Design Research
- what is a PhD thesis -

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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-)
Daniel KAHNEMAN
Map of Bounded Rationality: A Perspective on Intuitive Judgement and Choice.
Nobel Prize Lecture, 8 December 2002
# Categories of Problem-Solution

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

<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>
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.

Opportunity-driven problem solving

The jagged line of opportunity-driven problem solving is a picture of learning.

Problem | Solution
--- | ---
Gather data | Analyze data | Formulate solution | Implement solution
Time

Figure 2: The „jagged“ line
Science deals mainly with Tame Problems

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</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

<table>
<thead>
<tr>
<th></th>
<th>You don't understand the problem until you have developed a solution</th>
<th>Every solution exposes new aspects of the problem</th>
</tr>
</thead>
<tbody>
<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 &quot;one-shot&quot; 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:**
   - Lock down the problem definition
   - Assert that the problem is solved
   - Specify objective parameters by which to measure the solution’s success
   - Cast the problem as “just like” a previous problem that has been solved
   - Give up on trying to get a good solution to the problem
   - Declare that there are just a few possible solutions, and focus on selecting one of them

2. **Taming it:**
   - Describe it in a way that you can solve it or split it in a sub-problem and declare that to be a PROBLEM
   - What is measured becomes the problem
   - Ignore or filter out evidences that do not fit
   - Just follow orders, do your job
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 Patterns</th>
<th>Deduction</th>
<th>Induction</th>
<th>Abduction 1</th>
<th>Abduction 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Other reasoning patterns&quot;</td>
<td>what + how &gt; (result)</td>
<td>what + (how) &gt; observation</td>
<td>(what) + how &gt; value</td>
<td>(what) + (how) &gt; value</td>
</tr>
<tr>
<td>especially traditional science</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; analytic thought</td>
<td></td>
<td></td>
<td>Known: value to create + how this can be done &gt; unknown: what is needed?</td>
<td>Known: value to create &lt; unknown: what is needed? + how to get there?</td>
</tr>
<tr>
<td>Design thinking</td>
<td></td>
<td></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>designers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; creative thought</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Kees DORST
Deduction-Induction-Abduction
# Deduction, Induction and Abduction

**Deduction**: reasons from causes to effects
- **major premise**: All balls in the box are black
- **minor premise**: These balls are from the box
- **conclusion**: These balls are black

\[
A \implies B \\
\begin{array}{c} A \\ \hline B \end{array}
\]

**Induction**: reasons from specific cases to general rules
- **case**: These balls are from the box
- **observation**: These balls are black
- **hypothesized rule**: All ball in the box are black

\[
\text{Whenever A then B} \\
\begin{array}{c} A \\ \hline \text{Possibly } B \end{array}
\]

**Abduction**: reasons from effects to causes
- **rule**: All balls in the box are black
- **observation**: These balls are black
- **explanation**: These balls are from the box

\[
A \implies B \\
\begin{array}{c} B \\ \hline \text{Possibly A} \end{array}
\]
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><strong>[Causality]</strong></td>
<td>1-2 C</td>
<td>&gt;4 Causes</td>
</tr>
<tr>
<td><strong>[Reductionism]</strong></td>
<td>yes</td>
<td>no, holistic</td>
</tr>
<tr>
<td><strong>[Objectivity]</strong></td>
<td>yes</td>
<td>no, subjective</td>
</tr>
<tr>
<td><strong>[Universality]</strong></td>
<td>yes</td>
<td>no, contextual</td>
</tr>
</tbody>
</table>
“But life is short, and truth works far and lives long…” Schopenhauer

Ontological Reference

<table>
<thead>
<tr>
<th></th>
<th>Real Being</th>
<th>Formal Being</th>
<th>Ideal Being</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epistemological Method</td>
<td>Observation of Reality</td>
<td>Formal proof</td>
<td>Belief based on intuition</td>
</tr>
<tr>
<td>Inference Concept</td>
<td>Inductive logic</td>
<td>Deductive logic</td>
<td>Value system</td>
</tr>
<tr>
<td>Academic Paradigm</td>
<td>Natural Sciences</td>
<td>Mathematics</td>
<td>Humane Sciences</td>
</tr>
</tbody>
</table>

“Time Saving Truth from Falsehood and Envy” François Lemoyne, 1737
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
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PostDoc at Uppsala University, Sweden

Shadi KHEIRANDISH (2018). *HuValue - A tool to enrich design concepts with human values.*

Wan Jou SHE (2018). *Toward Empowerment - Screening prolonged grief disorder in the first six months of bereavement.* [TOOL]


Lecturer at College of Furniture and Industrial Design, Nanjing Forest University, China


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

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SAP consultant and Owner/CEO of HX research, Moscow, Russia.
Marie Skłodowska-Curie Fellowship at Bristol Interaction and Graphics Group

Roman GORBUNOV (2013). **Monitoring emotions and cooperative behavior.**
*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

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NWO VENI Award Laureate


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