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The strengths / limits of Systems Thinking denote the strengths / limits of Practice-Based Design Research

Abstract

If we focus on Practice-Based Design Research (PBDR) in its various forms and terminologies one can consider Design Research as a process of "generating the unknown from the known" or of "organizing the transition from knowns to unknowns" (Hatchuel, 2013: 5). It is thereby confronted with the fundamental problems of control (non-reducible complexity in design situations), of prediction (not-knowing of evolutionary emerging futures) and of incompatible domains of knowing. The problems become apparent in causal gaps between bodily, psychic and communicative systems and between the phases of evolutionary development. PBDR explores the possibilities of bridging these gaps in the medium of design projects and thereby creates new knowledge. This is necessarily done with scientific support, but in a situated, "designerly" mode, which means that the designer is part of the design / inquiring system. This is the epistemological characteristic of design. The text argues for a strong coupling of PBDR and advanced systems thinking to face the problems mentioned above.

Keywords: Systems thinking, Practice-Based Design Research, Research through Design

> *"There is no purer myth than the notion of a science which has been purged of all myth."* Michel Serres

1 Introduction and Framing of the Argument

One of the myths that Serres (1973: 259) addresses says that modern Science has achieved a clear and proper separation of the human (society) and the non-human (nature). Bruno Latour deconstructs this myth and argues that we experience (Latour 1998b: 208):

> ... the transition from the culture of \`science´ to the culture of \`research.´ Science is certainty; research is uncertainty. Science is supposed to be cold, straight, and detached; research is warm, involving, and risky. Science puts an end to the vagaries of human disputes; research creates controversies. Science produces objectivity by escaping as much as possible from the shackles of ideology, passions, and emotions; research feeds on all of those to render objects of inquiry familiar. ... Science and society cannot be separated; they depend on the same foundation. ...

Latour (1998a) also introduces the "paradoxical constitutional guarantees of modernity": (1) Even when we construct nature, it is as if we did not. (2) Even when we do not construct society, it is as if we did. (3) Nature and society must remain absolutely separate; the work of purification must therefore remain separate from the mediation work.

Design has – at least implicitly - always known this, or rather, has never built on these guarantees of modernity. The design of design research can and should build on this knowing in the development of its foundations. The fundamental problems of *control*, of *prediction* and of *incompatible domains of knowing* require new approaches. Systems thinking turns out to be a strong partner in this endeavour.

2 Practice-Based Design Research (PBDR)

Design conceives complex lifeworld situations in future contexts. We consider design as a process of "generating the unknown from the known" or of "organizing the transition from knowns to unknowns" (Hatchuel, 2013: 5). Design research is aiming at exploration and innovation. It may be labelled a "Science of Uncertainty" (Dilnot, 1998). Therefore, beside descriptive *Analysis*, the normative and practice-oriented phases of *Projection* and *Synthesis* are essential elements of design research processes (Chow & Jonas, 2008, Jonas et.al., 2010). Bruce Archer adheres to this idea and states (1995: 11):"It is when research activity is carried out through the medium of practitioner activity that the case becomes interesting." That means PBDR in its various forms and terminologies lies in the focus of interest.

The ongoing controversies regarding the scientific validity of PBDR (Friedman, 2003) indicate that its theoretical underpinnings are still improvable. The standard reaction to this challenge consists in the eager adaptation to established scientific standards from other disciplines such us the Social Sciences. This ignores, for example, the exciting and promising developments in *Science and Technology Studies*, which indicate a convergence of "scientific" and "designerly" processes of inquiry. The strategy of escaping to the "high ground" may provide short-term relief, but impedes the longer-term learning processes and the appreciation of designerly modes of inquiry. A new role for design will hopefully emerge, if we dare to approach and explore the "swampy lowland" (Schön, 1983: 42).

3 Fundamental Problems and Causal Gaps

Design and design research are confronted with the fundamental problems of *control* (non-reducible complexity), of *prediction* (not-knowing of evolutionary emerging futures) and of incompatible *domains of knowing*. The problems become apparent in the causal gaps between the autopoietic systems that constitute human beings: bodily, psychic and communicative systems. Furthermore, there are gaps between the phases of evolutionary development: variation, selection and re-stabilization (Luhmann, 1997). The incompatible domains of knowing are denoted as "the true", "the ideal" and "the real" (Nelson & Stolterman, 2003). Schön (1983: 42) puts it pragmatically:

> The dilemma of ´rigor or relevance´ arises more acutely in some areas of practice than in others. In the varied topography of professional practice, there is a high, hard ground where practitioners can make effective use of research-based theory and technique, and there is a swampy lowland where situations are confusing ´messes´ incapable of technical solutions. The difficulty is that the problems of the high ground, however great their technical interest, are relatively unimportant to clients or to the larger society, while in the swamp are the problems of greatest human concern. ...

In order to remove or at least alleviate this dilemma we need:

- A notion of *complexity* appropriate for messy real-world situations (Mikulecky, n.d.),
- appropriate ways of dealing with future *uncertainty*, which points to scenario approaches,
- an *epistemological framework*, which integrates thinking and making as well as teleological / normative, causal and evolutionary ways of knowing, and, finally
- a terminology for reflecting user / stakeholder / observer / designer involvement and a theoretical basis or "partner" (Glanville, 1980), which might be second-order cybernetics.

The following sections will refer to these issues in more detail.

4 Unresolvable blind spots

Design research is a human endeavour depending on human observers. The act of observation requires a distinction regarding what is in the focus and what is outside. Due to the complexity and value-orientation of design situations this process is prone to hide important aspects of the phenomenon. Blind spots in design research manifest themselves in multiple forms:

- Unconsciously defined and intransparent value systems, mainly based on today´s zeitgeist beliefs, and the un-reflected mixing of facts and values.
- Implicit driving forces based on the optimistic or pessimistic views of an assumed future from subjective perspectives, motivations and interests.
- Biased, selective pasts, which means that trajectories of the preferred past are continued. The pasts outside the observer‘s perspective are neither integrated in the present nor the future image.
- Pseudo-objective scenario techniques, which convey the illusion of an ideal, value-free observer. Scenarios are normative in any case. Observers who do not consider this are either unaware of their involvement or they are consciously concealing their normative role.

Blind spots are the necessary condition of every observation, but we can reflect and use them productively in managing complexity. The suggestion would be to use as many *incoherent* observer perspectives as possible, as Mikulecky (n.d.: 4) points out. Assuming that a complete and objective observation and representation of social reality is impossible, there might no other way to approach social complexity:

> 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.

5 Paradox and Oxymoron

The problem of control (describing and managing systemic complexity) and the problem of prediction (dealing with future uncertainty and evolution) are essential constituents of PBDR and they are related to each other. Even deterministic feedback systems of rather low complexity produce bifurcation patterns and chaotic, unpredictable behaviour. The considerations regarding the limits of predictability and control can be expanded in various ways, for example:

> Rittel (1972) argues that rationality means the attempt / claim to predict the consequences of intended actions. But he shows that paradoxes are unavoidable: (1) One cannot start to be rational, since one should have always started one step earlier, (2) one cannot stop to be rational because one should draw the consequence of every consequence, (3) the uncertainty of factors grows, the further we look into the future of a causal chain, and finally, (4) the causal model of the phenomena to be designed would have to include itself as central part. The consequence is Rittel´s description of design and planning as an argument, a cognitive and social process of creating, exploring and reducing variety, supported – for example - by the Issue-Based Information System (IBIS, Rittel & Kunz, 1970).

Krippendorff (2007), who characterizes design (research) as the social construction of meaning through language by stakeholders, still sharpens the argument and describes design research as an “oxymoron”, a contradiction in itself, since it is impossible to do research about something that does not yet exist.

Rorty (1989) suggests narrative, speculative, poetic methods in order to overcome the causality gaps. The potential of this approach is still widely unexplored. Among the few to follow this path are Dunne and Raby (2014).

6 Research Through Design (RTD) as an implementation of PBDR – C1

We consider design and design research as a cybernetic process of experiential learning, which follows evolutionary patterns. The combination of comprehensive evolutionary explanations of material, social and cultural development (Jantsch, 1979; Riedl, 2000) with a dedicated model of experiential learning (Kolb, 1984) provides a basis for the following argument. There are various 4-step models of design and design research processes, such as the one of the Institute of Design in Chicago, which directly relates to Kolb, and models with 5 or more steps. Yet 3-step models from various fields such as design, management, scenario planning and HCI as shown in Table 1 reveal the underlying logic most clearly: These are the 3 logical modes of inference *induction – abduction – deduction*, with abduction as the central designerly phase.

Table 1 shows a representative overview of these models. My own theoretical framework of Research Through Design (RTD) with the phases of *ANALYSIS – PROJECTION – SYNTHESIS* (Jonas, 2007) is chosen as one possible realization of PBDR. Projection represents the abductive step. Please note the analogy to the terminology of 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
Gausemeier et.al. (1996)	Scenario field analysis	Scenario prognosis	Scenario building
Nelson &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

Table 1: Triadic concepts of experiential learning processes in Design Research, especially providing the framework for Research Through Design and transdisciplinarity studies. The first phase is dominated by inductive reasoning, the second by abductive and the third by deductive reasoning.

7 Systems Thinking Constitutes RTD Processes

Practice-Based Design Research explores the possibilities of bridging the above mentioned gaps in the medium of design projects and thereby creates new knowledge. Systems thinking and systemic methods allow for the modelling of complex design / inquiring systems and thus provide a means of communicating *about* them. Matrix representations provide means for representing complexity (cross-impact analysis) or for discussing future uncertainty (cross-consistency analysis). For example, cross-impact matrices provide an instrument for identifying and locating required scientific contributions: each field of the matrix represents a relation between two variables and thus indicates a potential underlying scientific or designerly research problem. These are first-order cybernetics (C1), meaning that systems are considered as an observable "mechanism". Furthermore systems thinking and systemic methods allow for the reflection of observer modes and conditions of involvement in the systems of inquiry and thus provide a means of communicating *within* design / inquiring systems. This leads to second-order cybernetics (C2), which deals with the observation of observations of systems.

The very broad scope of subject matters (general human ecology) and the stance of the researcher (situated, aiming at change) characterize and determine the epistemological status of design research (Findeli, 2010). Both aspects suggest that a purely scientific approach is unsuitable. The differentiation between design and PBDR is fuzzy, the transition is continuous. Design research is necessarily done with scientific support and in a situated, "designerly" mode, which means that the design process provides the structure and that the designer is part of the design / inquiring system.

8 Reflecting Observer Modes – RTD Requires the Shift from C1 to C2

The cybernetic concepts of 1st and 2nd order observation are helpful for the distinction between classical detached inquiry and situated inquiry. Table 2, inspired by Ranulph Glanville, is an attempt to substantiate the concepts of research FOR / ABOUT / THROUGH design as introduced by Archer (1995) and Frayling (1993). It relates observer positions (inside or outside the design / inquiring system) and observer perspectives (looking at the design / inquiring system or looking at some external point of interest). It provides a fourth category, which I have tentatively called research AS design. It may be interpreted as the (inaccessible?) location of abductive knowledge production...

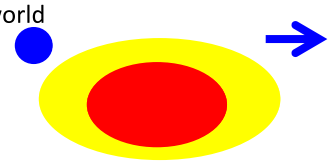
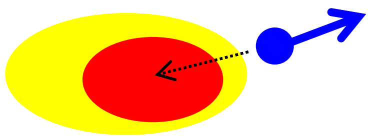
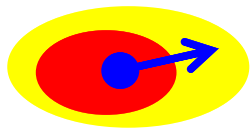
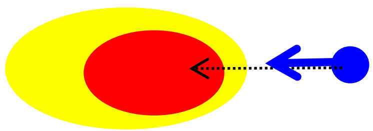
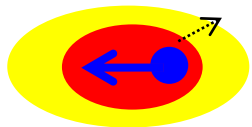
Observer position and perspective relative to the design / inquiring system and the life-world 	**1st-order cybernetics** Observer is situated outside the design / inquiring system producing facts	**2nd-order cybernetics** Observer is situated inside the design / inquiring system producing (arte)facts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

Table 2: The concepts of research FOR, ABOUT, THROUGH design, related to observer positions and perspectives. A fourth category is emerging, Research AS Design (Glanville 1997).

The notion of second-order observation might raise the question of the relation between Bateson´s (1979) five levels of learning to the orders of observation used here. Bateson suggests deeper and more far-reaching insights the higher the level of learning. My notion is just formal, that means it does not make sense to speak of 3rd or 4th order observation. Higher orders are not superior to lower orders. They can be generative in positive and negative respects, both liberating and limiting. Observing observation provides / generates new options and new blind spots at the same time, but does not provide better knowledge per se. It contributes to managing complexity by introducing variety and new perspectives (Mikulecky, n.d.).

9 Zooming In: RTD and (Critical) Systems Thinking

The RTD model, as derived above and shown in Table 2, can be further interpreted in a systemic perspective. It comprises three core systemic dimensions: (1) the *wider context* of a design situation or the relevant life-world environment, (2) the *design / inquiring system*, which may be a designer / scientist, a group, a company, a community, etc. and (3) the *driving force*, which is determined by the value base, the motivation and the goal of the inquiry (See Fig. 1 below).

In design-relevant situations all three of these systems are not „given", but have to be negotiated by stakeholders, designers and the wider public. Critical Systems Thinking (Ulrich, 1988) is probably one of the most advanced and comprehensive systemic approaches for dealing appropriately with systemic real-world design research situations. It does not claim the capacity of problem solving and goal achievement, but explicitly addresses the human involvement and the restrictions and limitations resulting from this.

Hard Systems Thinking	Soft Systems Thinking	Critical Systems Thinking
systematic	systemic	critical to ideas of reason
mechanistic paradigm	evolutionary paradigm	normative paradigm
instrumental	strategic	communicative
efficiency emphasised	effectiveness emphasised	ethics emphasised
Management of scarceness	management of complexity	management of conflict

Table 3: Characteristics of systems thinking schools (Hutchinson 1997, after Ulrich 1988).

The systemic model (Table 2, Fig. 1) denotes the fundamental difference to science, where the wider context is excluded as far as possible, where the design / inquiring system is considered as disembodied, detached, objective, Cartesian observer, and where the driving force remains implicit or mythic. Simon (1969: 6) gives the famous description, which can be nicely related to the three systems introduced here:

> An artifact can be thought of as a meeting point – an ´interface´ in today's terms – between an ´inner´ environment, the substance and organization of the artifact itself, and an ´outer´ environment, the surroundings in which it operates. If the inner environment is appropriate to the outer environment, or vice versa, the artifact will serve its intended purpose.

The outer environment is the wider context here, the inner environment corresponds to the design / inquiring system here. Yet Simon does not reflect the role of the observer appropriately. In social design situations, the fit at the ´interface´ will not be imposed by some detached external designer, but the designer is necessarily involved as a strong driving force in the inner environment. Or: Simon reflects this and considers too much observer involvement as dangerous with respect to reasonable design goals.

10 Relating RTD to a Generic Scenario Model

The future aspect is still missing in this endeavour to combine systems thinking and design research. The PROJECTION part of RTD, which deals with the problem of prediction and future uncertainty, requires further methodical support.

Scenario approaches, which are often based on systemic descriptions of design situations, seem to be promising. Most of them operate with a limited number of key variables of high impact and high uncertainty. Nonetheless, comprehensive scenario techniques require enormous effort and mathematical support such as cross-impact analysis, cross-consistency analysis and cluster analysis. See for example Gausemeier et.al. (1996). „Quattro stagioni" / „otto stagioni" approaches as suggested by Schwartz (1991) provide simplified methods with two or three key variables and two alternative extreme projections for each key variable.

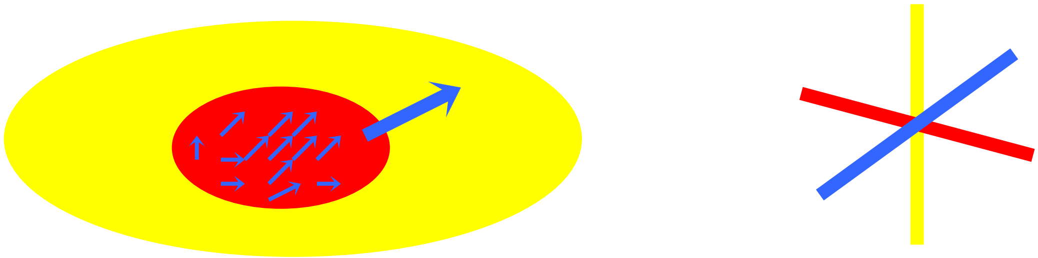


Figure 1: The wider context, the design / inquiring system (established by the involved actors) and the resulting driving force (left). The Cube of Future Uncertainty (right) is a scenario framework built from these three systemic dimensions. A situation of Research Through Design.

The "Cube of Future Uncertainty"(CFU) builds on these simplified techniques. It uses three key variables, which correspond to the three above-mentioned systemic dimensions of RTD: the first key variable is taken from the wider context, the second one from the design / inquiring system, and the third one denotes the driving force. Thus, by combining pairs of alternative projections of each variable the framework establishes the logic for 8 ("otto stagioni") different scenarios.

The "Cube of Future Uncertainty" can be considered as a generalized and simplified designerly model for scenario approaches It establishes the systems-based connection between ANALYSIS and SYNTHESIS by means of PROJECTION (Table 1).

11 So What? Turning Deficits and Threats into Strengths and Opportunities

The seeming deficits of PBDR / RTD as mentioned above should be turned into the strengths of a new paradigm of inquiry, which comprises:

- Systems thinking and the positive acceptance of multi-perspectivity. Mikulecky (n.d.: 4) proposes to develop "distinctly different ways of interacting with systems […] in the sense that when we make successful models, the formal systems needed to describe each distinct aspect are NOT derivable from each other."
- The conscious adoption of generative, designerly approaches like scenario thinking as "playgrounds" for explorations.
- The explicit integration of facts and values or "hard" and "soft" factors into our systems of inquiry.

Critical Systems Thinking (CST, Ulrich, 2000) can be regarded as an approach towards integration and transparency of this kind. CST comprises the reflection and determination of system boundaries and driving forces as well as questions of legitimacy. Even if Ulrich mainly refers to Churchman, there are various influences detectable such as Issue-Based Information Systems as dialogic instruments (Rittel and Kunz 1970), the notion of the Sciences of the Artificial and the reflections on designing the evolving artefact (Simon 1969), or dialogic approaches to systemic modelling, mixed causation problems, sensitivity modelling (Vester 1999). The diagram of the four „heroes" demonstrates the richness and integrative power of seemingly controversial positions and attitudes. They do not contradict, but complement each other. There is no „progress", but options for richer design considerations. It may be used as a map and navigation aid for reflecting our own positions and driving forces in doing design research.

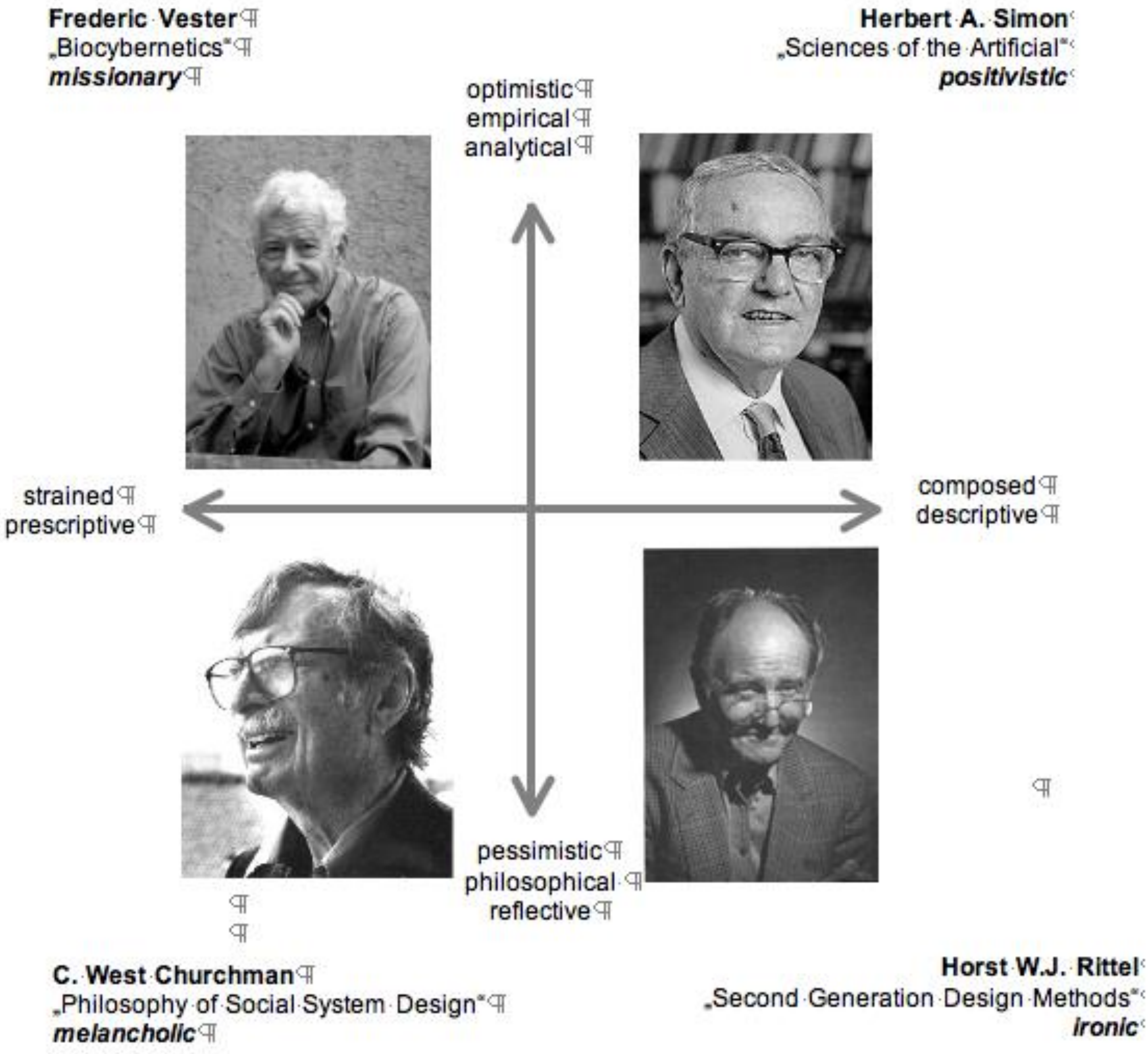


Figure 2: The diagram of the four "heroes" of systems thinking. A playful mapping aiming at new integrations of seemingly controversial positions.

12 Perspectives: Design as a New Model for Transdisciplinary Science

Up to this point we have developed the argument that design research has a strong but still underestimated partner in systems thinking.

The further development of this proactive position implies that design might become a new model for science, as suggested by Glanville (1980). He describes science and scientific research as a specific sub-category of design. The concept of Mode-2 science (Nowotny, Scott & Gibbons, 2001) with its emphasis on socially-robust instead of true knowledge might be a strong theoretical support, as well as the emerging framework of transdisciplinarity. Radical transdisciplinarity explicitly addresses all the indecent issues of designerly inquiry, as described above, and takes them as the basis for a new kind of science. Nicolescu (2008), for example, 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*: the transition from one level of reality to another is vouchsafed by the *logic of the included third*.
> (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.

Various perspectives are finally showing up:

John Dewey argued in *Democracy and Education* (1916) that only through the democratization of the means of social criticism can the tension between expert and lay authority be resolved. In short, the lay / expert question is best posed as an educational and social problem of enabling a citizenry to be able to conduct social inquiry. Democratic education shapes a community of heterogeneous *knowledges* that integrates facts and values in their inquiry and thus contributes to social progress. Practical answers to this problematique of *epistemic democracy* are still highly controversial.

There is the relation to De Zeeuw´s (1996, 2010) „third phase science". De Zeeuw distinguished First-phase science, the Cartesian paradigm, dealing with non-constructed objects, Second-phase science, dealing with constructed objects, and Third-phase science, dealing with self-constructing objects (2010: 19):

> Second phase science aims to resolve the ´overload´ that derives from using the Cartesian form to study the ´in there´, as if it is the ´out there´. It is the range of forms of transfer which it studies. [...] ´Third phase´ science aims to consider alternative selections of forms of transfer. It may be interpreted as improving on collective learning through ´texts´. ...

All this is suggesting the perspective, supported by various evidence, that design and science are approaching each other (Jonas, Chow & Grand, 2013). Latour´s "transition from the culture of ´science´ to the culture of ´research´" (Latour, 1998a) denotes the place where this convergence and this permanent mediation work between nature and society is taking place: the laboratory. And the activity in the laboratory is *design*.

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