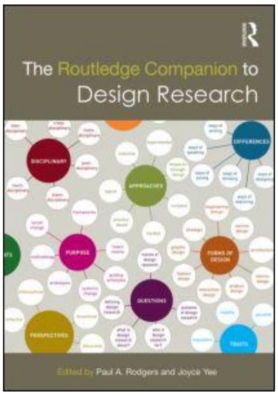

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A cybernetic model of design research

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A CYBERNETIC MODEL OF DESIGN RESEARCH

Towards a trans-domain[1] of knowing

Wolfgang Jonas

The situation

The cultures of the Sciences and the Arts were still largely integrated during the Renaissance. Their separation since the seventeenth century finally led to what we know as 'nineteenth century science' and 'art school design' today. Supposedly, science produces theoretical knowledge, which design, at best, applies in practice. In order to overcome the deficits and make design an academically respected discipline, it is often argued that designerly knowledge production has to adopt scientific standards.

Friedman (2003: 510) resorts to the established distinction of "clinical", "applied" and "basic" research in medicine. Basic research "involves a search for general principles", applied research "adapts the findings of basic research to classes of problems" and clinical research "applies the findings of basic research and applied research to specific situations". Medicine can refer to a stable reference system for assessing success or failure, whereas the usefulness in design remains unclear. The distinction of clinical/applied/basic corresponds to the degree of de-contextualisation of the subject matter. Yet, design deals with the fit of systemic wholes in life-world environments. These fits immediately lose their significance in de-contextualised situations. Therefore one might argue that 'basic' research is meaningless in design and that 'clinical' research is the most 'basic' and – at the same time – the most challenging form of Design Research. Glanville (1980) and Archer (1995) support this view. Friedman constructs a further antagonistic and, again, overly schematic distinction of reflection and research:

> Reflection [. . .] develops engaged knowledge from individual and group experience. It is a personal act or a community act, and it is an existential act. Reflection engages the felt, personal world of the individual. It is intimately linked to the process of personal learning [. . .] Research, in contrast, addresses the question itself, as distinct from the personal or communal [. . .] In short, research is the 'methodical search for knowledge. Original research tackles new problems or checks previous findings. Rigorous research is the mark of science, technology, and the "living" branches of the humanities' (Bunge 1999: 251). Exploration, investigation, and inquiry are synonyms for research.
>
> *Friedman 2002: 19*

This persistent attempt at eliminating the observing system and at keeping up the barrier and epistemological hierarchy between the 'swampy lowlands' of reflective practice and the 'high ground' of rigorous research (Schön 1983) is definitely a step back compared with the emerging conceptual models of Practice-based Design Research. It also ignores recent developments in Science Studies, as will be shown in the following section (The perspective: design and science converging) and the penultimate section (Mode-2 Science, Transdisciplinarity and RTD). Friedman's own words demonstrate the weakness of this position. In saying that "reflective practice is one of an array of conceptual tools used in understanding any practice – including the practice of research" (Friedman 2002), he implicitly states that reflective practice is an essential research medium, probably the most important one in the *Sciences of the Artificial*. A circular one, admittedly.

Norman (2010) supports Friedman's view and laments the lack of scientific rigour and content in design education: "There is little or no training in science, the scientific method, and experimental design". His vision seems to be the designer as 'applied behavioral scientist'. Reverently insisting on distinguishing 'mere' design from 'proper' research by ignoring the epistemological characteristics of design and science contributes to solidifying the supposed hierarchy between the two and promotes the 'colonisation of design' (Krippendorff 1995).

Changing economic, social, cultural and technological conditions present serious challenges for university education. The types and forms of knowledge currently imparted by universities are predominantly descriptive rather than projective, and generated for academic peers rather than the public good. Most socially and economically relevant knowledge is conveyed outside the university (Scharmer and Käufer 2000). University education can no longer be concerned primarily with the socialisation into established institutional and societal norms. It must rather provide spaces and opportunities for experimental actions, examine possible, desirable and promising futures and transcend the present world. Scharmer and Käufer's perspective offers opportunities for re-inventing the university as a utopian space of exploration, improvisation and controversial sense-making. It helps re-articulate the relationship between science and the public, between knowledge and research, and between academic and non-academic practices. Design can contribute significantly.

The 'Scholastic University' was focused on teaching a canonical set of disciplines. The 'Modern University' builds on Humboldt's classical ideal of the unity of teaching and research, in a growing number of disciplines. Its focus was knowledge generation in the 'ivory tower', separated from the rest of the society. The limits of this model are obvious today. In response to increased societal complexity, the university is now renewing its conceptual core. Humboldt's model is being expanded and re-founded on a new basis.

In the emerging 'Next University' (Baecker 2007) the strict separation from society is eroded and the focus shifts towards the *unity of practice, research and teaching*. Researchers and teachers abandon their positions as external observers to become active, committed co-designers of social, cultural and economic realities. The age of *Anthropocene* requires the reflection of values. 'Weltanschauung'[2] is an essential issue in socially relevant inquiry (Churchman 1971). Research (producing knowledge), teaching (disseminating knowledge) and practice (using knowledge to guide action) can no longer exist separately, nor can technology, design and art. The dynamics of these developments and the assumptions on which scientific knowledge production is based must be reconsidered.

We can build on important previous contributions from design, which has long been familiar with the basic epistemological 'problems of prediction and control' (Jonas 2003) and the situation of dealing with 'not-knowing' (Jonas and Meyer-Veden 2004). The early designerly concepts should be taken seriously and developed further. Current positions in Science Studies, which can be interpreted as the convergence of design and science, frame this ambitious endeavour.

The perspective: design and science converging

The dualism of the Sciences and the Arts still underpins today's prejudices against designerly modes of inquiry. One of the first strands of argument, which suggests the idea of re-integration, emphasises the importance of practice in knowledge generation. Pragmatism (Dewey 1986) argues that the separation of thinking, as pure contemplation, and acting, as bodily intervention into the world, is obsolete: thinking depends on life-world situations that have to be met. The active, intentional improvement of an unsatisfactory, problematic situation is the primary motivation for thinking, designing and, finally – in a refined and purified manner – for scientific inquiry. The achievement of projected consequences is the measurement of success. Knowing is a manner of acting and 'truth' is better called 'warranted assertibility' (Dewey 1941). This

Table 2.1 Convergences of science and design

Science → *Indications of the shift of science towards socially relevant innovation*	← *Design* *Indications of the shift of design towards socially robust knowledge creation*
The forgotten controversy at the beginning: Cartesian rationalism *vs.* Montaigne's scepticism (Toulmin 1992)	The concept of the *Sciences of the Artificial* (Simon 1969)
Pragmatist philosophy (Dewey 1986)	The definition of *scientific research as design activity* (Glanville 1980)
The concept of *problems of organised complexity* (Weaver 1948)	The de-mystification of the creative process as *evolutionary* (Michl 2002)
The increasing importance of generative and synthetic forms of research, e.g. in engineering, nano- and genetic design (e.g. Pfeifer and Bongard 2007)	The importance of design *beyond the product*: services, systems, organisations, scenarios, social design (e.g. Vezzoli and Manzini 2008)
Grounded theory building as creative action in the social sciences (Glaser and Strauss 1967)	The concept of the *trajectories of artificiality* (Krippendorff 2006)
The evidence generated by empirical *laboratory studies* (e.g. Knorr-Cetina 1999, Rheinberger 2006)	The concepts of *Practice-led Research, Project-grounded Research,* and *Research Through Design* (e.g. Jonas 2007, Findeli 2008a)
The considerations of *Science and Technology Studies* and *Actor-Network Theory* (Latour 1993, 2004)	The concept of *Design Thinking* (Brown 2009)
The emerging concept of *Mode 2 Science* and *Transdisciplinarity Studies* (Nowotny, Scott and Gibbons 2001, Nowotny 2006)	The approaches of *Design Fiction* (Bleecker 2010, Lukic and Katz 2010) and *Critical Design* (Dunne and Raby 2001)
Design-based research in *management, pedagogy, nursing*, etc. (e.g. Boland and Collopy 2004)	The exploration of the concept of *abduction* in design (Chow and Jonas 2010b)

comes close to what we argue to be emerging forms of Design Research and a convergence of design and science. Recent intellectual movements in both science and design support this hypothesis.

On the one hand, the social embeddedness and context-dependency of scientific inquiry have been widely acknowledged, and there are indications of science gearing towards a designerly process of innovation and change. Projects in bio-, nano- and genetic sciences are synthetic rather than merely explorative endeavours. Activities in informatics such as social networks and 'big data' research turn into global real-time design experiments. Not to speak of climate research and geo-engineering. The *Anthropocene* might become the age of joint endeavour of design and science, reconciling analysis, creative action and ethics. On the other hand, the intensity of knowledge production in design has been recognised; it is moving towards deliberately producing socially robust knowledge. These developments indicate a convergence of design and science towards a *trans-domain*, a tentative term for a social and intellectual space and mindset, which accommodates transdisciplinary projects and develops corresponding facilities and networks. An outline of the theories and concepts is sketched in Table 2.1. Some salient aspects will be discussed in the following sections: 'Research through design' and 'Mode-2 Science, Transdisciplinarity and RTD'.

The hypothesis of convergence arises from the observation that both traditions share the same underlying *cybernetic* process pattern of *experiential evolutionary learning*. This model assumes far-reaching structural identity from the biological to the cognitive and cultural level (Riedl 2000, Vollmer 1998). The basic structure reveals a circular process of trial (based upon expectation) and experience (success or failure, confirmation or refutation), or of action and reflection. The aim is not a true representation of some external reality, but rather a process of (re-) construction, for the purpose of appropriate (re-) action. An inductive/heuristic semi-circle leads from purposeful experiential learning to hypotheses, theories and prognoses about how the world works. It is followed by a deductive/logical semi-circle that leads to actions and interventions, which result in new experiences that confirm or refute existing theories.

One of the most prominent patterns of this type is Kolb's (1984) experiential learning process. The pattern finds application in various fields, especially in design methods (e.g. Owen 1998). Yet, many of these models have a deficit, which obscures their potential: they do not account for the essential step of creating the new. They neglect *abduction*, which is the central mechanism of knowledge generation in everyday life, design and science. There is, therefore, a need for models that explicitly acknowledge the creative phase and thus provide a theoretical framework for *Research Through Design* (*RTD*). Internal or external perturbations (called ideas, creativity, intuition, accidents, environmental changes, etc.) create variations in the circle, leading to stabilisations (negative feedback) or amplifications and evolutionary developments (positive feedback). Dewey's five-step cycle in Figure 2.1 includes the abductive step 'create'. Table 2.3 elaborates on this issue.

A solid base: evolving models of design

Beside the ongoing scientification of Design Research (Bayazit 2004), there are growing endeavours to take up and develop the original approaches. The evolution of schemes accounts for design-specific ways of knowing. Synthesising these may give rise to a new understanding.

Weaver (1948) supported the conceptualisation of Design Research by introducing 'problems of organised complexity' as the central challenge of the second half of the twentieth century. He anticipates *Mode-2 Science* (Nowotny, Scott and Gibbons 2001), which describes modern

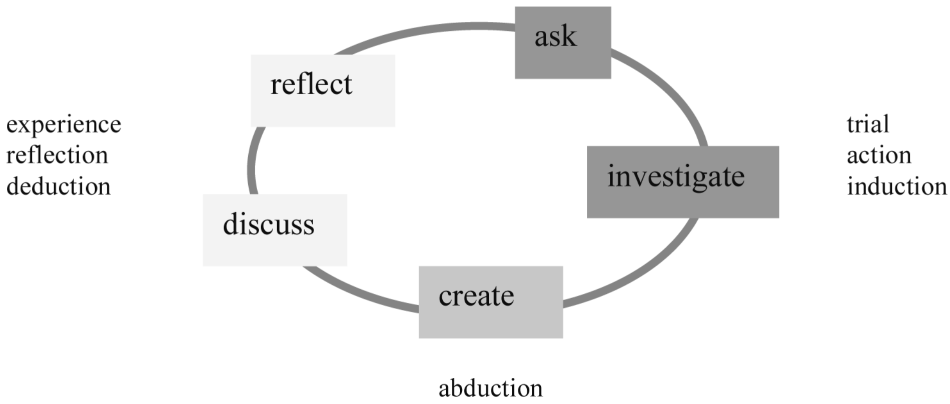


Figure 2.1 Learning cycle with inductive, abductive and deductive phases

Source: Dewey 1910

knowledge production as increasingly problem-oriented, normative, socially accountable and transdisciplinary. Simon (1969) was one of the first to conceive design as a distinct subject and form of research, different from the Sciences and the Humanities. Design Research is not conducted for its own sake, but to improve real-world situations, to 'transfer existing situations into preferred ones'. The concept of relevance shows up here, which seems to be in permanent conflict with scientific rigour; a polarity which may finally dissolve in a pragmatist view. In locating design at the interface between the artefact and its contexts, Simon introduced the idea of situatedness and context-dependency of Design Research. The parallels with *Mode-2 Science* 20 years later are obvious, but the exchange between Design Research and Science Studies is hardly developed. Grand and Jonas (2012) suggest a closer relationship.

Archer (1979) introduces 'Design as a discipline', which has to cover a huge diversity of heterogeneous subjects. The prolific paradox of the 'undisciplined' discipline (DRS 2008) has been present from the very beginning. Archer (1981: 30) took a Wittgensteinian stance[3] and argued "that my own approach to finding an answer to the question What is Design Research? is to try to discover what design researchers actually do." His 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" is similar to Findeli's (2008b): "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."

Archer (1981: 31, 35) lists ten areas of Design Research, from which "constituent sub-disciplines" emerge, namely "Design Phenomenology", "Design Praxiology" and "Design Philosophy". Cross suggests that (1999: 6) "design research would therefore fall into three main categories, based on products, process and people" and even relates them to historical epochs: the 1920s, the 1960s and the 2000s. Referring to Simon (1969) he introduces the "designerly ways of knowing" and warns:

> that we do not have to turn design into an imitation of science, nor do we have to treat design as a mysterious, ineffable art. [. . .] we must avoid totally swamping our research with different cultures imported either from science or art.
>
> *Cross 2001: 50*

In the 1920s, design was occupied with products. In the 1960s, the "design science decade" (Fuller 1999), there is the search for rationality. The *Conference on Design Methods* in 1962 marked the beginning of the *Design Methods Movement* with its desire to base the process on objectivity and rationality. The *Sciences of the Artificial* (Simon 1969) highlighted the culmination and the watershed of this development. Simon himself, in chapter 6 on 'Social Planning: Designing the Evolving Artefact' (1996: 163) made a considerable shift in acknowledging complexity, uncertainty and the evolutionary character of social design processes.

In pointedly illustrating the fundamental paradoxes that occur when design (as an activity projecting what should be) is misconceived as a scientific endeavour (analysing what is), Rittel (1972) made contributions to this debate that cannot be overestimated. The theory backlash of the 1970s obstructed the growth of these still vague ideas and it took a decade to recover. Cross summarises the Design Research Society's 1980 conference on *Design. Science: Method* (2001: 51):

> The general feeling from that conference was, perhaps, that it was time to move on from making simplistic comparisons and distinctions between science and design; that perhaps there was not so much to learn from science after all, and that perhaps science rather had something to learn from design.

In the 2000s, Cross detects the focus on people in Design Research**.** His phase model of products – process – people shows a stunning parallel to what Findeli later presents as the 'Bremen model' (Findeli and Bousbaki 2005), where he describes a shift of concern from aesthetics (products) to logic (process) and finally towards ethics (people) in Design Research. Cross (2001) tries to clarify the confusion about design and science. Reflecting on 'Scientific Design' (design with scientific and other foundations), 'Design Science' (design as science) and 'Science of Design' (design as subject matter of science) he finally argues for 'design as a discipline':

> Design as a discipline, therefore, can mean design studied on its own terms, and within its own rigorous culture. It can mean a science of design based on the reflective practice of design: design as a discipline, but not design as a science. [. . .] The underlying axiom of this discipline is that there are forms of knowledge special to the awareness and ability of a designer, independent of the different professional domains of design practice.
>
> *Cross 2001: 54*

He worries about the 'swamping' of Design Research, yet we cannot avoid it. The design community owes the metaphor of the 'swampy lowlands' and the 'high ground' to Schön (1983), who challenges the *Design Science Movement* and argues for an epistemology of practice, instead. His *Reflective Practitioner* explicitly raises the issue of rigour vs. relevance:

> There are those who choose the swampy lowlands. They deliberately involve themselves in messy but crucially important problems and, when asked to describe their methods of inquiry, they speak of experience, trial and error, intuition, and muddling through. Other professionals opt for the high ground. Hungry for technical rigour, devoted to an image of solid professional competence, or fearful of entering a world in which they feel they do not know what they are doing, they choose to confine themselves to narrowly technical practice.
>
> *Schön 1983: 42, 43*

Owen (1998), also in the pragmatist tradition, believes that, although design's own research culture is still young and weak, the import of seemingly approved paradigms and methods may be counter-productive (1998: 10):

> Yet, it is reasonable to think that there are areas of knowledge and ways of proceeding that are very special to design, and it seems sensible that there should be ways of building knowledge that are especially suited to the way design is studied and practiced.

In slight contrast to this assertion – and in line with our further argument – Owen analyses the circular process of knowledge building (inquiry) and knowledge using (application) in various scientific and non-scientific disciplines and argues that they are fundamentally the same. The differences lie in the purpose of the activity and in the codes and value bases used.

Research through design as cybernetic mode of inquiry

Frayling (1993) made the distinction of research 'INTO' (ABOUT), 'THROUGH' and 'FOR art and design' popular. Owen concentrates on building knowledge FOR the improvement of the design process and on applying this knowledge in design. The pragmatist focus, which integrates inquiry and application through feedback loops, indicates that the knowledge base is fed THROUGH the design processes. Design is object and instrument in Owen's model. He gives a number of recommendations, including an urge to do research ABOUT design:

> Initiate studies of the philosophy of design. Just as studies of the philosophy of science, history, religion, etc. seek to understand the underpinning values, structures and

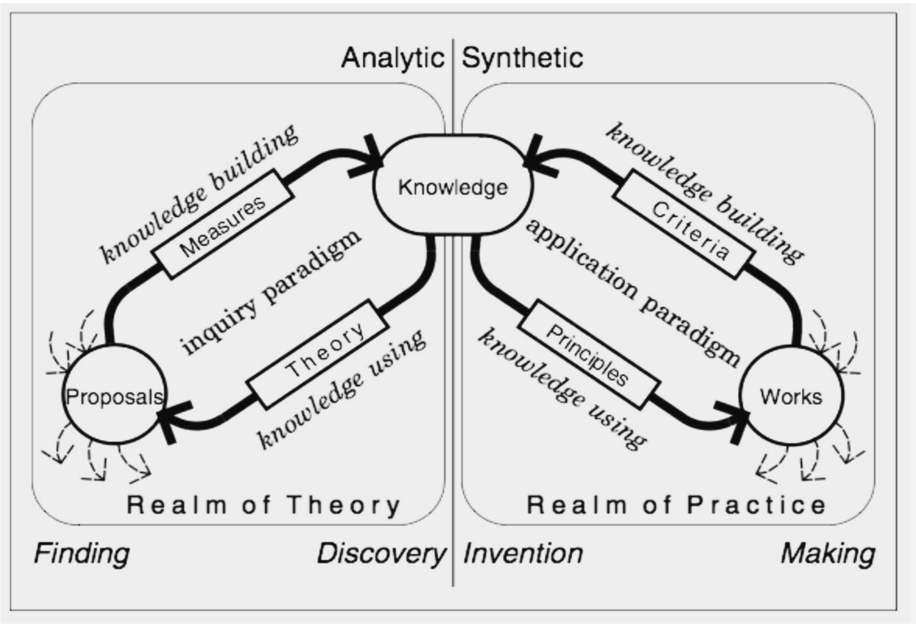


Figure 2.2 Circular processes of knowledge building in theory and practice

Source: Owen 1998

> processes within these systems of knowledge building and using, there need to be studies of the nature of design.
>
> *Owen 1998: 19*

The categorisation FOR/ABOUT/THROUGH, which – for the first time – does not distinguish as to subject matter or an assumed categorisation of the 'real world' as in other disciplines, but according to purpose, intentionality and attitude towards subject matters, is essential for a genuine designerly research paradigm.

Research ABOUT and FOR design is unambiguous. The epistemological status of *RTD*, however, is still fragile. Grounded Theory as well as Action Research will probably contribute. Both admit the involvement of the researcher as well as the abductive emergence of theories from empirical data, in contrast to the established concept of theory building as the verification of previously formulated hypotheses. Archer (1995) adheres to the distinction and puts *RTD* in the level with Action Research (1995: 11): "It is when research activity is carried out through the medium of practitioner activity that the case becomes interesting". Findeli (1998) explains:

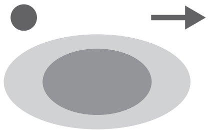
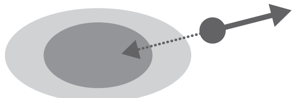
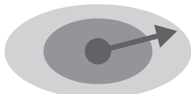
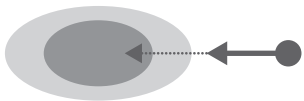
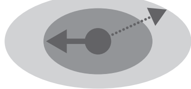
> 'project-grounded research' [. . .] is a kind of hybrid between action research and grounded theory research, but at the same time it reaches beyond these methods, in the sense that our researchers in design are valued both for their academic and professional expertise, which is not the case even in the most engaged action research situations.
>
> [. . .] although the importance of the design project needs to be recognized in project-grounded research [. . .] practice is only a support for research (a means, not an end), the main product of which should remain design knowledge.

In *cybernetic* terms, this means a shift from 1st to 2nd order observation. We include our own observing and acting, not as deplorable limitation but as a constitutive and essential part of the inquiry. This resolves Friedman's alleged antagonism of reflection and research. Design Research is conceived as a process of 1st order cybernetics regarding scientific inputs of any kind and of 2nd order cybernetics regarding the ways of using and integrating this knowledge by means of reflecting purposes and observer involvement. Table 2.2 illustrates four generic situations of inquiry: There is the wider context/life-world and the design/inquiring system. Researchers can be situated outside these systems as disembodied Cartesian observers or inside the inquiring system as embodied/situated/intentional observers. And we have the observer perspective, which can focus either on the inquiring system or on some goal outside (such as material or market research, etc.). The scheme provides a fourth mode, which will be tentatively called 'research AS design'.

Research FOR design: An idealised/disembodied/objective observer of some isolated external phenomenon, generating knowledge FOR a design/inquiring system. Research is defined/determined by underlying basic theoretical assumptions regarding the structure/nature of the design process (What is design? How does it work?). → Design as: cognitive/semiotic/communicative/learning process, etc. Research by means of disciplinary scientific methods, aiming at the improvement of the design/inquiring system regarding various externally determined criteria (so-called 'applied science').

Research ABOUT design: An idealised/disembodied/objective observer of a design/inquiring system, generating knowledge ABOUT this system. Research is defined/determined by motivations aiming at inquiring and understanding the nature of diverse aspects of design. →

Table 2.2 The concepts of research FOR, ABOUT, THROUGH design, related to observer positions and perspectives. A fourth category is emerging: Research AS design

Observer position and perspective relative to the design/inquring system and the life-world 	**1st order cybernetics** Observer is situated outside the design/inquiring system producing facts	**2nd order cybernetics** Observer is situated inside the design/inquiring system producing (arte)facts based on values
Observer looking outwards	**Research FOR design** 	**Research THROUGH design** 
Observer looking inwards	**Research ABOUT design** 	**Research AS design (?)** 

Source: Glanville 1997

Design as subject of disciplinary scientific research: philosophical, anthropological, historical, psychological, etc.

Research THROUGH design: An embodied/situated/intentional observer inside a design/inquiring system, generating knowledge and change THROUGH active participation in the design/inquiring process. Research is defined/determined by ethical assumptions regarding the purpose of designing (What is design good for? How do we want to live?). → Design as: projective/human-centred/innovation/emancipatory/political/social process, etc. Research in the medium of design, guided by the design process, aiming at transferable knowledge and innovation according to various internally determined criteria. For a comparison of the different versions of *RTD* see Chow (2010).

Research AS design: An embodied/situated/intentional observer inside a design/inquiring system, concentrating on the production of 'variations' AS raw material for the design/inquiring process. Research in action, performed in the medium of design. → Design as the inaccessible medium of knowledge production: a learning process. Probably the essential mental and social 'mechanism' of generating new ideas, the location of abductive reasoning. Research AS design may denote 'Design Thinking' as a cognitive and social process, which, in turn, can be the subject of inquiry ABOUT or THROUGH design.

The issue of rigour vs. relevance occurs again. Findeli (2008a, b) introduces a new perspective in arguing that 'project-grounded research' (his term for *RTD*) has to combine research FOR and ABOUT design in order to become both relevant and rigorous. Thus, one may conclude that research in design only makes sense if all observation modes are taken into consideration. *RTD* requires 'objective' scientific input generated by research FOR or ABOUT design. But the process remains locked in sterile assumptions, if research THROUGH the medium of design is neglected. It is the abductive step, research AS design, which is able to combine the logical syllogisms of induction and deduction into a productive cycle. This playful dance of perspectives seems to be the most important conversational medium for the generation of new design knowledge.

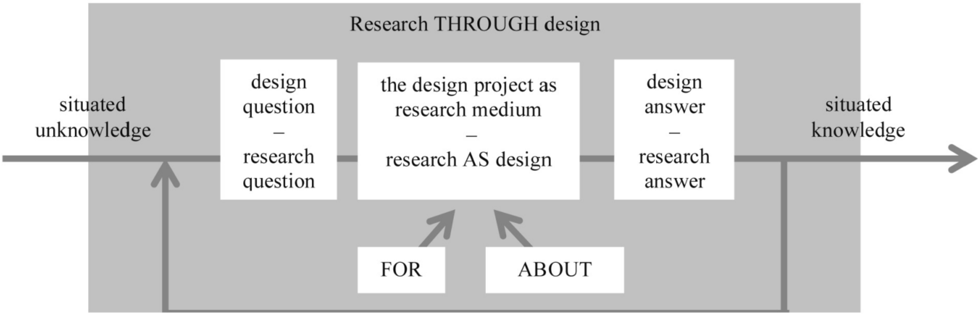


Figure 2.3 Research THROUGH design means the reflected, purposive and playful use of observer modes during the design research process

The nature of design prohibits the reduction of Design Research to scientific research. On the contrary: scientific research has to be embedded in designerly models of inquiry. There are the all-embracing *subject matters* of aesthetics/products – logic/process – ethics/people, and the essential distinguishing *purposes* of understanding design-relevant phenomena, of improving the design process and of improving the human condition. Theses purposes can be related to the *epistemological attitudes* or modes of research ABOUT design, FOR design and THROUGH design.

Mode-2 Science, Transdisciplinarity and *RTD*

Integrative approaches are needed to bridge the gaps between incompatible knowledge cultures and types of knowing. Design has always had this 'problem', whereas science has faced it only recently. This is where science can learn from design.

Baecker (2000) extends Luhmann's (1996) social systems theory, in which humans are conceived as combinations of two closed autopoietic[4] systems, namely bodies and consciousnesses (Maturana and Varela 1987). The social is created by a third autopoietic system, which is communication. The closure of these three system types means that they cannot control but only irritate each other. They are causally de-coupled; each of them operates according to its own internal structure and organisation. Design is used to deal with knowledge gaps between these causally de-coupled systems (Baecker, 2000: 163; own translation):

> Design as a practice of not-knowing may be read in reference to diverse interfaces, but the interfaces between technology, body, psyche and communication are probably dominant. If these 'worlds', each described by a more or less elaborate knowledge, are brought into a relationship of difference, this knowledge disappears and makes room for experiments, which are the experiments of design. [. . .] Not to take anything for granted here anymore, but to see potential of dissolution and recombination everywhere, becomes the playground of a design that eventually reaches into pedagogy, therapy, and medicine.

Further knowledge gaps originate from the causally de-coupled evolutionary phases of variation/selection/re-stabilisation in every real-world design process (Jonas 2003).

The argument for convergence, as put forward in the second section of this chapter (The perspective: design and science converging), is implicit in Table 2.3: various *Sciences of the*

Table 2.3 Triadic concepts of experiential learning processes in Design Research, emphasising the frameworks for *Research Through Design* and *Transdisciplinarity Studies*

Authors	*phases/components/domains of knowing in Design Research*		
Jones (1970)	divergence	transformation	convergence
Archer (1981)	science	design	arts
Simon (1969), Weick (1969)	intelligence	design	choice
Nelson and Stolterman (2003)	the true	the ideal	the real
Jonas (2007) *RTD*	Analysis	Projection	Synthesis
Fallman (2008)	Design Studies	Design Exploration	Design Practice
Brown (2009)	Inspiration	Ideation	Implementation
Nicolescu (2002) *Transdisciplinarity Studies*	System knowledge	Target knowledge	Transformation knowledge

Artificial, such as Design (Archer 1981, Jonas 2007, Jones 1970 and Nelson and Stolterman 2003), Management Studies (Simon 1969, Weick 1969) and Human-Computer Interaction (Fallman 2008) reveal the generic three-stage pattern of inductive, abductive and deductive reasoning. The essential 'designerly' competences are located in the middle column. The process of *RTD* integrates Analysis (science) and Synthesis ('normal design') by means of abductive Projection (Chow and Jonas 2010a, b). See also Table 2.5.

There is a striking structural resemblance of *RTD* and *Transdisciplinarity Studies* (Nicolescu 2002, 2008), which claims to integrate system knowledge, target knowledge and transformation knowledge. In the *RTD* scheme, the first type of knowledge addresses the causes of present problems and their future development (system knowledge/Analysis). The second type concerns the values and norms that define the goals of problem-solving processes (target knowledge/Projection). The third type relates to the potential transformations and improvements of a problematic situation (transformation knowledge/Synthesis). Nowotny (2006) calls *Transdisciplinarity* a central feature of *Mode-2 Science*, which denotes a new form of knowledge production since the mid-twentieth century (Scott et al. 1994). While *Mode-1* knowledge production is academic, investigator-initiated and disciplinary-based, *Mode-2* is problem-focused, context-driven and interdisciplinary. According to Häberli et al. (2001: 4) 'The core idea of transdisciplinarity is different academic disciplines working jointly with practitioners to solve a real-world problem.' Like in *Mode-2 Science*, the goal is to understand and change the world. When the very nature of a problem is under dispute, *Transdisciplinarity* can help generate or design relevant problems and research questions.

The distinction between *Mode-2* and *Transdisciplinarity* remains fuzzy, which reflects a typical German use of the latter (Nowotny 2006). Yet, there are more radical conceptions. Nicolescu (2002, 2008), for example, strives to deal adequately with the problem of complexity by integrating diverse and often contradictory perceptions without destroying them. He suggests three *Axioms of Transdisciplinarity*, which explicitly address the knowledge gaps between the different levels of reality and the perceiving subject: (1) the 'ontological axiom' – in nature and society, as well as in our perception of and knowledge about them, there are *different levels of reality* for the subject, which correspond to different levels of the object; (2) the 'logical axiom'

Table 2.4 *Transdisciplinarity* integrates different 'worlds' (Brown et al. 2010: 46); the relation to Luhmann (1996)

Segment of reality	*Human interest*	*Domain of science*
The external physical world (bodies)	Technical (instrumental)	Empirical-analytic/physical sciences
The inner subjective world (consciousnesses)	Practical (values/practical rationality)	Hermeneutics; social and historical sciences
The normative social world (communications)	Emancipatory (critical or self-reflection)	Critical social sciences; critical systems thinking

– the transition from one level of reality to another is vouchsafed by the *logic of the included third*; and (3) the 'epistemological axiom' – the structure of the totality of all levels of reality is *complex*; each level is determined by the simultaneous existence of all other levels.

Open Transdisciplinarity (Brown et al. 2010) goes further and implies the equal practice of various heterogeneous knowledge cultures in a collective learning/designing process. Here, 'specialised' (scientific) knowledge is but one of five relevant types comprising 'individual knowledge', 'local community knowledge', 'specialised knowledge', 'organisational knowledge' and 'holistic knowledge'. The concept thus contributes to the interface-building between epistemologically different 'worlds', or to the bridging of 'knowledge gaps'. Table 2.4 reveals the relation to Luhmann's systems of body, consciousness and communication.

So what: towards a *trans-domain*

Scientific and designerly research may converge towards a new *trans-domain*. This does not mean that two original components merge into one and then disappear. Rather, a new intellectual mind-set and communicative space emerges, which allows a multitude of approaches in the 'beauty of grey' between the fundamentalist poles of pure black and white. Advanced systems thinking and cybernetics are the integrative core of the new space, which creates an experimental platform for negotiations of *Transdisciplinarity*, *Mode-2*, *Not-Knowing* and other not yet solidified or substantiated aspects of a new intellectual tendency. The provisional character of the *trans-domain* allows for a multitude of alternative approaches providing life-world perspectives, including the preservation of traditional disciplines and their interactions. In line with this, Glanville (1980: 93), in his classical paper 'Why Design Research?', conceives of 'research as a design activity' and regards scientific research as a sub-discipline of Design Research:

> Under these circumstances, the beautiful activity that is science will no longer be seen as mechanistic, except in retrospect. It will truly be understood honestly, as a great creative and social design activity, one of the true social arts. And its paradigm will be recognised as being design.

So what? In the *trans-domain*, it is imperative for Design Researchers to develop and reflect on their own specific knowledge production processes, rather than fetishizing science. *Projective abduction* integrates science and design and is thus instrumental to establishing the new model. The above mentioned 'problems of prediction and control' are addressed adequately. Research on complex problems is presented as a reflexive play with observer positions, guided by the logic

Table 2.5 The topology of the *trans-domain*. *Mode-2 Science*, *Transdisciplinarity* and *RTD* link design and science by means of projective abduction

	Analysis/Induction	*Projection/Abduction*	*Synthesis/Deduction*
design practice, *normal design*			. . . just addresses a given brief
scientific research, *Mode-1 Science*	. . . does not aim at change		
Mode-2 Science, *Transdisciplinarity*, *RTD*	system knowledge	target knowledge	transformation knowledge

of the design process. This playful dance of perspectives is – in our view – the most important conversational medium for the generation of new knowledge. Incoherent knowledge types and domains of knowing are integrated by accepting irreducible complexity (Mikulecky no year):

> Complexity is the property of a real world system that is manifest in the inability of any one formalism being adequate to capture all its properties. It requires that we find distinctly different ways of interacting with systems. Distinctly different in the sense that when we make successful models, the formal systems needed to describe each distinct aspect are NOT derivable from each other.

Research THROUGH design turns out to be the 'wormhole', through which we can escape the dead end of current Design Research. We can finally stop to desperately seek the recognition of science and instead present design as a role model for a new form of science.

Notes

1 The European Commission is using the term in its COST programme, see www.cost.eu/domains_actions/TDP, accessed 27 December 2012: 'Trans-Domain (TD) COST Actions offer researchers fertile ground for future networks across many science and technology disciplines, by allowing unusually broad, interdisciplinary proposals to cover several scientific Domains.'

2 Churchman uses the German word for the framework of ideas and beliefs through which an individual, group or culture interprets the world and interacts with it.

3 Ludwig Wittgenstein's turn from formal logic to ordinary language is often characterised by the notion that 'the meaning of a word is its use in the language'.

4 The term autopoiesis was introduced in 1972 by Chilean biologists Humberto Maturana and Francisco Varela to define the self-maintaining chemistry of living cells. Since then the concept has also been applied to the fields of systems theory and sociology.

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