required to allow for this fluidity.

Furthermore, given the insight that it is not so much the elements but rather the relations between them that constitute the system, special relations can be discussed in more detail. Each relation presents at least one research question / philosophical question / pragmatic question of its own, for example (10 —> 2): Designers are not the experts for human needs? What does that mean? Or (1 —> 4): Does this imply that design research is mainly a humanitarian endeavour? Does this establish the main difference to sciences?

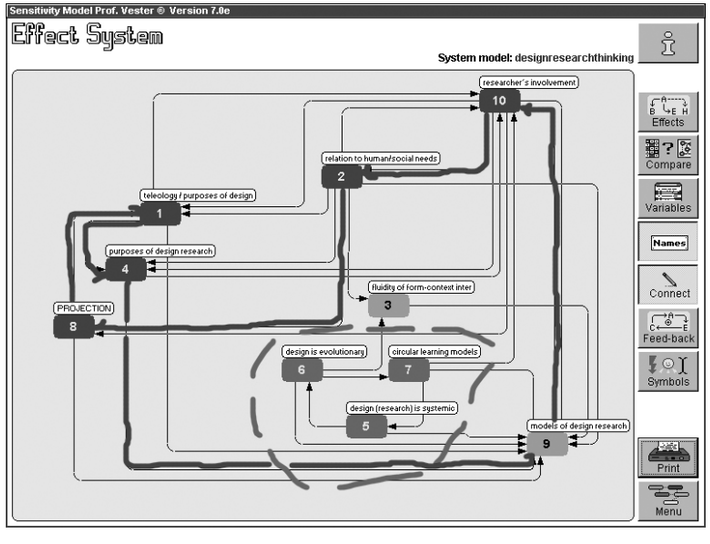

Figure 1
The effect system of constituent parts and relations (Vester 1999).

Conclusions

A good design theory, as a designed artefact, should be able to explain its own emergence. So far, evolutionary thinking and 2nd order cybernetics provide the only models, which satisfy this self-referential requirement. Any other explanation would be either a vicious circle or an infinite regress.

We designed the prototype of a systemic model of relevant issues for theory-building in design research. It allows further evolutionary development. Initial assumptions and final outcomes are closely linked. Parallels of design and design research are showing up. The solution emerges during the clarification (design) of the problem. In the end the problem is the solution – and the solution is the new problem.

The perspective for design research seems to consist of procedural approaches to deal with the behaviours of interacting autopoietic systems, which means a shift from 1st order prediction & control towards 2nd order learning & design. Without the societal embrace of scientific and technological development, no collective or individual meaning can be assigned to the production of complex new knowledge and artefacts. Without their embedding in persons and their relations, in things and in the self as well as in institutions, the necessary social skills to put this knowledge to beneficial use in concrete situations, will not arise (Nowotny 2005: 28,29):

"A deeper theoretical understanding of complexity, not as a mathematical, but as a social phenomenon is required, which can be usefully guided by metaphors taken from mathematical complexity theory."

1. References

Alexander, C.: 1964, Notes on the Synthesis of Form, Harvard University Press, Cambridge, MA.

Archer, B.: 1981, A View of the Nature of Design Research, in R. Jacques and J. Powell (eds), Design: Science: Method, Westbury House, Guildford.

Baecker, D.: 2000, Wie steht es mit dem Willen Allahs?, Zeitschrift für Rechtssoziologie, 21 (2000), Heft 1, pp. 145-176.

Campbell, D.T.: 1960, Blind Variation and Selective Retention in Creative Thought as in other Knowledge Processes, Psychological Review, 67, pp. 380-400.

Chow, R.: 2009, Interaction Design Research Triangle meets Research Through Design: Compare and Contrast, submitted to CHI 2009, Boston, MA, USA, 04/2009.

Chow, R. and Jonas, W.: 2008, Beyond Dualisms in Methodology – an integrative design research medium ('MAPS') and some reflections, DRS conference Undisciplined!, Sheffield, UK, 07/2008.

Davis, W. H.: 1972, Peirce's Epistemology, Martinus Nijhoff, The Hague.

Dewey, J.: 1986, Logic: The Theory of Inquiry, Southern Illinois University Press, Carbondale.

Fallman, D.: 2005, Why Research-oriented Design Isn 't Design-oriented Research, Proceedings of Nordes: Nordic Design Research Conference, Copenhagen, Denmark, 05/2005.

Fallman, D.: 2008, The Interaction Design Research Triangle of Design Practice, Design Studies, and Design Exploration, Design Issues, 24 (3), pp. 4-18.

Findeli, A.: 2008, Searching for Design Research Questions, keynote at Questions & Hypotheses, Berlin, 10/2008.

von Foerster, H.: 1981, Observing Systems, Seaside, Cal.

Friedman, K.: 2002, Theory Construction in Design Research: Criteria, Approaches, and Methods, in D. Durling and J. Shackleton (eds.), Common Ground, Proceedings of the Design Research Society International Conference at Brunel University, Staffordshire

University Press, Stoke on Trent, UK, 09/2002.
Glanville, R.: 1980, Why Design Research?, in R. Jacques and A. Powell (eds.), Design: Science: Method, Westbury House, Guildford.
Glanville, R.: 1997, A Ship without a Rudder, in R. Glanville, R. and G. de Zeeuw (eds.), Problems of Excavating Cybernetics and Systems, BKS+, Southsea.
Glanville, R.: 2008, Design and mentation: Piaget's constant objects, in The 'Radical' Designist, Zero Issue, http://www.iade.pt/designist (not accessible there, personal version).
Hugentobler, H. K., Jonas, W., & Rahe, D.: 2004, Designing a Methods Platform for Design and Design Research, in Proceedings of futureground, DRS International Conference, Melbourne, 11/2004.
Jonas, W.: 1999, On the Foundations of a 'Science of the Artificial', International Conference on Art and Design Research, UIAH, Helsinki, 11/1999.
Jonas, W.: 2007, Research through DESIGN through research - a cybernetic model of designing design foundations, Kybernetes, 36 (9/10), special issue on cybernetics and design.
Jones, J. C.: 1970, Design Methods: Seeds of human futures, John Wiley & Sons, London. Second edition, Van Nostrand Reinhold, New York 1992.
Kolb, D. A.: 1984 Experiential learning: experience as the source of learning and development, Prentice-Hall, New York.
Kuhn, T.: 1973, Die Struktur wissenschaftlicher Revolutionen, Suhrkamp, Frankfurt/M. (2. rev. Auflage 1976).
Latour, B.: 2005, Reassembling the Social: An Introduction to Actor-Network-Theory, Oxford University Press, Oxford.
Luhmann, N.: 1984, Soziale Systeme, Suhrkamp, Frankfurt/M.
March, L. J.: 1984, The Logic of Design, in N. Cross (ed.), Developments in Design Methodology, John Wiley & Sons, Chichester, pp. 265-276.
Michl, J.: 2002, On Seeing Design as Redesign: An Exploration of a Neglected Problem in Design Education, Dept of Industrial Design, Oslo School of Architecture, Norway.
Nelson, H. G. and Stolterman, E.: 2003, The Design Way: Intentional Change in an Unpredictable World, Educational Technology Publications, Englewood Cliffs, New Jersey.
Nowotny, H.; Scott, P.; Gibbons, M.: 2001, Re-Thinking Science: Knowledge and the Public in the Age of Uncertainty, Polity Press, Cambridge, UK.
O.O.D.A., http://de.wikipedia.org/wiki/OODA-Loop, 03/01/2007.
Roozenburg, N. F. M.: 1993, On the pattern of reasoning in innovative design, Design Studies, 14 (1), pp. 4-18.
Rosenblueth, A., Wiener, N., & Bigelow, J.: 1943, Behavior, Purpose and Teleology. Philosophy of Science, 10 (1), pp. 18-24.
Serres, M.: 1987, Der Parasit, Suhrkamp, Frankfurt / M.
Serres, M.: 1991, Das Kommunikationsnetz: Penelope, in I. Hermes, Kommunikation, Berlin, pp. 9-23.
Simon, H.: 1945, Administrative Behavior: A study of decision-making processes in administrative organizations, The Free Press, New York, fourth edition 1997.
Simon, H. A.: 1969, The Sciences of the Artificial, MIT Press, Cambridge, MA, 3rd ed. 1996.
Vester, F.: 1999, Die Kunst vernetzt zu denken: Ideen und Werkzeuge für einen neuen Umgang mit Komplexität, DVA, Stuttgart.
Weick, K.: 1969, Social Psychology of Organizing, Addison Wesley, Reading MA.