Design Research
- what is a PhD thesis in design -

Matthias Rauterberg
Eindhoven University of Technology
2018
Thinker versus Tinker

“Don't worry about what anybody else is going to do… The best way to predict the future is to invent it. Really smart people with reasonable funding can do just about anything that doesn't violate too many of Newton's Laws!”

(1971)

"There is nothing so practical as a good theory."

Ludwig BOLTZMANN (1884-1906)

Alan C. KAY (1940-)

Science

Design
Daniel KAHNEMAN
Map of Bounded Rationality: A Perspective on Intuitive Judgement and Choice
Nobel Prize Lecture, 8 December 2002
How to define problems?

* Thordike, 1933: Problem = where the actions necessary to attain goal(s) are not obvious.
# Categories of Problem-Solution

Kurtz, CF and Snowden, DJ (IBM Systems Journal 43, 3 Mar 2003) [PDF]

<table>
<thead>
<tr>
<th>Category</th>
<th>Qualities</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Solution knowledge exists in your domain</td>
</tr>
<tr>
<td>II</td>
<td>Solution knowledge in another domain</td>
</tr>
<tr>
<td>III</td>
<td>No solution exists. Complex, but responds consistently to same stimuli</td>
</tr>
<tr>
<td>IV (Wicked)</td>
<td>No solution exist. Chaotic and adaptive</td>
</tr>
</tbody>
</table>
The „waterfall“

Opportunity-driven problem solving

The waterfall is a picture of already knowing – you already know about the problem and its domain, you know about the right process and tools to solve it, and you know what a solution will look like.

The "jagged" line

Opportunity-driven problem solving

The jagged line of opportunity-driven problem solving is a picture of learning.
## Science deals mainly with Tame Problems

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Has a well defined and stable problem statement</strong></td>
</tr>
<tr>
<td>2</td>
<td><strong>Has a definite stopping point (i.e. when solution is reached)</strong></td>
</tr>
<tr>
<td>3</td>
<td><strong>Has s solution that can be objectively evaluated as right or wrong</strong></td>
</tr>
<tr>
<td>4</td>
<td><strong>Belongs to a class of similar problems that are solved in the same similar way</strong></td>
</tr>
<tr>
<td>5</td>
<td><strong>Has solutions that can be easily tried and abandoned</strong></td>
</tr>
<tr>
<td>6</td>
<td><strong>Comes with a limited set of alternative solutions</strong></td>
</tr>
</tbody>
</table>


Design deals mainly with Wicked Problems

Any problem is a nail problem if I have only a hammer.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>You don't understand the problem until you have developed a solution</td>
<td>Every solution exposes new aspects of the problem</td>
</tr>
<tr>
<td>2</td>
<td>Wicked problems have no stopping rule</td>
<td>No-definitive solution</td>
</tr>
<tr>
<td>3</td>
<td>Solutions to wicked problems are not right or wrong</td>
<td>Solution quality is not objective or based on formula</td>
</tr>
<tr>
<td>4</td>
<td>Every wicked problem is essentially unique and novel</td>
<td>Solutions need to be custom designed and fitted</td>
</tr>
<tr>
<td>5</td>
<td>Every solution to a wicked problem is a “one-shot” operation</td>
<td>You can't learn about the problem without trying solutions</td>
</tr>
<tr>
<td>6</td>
<td>Wicked problems have no given alternative solutions</td>
<td>You need creativity to devise solutions, and judgment to determine which is valid</td>
</tr>
</tbody>
</table>

A problem doesn’t have to possess all six characteristics in order to be wicked!


How can we cope with Wicked Problems?

Two approaches:

1. *Studying* the problem; 2. *Taming* it

<table>
<thead>
<tr>
<th></th>
<th>1. <em>Lock down the problem definition</em></th>
<th>2. Describe it in a way that you can solve it or split it in a sub-problem and declare that to be a PROBLEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td><em>Assert that the problem is solved</em></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><em>Specify objective parameters by which to measure the solution’s success</em></td>
<td>What is measured becomes the problem</td>
</tr>
<tr>
<td>4</td>
<td><em>Cast the problem as “just like” a previous problem that has been solved</em></td>
<td>Ignore or filter out evidences that do not fit</td>
</tr>
<tr>
<td>5</td>
<td><em>Give up on trying to get a good solution to the problem</em></td>
<td>Just follow orders, do your job</td>
</tr>
<tr>
<td>6</td>
<td><em>Declare that there are just a few possible solutions, and focus on selecting one of them</em></td>
<td></td>
</tr>
</tbody>
</table>
Analysis & Synthesis, Deduction & Induction

*Analysis (reduction):* Separating of any material or abstract entity into its constituent elements.

*Synthesis:* Combining of the constituent elements or separate material or abstract entities into a single or unified entity.

*------------------*

*Deduction:* A form of inference; if the premises are true, the conclusion must be true, i.e., deduction preserves the truth (equivalent to analysis).

*Scientific induction:* a form of inference in which the conclusion, though supported by the premises, does not follow from them necessarily, i.e., induction does not necessarily preserve the truth (equivalent to synthesis).
<table>
<thead>
<tr>
<th>Reasoning Pattern</th>
<th>Type</th>
<th>Description</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deduction</td>
<td>what + how &gt; (result)</td>
<td>Known: what is observed + how it works &gt; makes predictions of results possible</td>
<td></td>
</tr>
<tr>
<td>Induction</td>
<td>what + (how) &gt; observation</td>
<td>Known: what is observed + unknown: how does it work? &gt; known: changes observed &gt; leads to theorising, hypothesising; explaining observations</td>
<td></td>
</tr>
<tr>
<td>Abduction 1</td>
<td>(what) + how &gt; value</td>
<td>Known: value to create + how this can be done &gt; unknown: what is needed?</td>
<td></td>
</tr>
<tr>
<td>Abduction 2</td>
<td>(what) + (how) &gt; value</td>
<td>Known: value to create &lt; unknown: what is needed? + how to get there?</td>
<td></td>
</tr>
</tbody>
</table>

**Kees DORST**
Design Thinking

**REF:** Dorst K. (2011) The core of 'design thinking' and its application. *Design Studies*, vol. 32, no. 6, pp.521-532
Deduction, Induction and Abduction

**Deduction**: major premise: All balls in the box are black
minor premise: These balls are from the box
conclusion: These balls are black

\[ A \Rightarrow B \\
A \\ \ldots \\
B \]

**Induction**: case: These balls are from the box
observation: These balls are black
hypothesized rule: All ball in the box are black

Whenver
\[ A \Rightarrow B \]
-------------
Possibly
\[ A \Rightarrow B \]

**Abduction**: rule: All balls in the box are black
observation: These balls are black
explanation: These balls are from the box

\[ A \Rightarrow B \\
B \\ \ldots \\
\]

Possibly A

**Deduction** reasons from causes to effects
**Induction** reasons from specific cases to general rules
**Abduction** reasons from effects to causes
Positivistic sciences

• An assumption of linear causality; there are no effects without causes and no causes without effects. [Causality]

• A single, tangible reality "out there" that can be broken apart into pieces capable of being studied independently. [Reductionism]

• The separation of the observer from the observed. [Objectivity]
  – So that the results of an inquiry are essentially free from beliefs, interpretations, etc.

• What is true at one time and place will also be true at another time and place. [Universality]
<table>
<thead>
<tr>
<th></th>
<th>Science</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Causality]</td>
<td>1-2 Cs</td>
<td>&gt;4 Cs</td>
</tr>
<tr>
<td>[Reductionism]</td>
<td>yes</td>
<td>no, holistic</td>
</tr>
<tr>
<td>[Objectivity]</td>
<td>yes</td>
<td>no, subjective</td>
</tr>
<tr>
<td>[Universality]</td>
<td>yes</td>
<td>no, contextual</td>
</tr>
</tbody>
</table>

[C means Cause-Effect relationship]
“But life is short, and truth works far and lives long…” Schopenhauer

<table>
<thead>
<tr>
<th>Epistemological Method</th>
<th>Real Being</th>
<th>Formal Being</th>
<th>Ideal Being</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation of Reality</td>
<td>Formal proof</td>
<td>Belief based on intuition</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inference Concept</th>
<th>Inductive logic</th>
<th>Deductive logic</th>
<th>Value system</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Academic Paradigm</th>
<th>Natural Sciences</th>
<th>Mathematics</th>
<th>Humane Sciences</th>
</tr>
</thead>
</table>

Scientific methods

**Nomothetic** research (in natural sciences and engineering): the aim is to find general causal laws to explain phenomena, theories are usually axiomatic (deductive) systems or sets of models.

**Constructive** research (in engineering and design): the solution of the problem is not only shown to exist but it is also constructed.

**Idiographic** (ideographic) research trying to provide all possible explanations of a particular case, for example in history.
Scientific methods (cont’d)

**Action research** (in design sciences): the problem is solved by certain actions whose consequences are evaluated and new actions are specified (iterative improvement, trial and error).

**Case study** (in design sciences): an in-depth, longitudinal examination of a single instance or event, which is called a case.

**Questionnaire study** (in social sciences): a series of questions are used for the purpose of gathering information, which is usually analyzed statistically.

Thank you for your attention…

“Traditional scientific method has always been at the very best 20-20 hindsight. It’s good for seeing where you’ve been. It’s good for testing the truth of what you think you know, but it can’t tell you where you ought to go.”

Robert Pirsig, 1974
“Zen and the art of motorcycle maintenance”

Watch the vision videos!
Survival Guide for PhD students

YU Haifeng (2017) How to do good research?
My favourite 26 PhD students [BACK TO TOP]


Huang Ming Chang (2014). Emotions in archetypal media content.
Awarded in 2014 with CUM LAUDE, the top 5% thesis at TU/e.
Front-end Developer at Connectis B.V., Rotterdam, Netherlands.

Awarded in 2014 with CUM LAUDE, the top 5% thesis at TU/e.
SAP consultant and Owner/CEO of HX research, Moscow, Russia.
Marie Skłodowska-Curie Fellowship at Bristol Interaction and Graphics Group.

This PhD is Roman’s 2nd Doctoral Degree.
Data Scientist at Supercrunch, Nurnberg, Germany.

CheeFai Tan (2010). Smart system for aircraft passenger neck support.
Awarded in 2011 with Bronze Medal at Malaysia Technology Expo [PDF]
Senior Lecturer, Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Malaysia.

R&D manager of Xiaomi Inc., Beijing, China.

Professor, Design Architecture Building, University of Technology Sydney, Australia.

NWO VENI Award Laureate.
Dennis ABRAZHEVIC (2004). *Electronic payment systems: A user-centered perspective and interaction design.*
Owner and CEO of *Mobilnova*, Eindhoven, Netherlands

Professor, *Department of Computer Science*, University of Bristol, UK

*Starter Grant Holder*

Associate Professor, *Marketing and Consumer Behaviour Group*, Wageningen University, Netherlands

Dzmitry ALIAKSEYEU (2003). *A computer support tool for the early stages of architectural design.*
Senior Scientist, *Philips Research*, Eindhoven, Netherlands

Founder UX Berlin - Innovation Consulting, Berlin, Germany
Professor at University of Applied Sciences for Media, Communication and Management, Germany

*Awarded in 2001 with the ETH medal, the top 5% thesis at ETH Zurich.*
Professor, Department of *Computing Science*, Chalmers Göteborg University, Sweden
References

Design Research through Practice.
by Ilpo Koskinen, John Zimmerman, Thomas Binder, Johan Redstrom, Stephan Wensveen (Authors)
Paperback: 224 pages
Publisher: Morgan Kaufman (September, 2011)
Language: English
ISBN-10: 0262122634

Design Research: Methods and Perspectives.
by Brenda Laurel (Editor), Peter Lunenfeld (Preface)
Hardcover: 334 pages
Publisher: The MIT Press (October 1, 2003)
Language: English
ISBN-10: 0262122634

Research Methodology: A Step-By-Step for Beginners.
by Ranjit Kumar (Author)
Paperback: 332 pagina's
Publisher: Sage Publications; 2de Edition; mei 2005
ISBN10: 141291194X
ISBN13: 9781412911948
References (cont’d)

Test Scores and What They Mean.
by Howard B. Lyman (Author)
Paperback: 190 pages
Publisher: Allyn & Bacon; 6 edition (November 6, 1997)
Language: English
ISBN-10: 0205175392

Questionnaire Design: How to Plan, Structure and Write Survey Material for Effective Market Research (Market Research in Practice).
by Ian Brace (Author)
Paperback: 304 pages
Publisher: Kogan Page; 2nd edition (September 28, 2008)
Language: English
ISBN-10: 0749450282

Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory.
by Anselm C. Strauss (Author), Juliet Corbin (Author)
Paperback: 336 pages
Publisher: Sage Publications, Inc; 2nd edition (September 22, 1998)
Language: English
ISBN-10: 0803959400