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Design experiments – a method for working with wicked problems

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Abstract

Sustainable development and climate change adaptation are poorly formulated problems. The planning and development of technology to resolve these problems affects society and other technologies tremendously, yet the nature of the knowledge and information required for this process is not as yet evident.

The design process confronts, contextualises and integrates different kinds of technical, spatial, experimental and social knowledge. This article describes three design experiments which attempted to understand and solve societal problems, while supporting and elaborating inter-disciplinary and trans-disciplinary research approaches, and involved key persons in research, planning and design. Based on the three design experiments; Rittel and Webber (1973); and recent contributions to social-technical transitions, it is discussed how and why the combined knowledge deriving from these studies may help to further the use of design experiments as a method of working with wicked problems.

Design experiments bring actors and networks together. They allow the development of integrated solutions within a limited timeframe, which specialist scientists and engineers can use in their research. In general, design experiments enable the conscious framing and elaboration of wicked problems. Design experiments employ both the components and the whole in a way which communicates to stakeholders, lay-people, landscape architects, scientists and engineers – adaptively, participatory and transdisciplinary.

Introduction

Sustainable development and climate change adaptation are issues which urgently need alternatives to conventional methods and technologies. The problems are ill-formulated and the development of technology and planning for such issues affects society and other technologies tremendously. Politicians, decision-makers and planners depend on finding key-persons and key-stages where solutions can be implemented; in complex situations this can be difficult.

Formal and theoretical procedures do not always highlight the key components, because informal routine has established a tradition (Latour, 2005; Lawson, 2000:47). When society addresses problems and formulates policies, there is often a demand for more knowledge and information, though the exact nature of this knowledge and information is not known. Basically, any additional knowledge and information can improve conditions for a sustainable solution. Specialist disciplines and planners need to know more about the process, interactions and the relation between the solution and knowledge. The situation is complex.

Many scientists and engineers using technical rationality, face difficulty formulating an alternative solution which reaches further than their own field, and which will be generally accepted in society (Schön, 1991). The appreciation of sustainability as an idea is not enough. Therefore the need for a more holistic way of working across disciplines has arisen, and the methods of planning and designing are, to an increasing extent, explored as a means of solving complex problems and providing a framework for research.

The design process confronts, contextualises and integrates different kinds of technical, spatial, experimental or social knowledge (e.g. Stapers, 2007; von Seggern, Werner, and Grosse-Bächle, 2008), in a spiralling process of different stages of consideration, action and re-consideration (Schön, 1991). A skilled designer can focus on and develop a final product, even if not all seemingly necessary information is available. The resulting product, i.e. the solution to a problem, is variable; there are always various solutions that would work in the given context (Steenbergen, 2008).

While designers are focused on achieving the desired result, the classical scientists, with their methods based on theory building and empirical testing, are focused on discovering the underlying rules (Lawson, 2005). Combining both worlds enables research to be conducted very close to practice, and thus opens new paths to gaining the knowledge that is needed to solve our time’s wicked problems. Following the classification developed by De Jong and Van Der Voordt (2005) and processed by Streenbergen (2008), the research method presented in this article is called "design experiment". Design experiments can be used to investigate the context of a variable object, or the variability of an object in a context (Steenbergen, 2008). Besides this classification, there is little or no scientific literature introducing and reflecting upon the methodology "design experiment" in more detail.

This article aims to contribute to this field by describing three design experiments initiated in order to understand and solve complex societal problems; support and elaborate inter-disciplinary and trans-disciplinary research approaches; and embrace the phenomenological inclusion of the acting persons in research, planning and design.

The three design experiments are: (A) a one-year interdisciplinary Sustainable Urban Drainage System (SUDS) retrofit design project for a 15 km^2 catchment area in Copenhagen, involving eight PhD students (Backhaus and Fryd, 2012; Roldin et al., 2012; Fryd et al., 2013). (B) a two-week design workshop with six teams of professional landscape architects exploring SUDS retrofit options for a school and a fully urbanised sub-catchment area in the Vanløse district of Copenhagen (Backhaus, Dam, and Jensen, 2012). (C) a three-week workshop involving four teams of professional landscape architects together with concrete manufacturers, exploring the possibilities for a typical suburban residential street (Støvring and Dam, 2013).

The objective of the design experiments was to develop initial resolutions in a real-life social context in order to improve understanding of the problem as a whole, and to facilitate collaborative behaviour amongst stakeholders. All three design experiments were set up as collaborations between researchers and practitioners, and all authors of this article have been personally involved with the development, implementation and analyses of at least one of the three design experiments. None of the experiments have previously been thoroughly discussed in the light of theories of the wicked problem.

In this article, the methods and results from the three design experiments are summarised. Based on the gathered experiences; Rittel and Webber (1973); and recent contributions on social-technical transitions, the article discusses how and why the combined knowledge deriving from these studies might help to further the use of design experiments as a method for working with wicked problems, and thus support the evolution of urban ecological, social and economic sustainability.

Theory and Methods

Dilemmas in a *General Theory of Planning* caught our attention with "the wicked problem". It was generally appraised because "the process of formulating the problem and of conceiving a solution are identical" (Rittel and Webber, 1973:161) and "because one cannot meaningfully search for information without knowing of a solution concept" (Rittel and Webber, 1973:162).

In 1973, Rittel and Webber introduced the theory of the wicked problem, as opposed to tame problems. Their mission was to clear out planning and find another approach, because the cognitive style of science and the occupational style of engineering did not work on social problems. At around the same time, Riceour (1969) and Habermas (1968) also advocated the hermeneutic humanistic theories instead of research as natural science.

Harvey Brooks from Harvard Engineering School wrote *Dilemmas of Engineering Education* in 1967 (Schön, 1991:171), where he warned about the specialisation of the engineering education. He perceived that the disappearing art of engineering design presented an educational dilemma.

Rittel and Webber (1973) juxtaposed the theory of wicked problems with tame natural science based problems. Many of the characteristics of natural science and engineering originate from similar writings. Rittel and Webber refer to Popper (1961), as Karl Popper argues in the *The Logic of Scientific Discovery*, it is a principle that solutions are only hypotheses offered for refutation… consequently; the scientific community does not blame its members for postulating hypotheses that are later refuted (Rittel and Webber, 1973:167). The method is described as 'systems engineering', and Donald Schön characterises it as 'technical rationality' when he argues for reflection in action (Schön 1991:39).

Schön (1991) combines the experiment with the art of scientific investigation: "Experiments functions at the same time to test technological moves, discriminate among plausible scientific hypotheses and explore puzzling phenomena" (Schön, 1991:177). Krog (1983), Buchanan (1992), Lawson (1997), Latour (2005), and Cross (2006) have over the years since the 1970s established an understanding of the hermeneutic planning / design approach, where it is no longer necessary to define planning and design in opposition to natural science. Design is not science, but as Buchanan describes design generally: "once a product is conceived, planned and produced, it may indeed become an object for study by any of the arts and sciences" (Buchanan, 1992:18).

In the development and framing of the design experiments, the introduction of new technologies, methods and practices has been approached with consideration for wicked problems (Rittel and Webber, 1973; Conklin, 2005), socio-technical transitions (Geels, 2002; Loorbach, 2004; Rotmans, 2005; Schot and Geels, 2008; Geels, 2011), and complex adaptive systems (Geldof, 2005; Uhl-Bien, Marion, and McKelvey, 2007).

In 2008, as part of a trans-disciplinary research project in Denmark (see Design experiment A below), the notion and nature of wicked problems was introduced to the authors by one of the champions of integrated urban water management in Europe, Dr. Govert Geldof. The traditional linear and stepwise approach to problem solving (Rittel and Webber, 1973:162), described by Conklin, 2005, as the waterfall model (with the phases: data collection, data analysis, solution development, and implementation), was presented as inadequate to address wicked problems. Instead, we should acknowledge the many individuals' conflicting views of the problem and the scope of solutions, and address problem solving as a nonlinear iterative process, alternating between problem solving and problem identification (i.e. the jagged line presented by Conklin, 2005). To confront wicked problems, specifically to confront conventional urban drainage practice in Denmark, and introduce new landscape-based stormwater management practices, we were encouraged to collaborate across disciplines and across sectors, to "get the whole system in the room" (Roberts, 2000), and to learn our way out of the problem.

The initial framework of wicked problems was gradually expanded by theories concerning socio-technical transitions and complex adaptive systems.

Socio-technical transitions can be described as the interplay between micro-level niche innovations, a macro-level contextualising "landscape" and meso-level socio-technical regimes (Geels, 2002). The meso- and macro-levels are more stable than the micro-level in terms of the number of actors and level of integration between system elements (Geels, 2011). Yet, at the meso-level there is "much resistance to change and innovation, because existing organizations, institutions and networks want to maintain the status quo" (Rotmans, 2005:25). In contrast, the micro-level is where short term experiments can take place (Rotmans, 2005) and where niches can work as "protected spaces" for system innovation (Geels, 2011). These niches are regarded as necessary for socio-technical transitions because they facilitate "organization-transcending innovations that drastically alter the relationship between the companies, organizations and individuals involved in the system." (Rotmans, 2005:11). Transitions can occur over time through phases of pre-development, take-off, acceleration and stabilisation (or system breakdown, if unsuccessful) (Loorbach, 2004: Rotmans, 2005). Problem identification, experimentation and strategy development are part of the pre-development phase. Coalition-building, leadership and knowledge diffusion are in the take-off phase, while institutional alignment, new legislation and new common practice characterise the acceleration phase, and are further consolidated in the stabilisation phase (Loorbach, 2004).

Complex adaptive systems can be described as dynamic networks of interacting and interdependent agents that are cooperatively bonded by a common need or purpose (Uhl-Bien et al., 2007). In complex adaptive systems, order is emergent, not predetermined; it carries an irreversible history and its future is largely unpredictable (Dooley, 1996, in Uhl-Bien et al., 2007). Complex adaptive systems emerge naturally in social systems. They are "capable of solving problems creatively and are able to learn and adapt quickly" (Uhl-Bien et al., 2007). In complex adaptive systems, individuals must be capable of interacting with each other, they must be interdependently related and they must experience tension in order to elaborate (Uhl-Bien et al., 2007).

Based on the abovementioned characteristics, design experiments have been introduced as a method to work with wicked problems. Design experiments test moves, hypotheses and phenomena (Schön, 1991) and they fall into the operational pre-development phase described by Rotmans (2005) and Loorbach (2004). Design experiments serve to get the whole system in the room (Roberts, 2000). They facilitate interaction, interdependency and tension, and they emphasise that the processes of problem solving, problem understanding, and collective learning are intertwined. Design experiments work as a first loop (Fryd, Jensen, Ingvertsen, Jeppesen, and Magid, 2010) to gather stakeholders, to facilitate shared problem understanding and to develop a niche system or network for change.

Three design experiments

	Design experiment A	Design experiment B	Design experiment C
Original title	River Harrestrup Case Study	Go with the flow – lokal regnvandshåndtering af Vanløse Skole English: *Go with the flow – Sustainable drainage systems at the Vanløse school, Copenhagen*.	Bedre boligveje; English: *Better residential streets*
Published	Fryd et al. (2013) Backhaus and Fryd (2012) Roldin et al. (2012) Dam, Fryd, Backhaus and Jensen (2012)	Backhaus et al. (2012)	Støvring, Dam, and Tvedt (2013) Støvring and Dam (2013) www.bedreboligveje.dk
Participants	Eight PhD students (within the fields of civil and environmental engineering, environmental economics, environmental science, hydrogeology, landscape architecture, urban planning and governance), their academic supervisors from three universities, and representatives from the City of Copenhagen and the water utility, Copenhagen Energy Ltd.	Developed and coordinated by one PhD student and two supervisors. Six teams of professional landscape architects were given one design task. At the start-up seminar, specialists were invited to give lectures within the fields of climate change, sewer systems, SUDS, dimensioning, rainfall, soil infiltration, water quality, European case study references, user- and management needs.	The experiment was organised by two senior members of University of Copenhagen staff. Four teams of professional landscape architects were given the design task. The lectures and seminars were attended by various specialists within the fields of planning, landscape detailing and social issues regarding residential areas. These included traffic engineers, planning and maintenance staff from two municipalities, sociologists, construction engineers and paving manufactures.
Intention / objective	Identifying options and limitations for sustainable urban drainage system retrofits in an existing 15 km^2 combined sewer catchment in Copenhagen, by employing research methods from multiple disciplines.	To identify and meet the challenges associated the retrofitting a school and its surroundings for the management of stormwater runoff.	To frame a discussion about tradition and new technologies regarding planning and construction of residential streets, between different stakeholders involved in the chain of decisions from initial design concept to the constructed site. As design-case studies, streets within a residential area of 5 hectares was used.
Set up / time schedule	Implemented between October 2008 and December 2009. Structured by two workshops and five additional joint meetings between researchers and end-users. Concluded by a National seminar in December 2009.	Carried out within two weeks in October 2010. Structured with a one-and-a-half day start-up seminar to build a joint knowledge base for all participants. Followed by an observed design phase with midterm presentation and a final public presentation of design results.	Carried out within three weeks in September-October 2011, structured with a two day start-up seminar followed by a design phase with midterm presentation, and a public presentation of design results.
Results in relation to objective	The study developed a catchment strategy comprising five sub-strategies. The strategy is being partially adopted by the City of Copenhagen. The study generated one interdisciplinary	The workshop resulted in six design proposals, publically presented by the teams. As well as being published in two professional journal articles. Research findings on the nature of the design process	The workshop resulted in five design proposals (one team handed in two). Each presented on two A2-posters that were presented orally at a close-up seminar. An internal report summed up discussions

	report, two professional journals articles, four conference papers and four peer-reviewed journal papers.	and the challenges met when designing for urban landscape based stormwater management were published in a peer reviewed journal.	and the meaning of various design solutions. Conclusions were put forward in a conference paper and a professional journal article.
Gained insights into the wicked problem	The importance of framing wicked problems. The practical relevance of identifying and working with sub-problems. The need to work with incremental steps and collectively accepting the 'incomplete' solution.	From the 11 identified challenges when designing for urban landscape based stormwater management, 7 were confirmed by the experiment and 4 emerged during the design phase (see main text). The six teams used different aspects of the given information in order to develop their design proposal /find a solution.	Synergies were created when multiple disciplines in the start-up seminar were put together to debate what is normally taken for granted. By insisting on the fact that more solutions are possible, it was possible to get a deeper insight into the problem.
Lessons learned about design experiments as a research method	The importance of knowledge exchange and explicit oral/ visual/ written communication to achieve shared problem understanding.	The choice of explanation determines the nature of the problem's resolution; an introductory workshop can therefor never cover all aspects.	

Design experiment A: In 2008 a group of scientists, engineers and landscape architects sought common ground in a research program on climate change adaptation and SUDS in Copenhagen. The notion of the "wicked problem" supported substantial leaps forward for the group's research. In the joint case study, many formulated problems and solutions were suggested and shot down, but through the collective and interdisciplinary design process, a common ground for the information needed was generated.

Design experiment A resulted in five main strategies for the given retrofitting task. With these strategies, the planners and science-based researchers were able to elaborate on detailed information and knowledge in their own field of research. *Design experiment A* exposed an old and on-going debate between natural science and the humanities (see e.g. Rittel and Webber, 1973; Kjørup, 1996; Qvortrup, 2004; Cross, 2007; Rotmans, 2005); the balance between goal formulation and problem definition, how to start a research process and the preferred level of certainty about the expected outcome before the project commences.

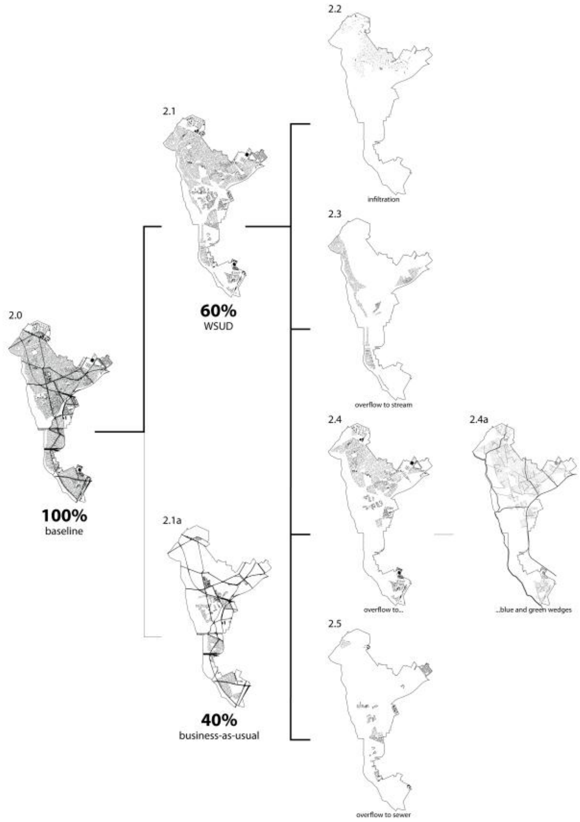

Figure 1: The strategy with 5 sub-strategies. Four of which provided a problem formulation adequate for a hypothesis, the fifth (overflow to the sewer) eliminated concerns which corrupted a common acceptance of a resolution in the four other (Adapted from Fryd et al, 2013).

Design experiment B: In 2010 six teams of landscape architects took part in a design workshop concerning a SUDS solution for a local school. While aiming to find an appropriate design solution for the site, the workshop participants realised that the initial information was insufficient, and instead, the information necessary to understand the problem depended upon their own idea of solving it.

Design experiment B was initiated by researchers and fuelled by the design team's personal knowledge and experience. The number of identified challenges increased from seven to eleven during the design experiment. *Design experiment B* exemplified the struggle of gathering adequate knowledge and information ahead of a design or a research project.

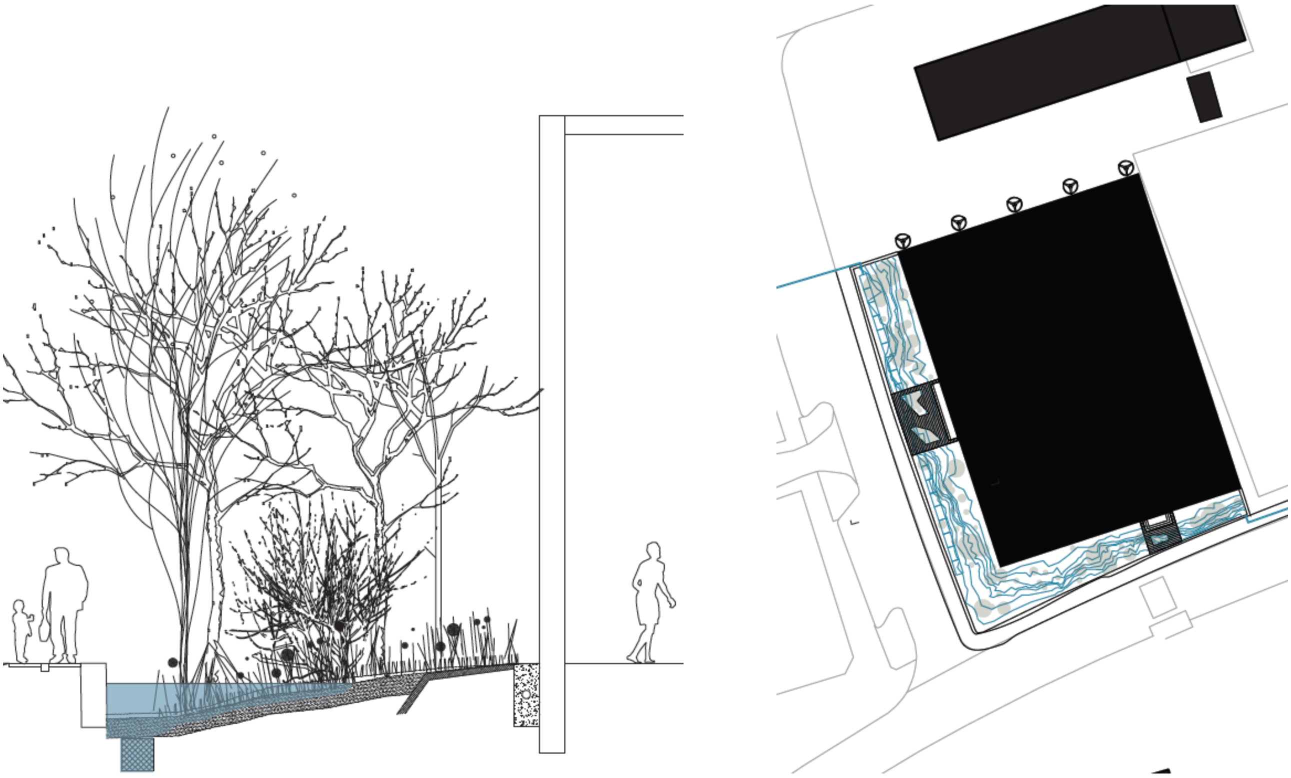

Figure 2: One team explained the landscape architecture as a stylised landscape element in an urban context; thus SUDS are accommodated in a stylised beach-meadow, stream and *Alnus*-bog. Courtesy: 1:1 landscape.

Design experiment C: In 2011, manufacturers and members of the Danish Concrete Association were contemplating where to address their product information in order to reach the key decision-makers who determine the choice of paving material. With the awareness of the nature of wicked problems, a design workshop was set up with the aim of formulating a resolution for neighbourhood streets, rather than literally addressing the proposed problem. Thus the solution of a design experiment, which was easier to propagate, clarified the problem.

Design experiment C learned the lesson of a quick approach towards a resolution, and the answer to the original problem posed by the manufacturers received a response in the resolution. *Design Experiment C* confirmed that one problem can be a symptom of another; and that ill-defined problems benefit from a quick design experiment to solve wicked problems and to put forward new questions to be solved.

Figure 3: The neighbourhood streets with contemporary values open for the interest of decision makers in the field of paving materials. Courtesy: BOGL Landscape.

Discussion

Design experiment A.

The debate of hypothesis / refutation and design thinking was certainly also present in 2008. Natural science research programs based on hypotheses are far along in the process, and much of the funding is already used before the hypothesis is supported or refuted, which leaves only a few possibilities for redirecting the research, or as Rittel and Webber puts it: "the next day's consequences of the solution may yield utterly undesirable repercussions which outweigh the intended advantages or the advantages accomplished hitherto" (Rittel and Webber 1971:163). First attempts by engineers and natural scientists to propose a hypothesis were met with a lack of information, and if existing information was the base of a hypothesis for this new, indeterminate problem, it remained only a part of the solution. The research program was cross-disciplinary and the theory of the wicked problem served as a common platform for the disciplines to meet.

Through a total of five sub-strategies, *Design Experiment A* identified areas where (i) storm water would run off the surface and follow terrain towards the river and connected streams; (ii) it found existing and planned green infrastructure and sites in a transitional process where SUDS could be implemented; (iii) it detected areas with significant deficits in the water table, where infiltration should be promoted; (iv) it outlined areas where non-infiltration SUDS measures should be implemented, and finally (v) the plan encapsulated areas where no change was likely to happen. All strategies encouraged the researchers to solve the problem collectively: the resolution developed in sub-strategies i, ii and iii made a profound formulation of the problem. The delineation of strategies iv and v addressed a general conception which prevented them from seeing other possibilities. Rittel and Webber emphasise the search for a causal explanation of the discrepancy between the state of affairs and how it ought to be (Rittel and Webber, 1973:165), and this became a conclusion through the five mentioned strategies.

The higher level problem became manageable when divided into five sub-strategies. Further research into stormwater, soil and groundwater interactions in one of the sub-strategies (reported by Roldin et al., 2012) revealed problems with infiltrating sufficient stormwater. This knowledge gave important insight into the relations between climate change, SUDS and the soil's capability to infiltrate and detain storm water, which could be used in other projects. The refutation of this particular strategy on the specific site didn't influence the other strategies for the catchment area. It only suggested increasing the scale of sub-strategy ii and iv. The wicked theory managed the collaborative appreciation. An implemented plan is a one-shot operation; however, remaining at the predevelopment design stage, other explanations might determine other natures of the problem's resolution, which was also the case for further research (e.g. Dam et al., 2012 regarding the political perspective).

Design experiment B

Design experiment B revealed the design team's correlation between their resolution and the kind of information needed. Rittel and Webbers outlines: "the choice of explanation determines the nature of the problem's resolution" (Rittel and Webber, 1973:166). Eleven identified problems evolved from organisers' previously assumed seven, during the design experiment. This indicates that the indeterminacy of the problem came from conceptual repositioning rather than a deductive conception of the organisers' limited imagination. Cross (2007) and Høyer (2008:5) describe the amount of information gathered and the left-overs from that process. It underlines Rittel and Webber's point of an "exhaustive inventory of all conceivable solutions" (Rittel and Webber, 1973:161). The question is how specialists profit from the correlation between information given and information used in the resolution. The design teams seemed to select useful information, and the fact that "wicked problems don't have any stopping rule" (Rittel and Webber, 1973:162) seemed to encourage the teams to be innovative; this behaviour overruled obstacles between disciplines and their approach to knowledge. "Do we have generic knowledge for all wicked problems or do we have a set of feasible plans of action, which relies on realistic judgement, the capability to appraise "exotic" ideas and on the amount of trust and credibility " as Rittel and Webber put it (Rittel and Webber, 1973:164). Design theory recognises the blending of explorative and thorough research and survey, it is a matter of which comes first (Krog, 1983). Hypothetically, this might be a disadvantage for specialists who appreciate their knowledge being used, and then experience a design proposal where they can't distinguish their contribution to the resolution of the wicked problem. This might negatively influence the transdisciplinary cooperation. Both Rittel and Webber (1973) and Geels (2002) address this concern by characterising the process, or suggesting niches where innovation can take place.

When starting a design experiment, the organisers don't need to cover all aspects in an introductory workshop, nor should they be afraid of wasting time on irrelevant information. "There is no definitive formulation of a wicked problem "(Rittel and Webber, 1973:161). Analysing the models for design thinking, they should rather provide knowledge and information "modified after definition of solution space, the system of constraints and measure of performance "(Rittel and Webber, 1973:162).

Designers and planners involved in design experiment B were familiar with the design and planning method generally accepted as an intuitive, hermeneutic circular process, where concern about the component and the whole both receive interest. However, they also experienced challenges meeting highly respected specialists and their knowledge who still conduct a process precipitating a lot of information and questions in order to resolve uncertainties and thereby gather relevant information.

Design experiment C

Design experiment C deliberately started with a lower level problem, even though any wicked problem is essentially unique, the original problem from the manufacturers was shelved correspondingly with "the art of not knowing too early which type of solution to apply " (Rittel and Webber, 1973:164). As solutions to "wicked problem are not true or false and they don't have any ultimate test "(Rittel and Webber, 1973:163). The focus of this study gave insight into the value-sets and their causal chains and the matter of judgement: "One cannot understand the problem without knowing about its context; one cannot meaningfully search for information without the orientation of a solution concept; one cannot first understand, then solve"(Rittel and Webber, 1973:161). The discussions during the start-up seminar showed that road construction is a well-known technology, with guidelines and standards governing traditional road design for municipalities planning new residential areas. The primary purpose of the street design is the distribution of traffic, but the design experiment found that synergies are created when multiple disciplines are put together to debate what is normally taken for granted, e.g. the layout and construction of residential roads. When analysing the four design proposals, it's clear that they are all focusing on the same problems, but proposing unique design strategies. By insisting on the fact that more solutions are possible, they were able to get a deeper insight into the wicked problem: "The level at which a problem is settled depends upon the self-confidence of the analyst" (Rittel and Webber, 1973:165). Design experiment C had a higher level problem: who decides on the paving material in residential streets? The answer after design experiment C is that, only when new concerns and objectives are addressed, such as the four design proposals offer, can the urban planner makes a choice of paving material.

Research into complex issues generally profits from the wicked theory. Transition Management and Complex Adapted Systems are contemporary examples of similar concerns. Rittel and Webber accepted the hermeneutic approach in opposition to (natural) science, a radical approach in 1973. Transition management suggests a framework for explanation, and the design experiment suggests a way out. Especially when the problem / resolution supports a quick rush for a first and second generation of solutions. The research field is still open after the design experiment and yet the problem is much clearer and the causal chain is visible.

Rittel and Webber write about planning in the sense of conceived plans, and not the interim design stages, where it is OK to be wrong and where it is more than a one-shot operation. The designers, however, are aware of finding the best possible solution, and appreciate the alterations under the process, convinced of the qualities of the iterative process. There is a risk that the theory of the wicked problem paralyses the situation with a sense of despair. Here landscape architects and designers have the task of communicating, as seen in recent publications on transition management and actor-network-theory (Tietjen, 2011; Fratini, Elle, Jensen, and Mikkelsen, 2012)

Conclusion

Design experiments are a method for working with wicked problems. They bring actors and networks together and they allow the development of integrated solutions within a limited timeframe. Design experiments can be done quickly and with a limited use of resources, as exemplified in this paper with the 2- and 3-week timeframes of design experiment B and C, respectively.

Design experiment A concludes that a wicked problem gains from a proposed strategic solution, and that research benefits from these concrete and nuanced views of a wicked problem. From the first loop, new solutions are easily found and the end result is improved. Design experiment B concludes that information and knowledge relate to the solution, and that it should be directed, to a greater degree, towards specific phases in the design process: inspiration, understanding, causal chain, project proposal. Finally, design experiments should present relevant subjects, but never try to cover everything. Design experiment C concludes that a quick response to a wicked problem informs about the higher level problem and generates shared understanding.

It is an effective method to understand and acknowledge the complexity of the task, to facilitate collaborative behaviour across stakeholder groups, to start research and to come up with multiple sets of solutions that frame discussions. Specialist natural scientists and engineers can use the integrated solutions as a hypothesis in their own research. Refutation after scientific research, influences off-course integrated solutions and will improve planning and design, which has no stopping rule, so multidisciplinary research collaborates and there is balanced cooperation. The only new addition is a short design experiment at the beginning.

Design experiments relate to scientific knowledge and to other information in a way which mirrors the world where research is meant to be used. Both utilised knowledge, knowledge used in an extraordinary way, and unused knowledge all inform the scientific method and the communication of information. The design experiment is a micro-cosmos, where problems and solutions come into play. Afterwards, the result of the design experiment advises many facets of a wicked problem; collaborative multidisciplinary research and management of information and communication.

The wicked problem theory, originally conceived in association with social policy and planning, also encompasses more specific and alternate design experiments, which address ill-defined, complex problems.

The success of design experiments depends on acknowledgement from engineers and scientists, and on design experiments which truly improve the hypothesis. The success implies a common appreciation of the idea of the wicked problem, and therefore research in the complexity of societal problems and policy goes hand-in-hand with convincing examples of multidisciplinary socio-technological-transitional research, including design experiments.

Design experiments have the potential to be a powerful tool to frame discussions regarding wicked problems:

- Setting the scene:
    - The design experiment provides a clear project formulation that highlights a theme for the participants to work with.
    - Design experiments are niches (Geels, 2002) where innovation is possible.
    - Seminars, midterm evaluations and discussions involving multiple disciplines, speed up the process of the formulation and solving of problems.
- Organising:
    - The time limitation is a key to benefiting from explorative loops between resolution and problem.
    - Participants promote a great variety of knowledge and design solutions without any being right or wrong.
- Moving on
    - Statements in design experiments stimulate (research) questions of interest.
    - Addressing a wicked problem on an alternative level transports results from a unique situation into a general discussion about the subject matter.

In general, design experiments enable the conscious framing and elaboration of wicked problems. Design experiments engage both the components and the whole in a way which communicates to stakeholders, lay-people, landscape architects, scientists and engineers – adaptively, participatory, and transdisciplinary.

Acknowledgement
The approach to wicked problems through design experiments was inspired by the 'mastercase' approach developed by the Dutch consultancy company, Tauw, which aims at bringing professional and institutional stakeholders together, encouraging them to develop a joint solution for a specific given task within a short period of time. See also:
http://www.tauwweetwaterspeelt.nl/downloads/mastercase-waterwetgeving.pdf

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