Arch 467 Design Methods

Fall 2018 – 2019

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What is design?

This is the first question of design theory,design methods, philosophy of design, etc.

- Types of problems –

  design, diagnosis, classification

- Types of reasoning –

  deduction, induction, abduction

Types of Reasoning

- Deduction
  - All men are mortal.
  - Socrates is a man.
  - Therefore, Socrates is mortal.
- Induction
  - All of the swans we have seen are white.
  - Therefore, all swans are white.

Types of Reasoning

- Abduction (Hypothesis)
  - The grass is wet.
  - It has rained.

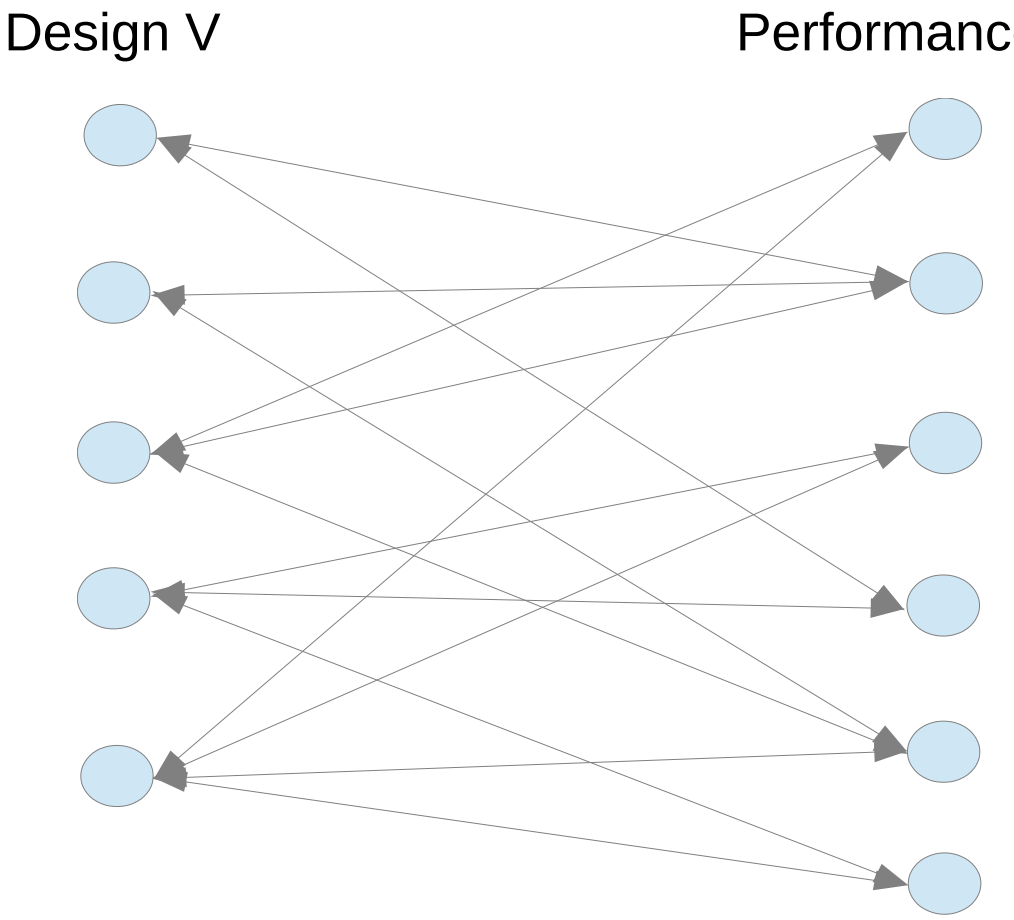
Abduction in Design

- Abduction 1
  - We know both the value we wish to create,
  - and the ‘how’, a ‘working principle’ that will help achieve the value we aim for.
  - missing is a ‘what’ (an object, a service, a system),
- Abduction 2
  - We know the value we wish to create,
  - coming up with both a ‘thing’
  - and its ‘working principle’

Elements

- Designer
- Design process
- Design product

Design & Performance Variables



Many to many relations between design and performance variables

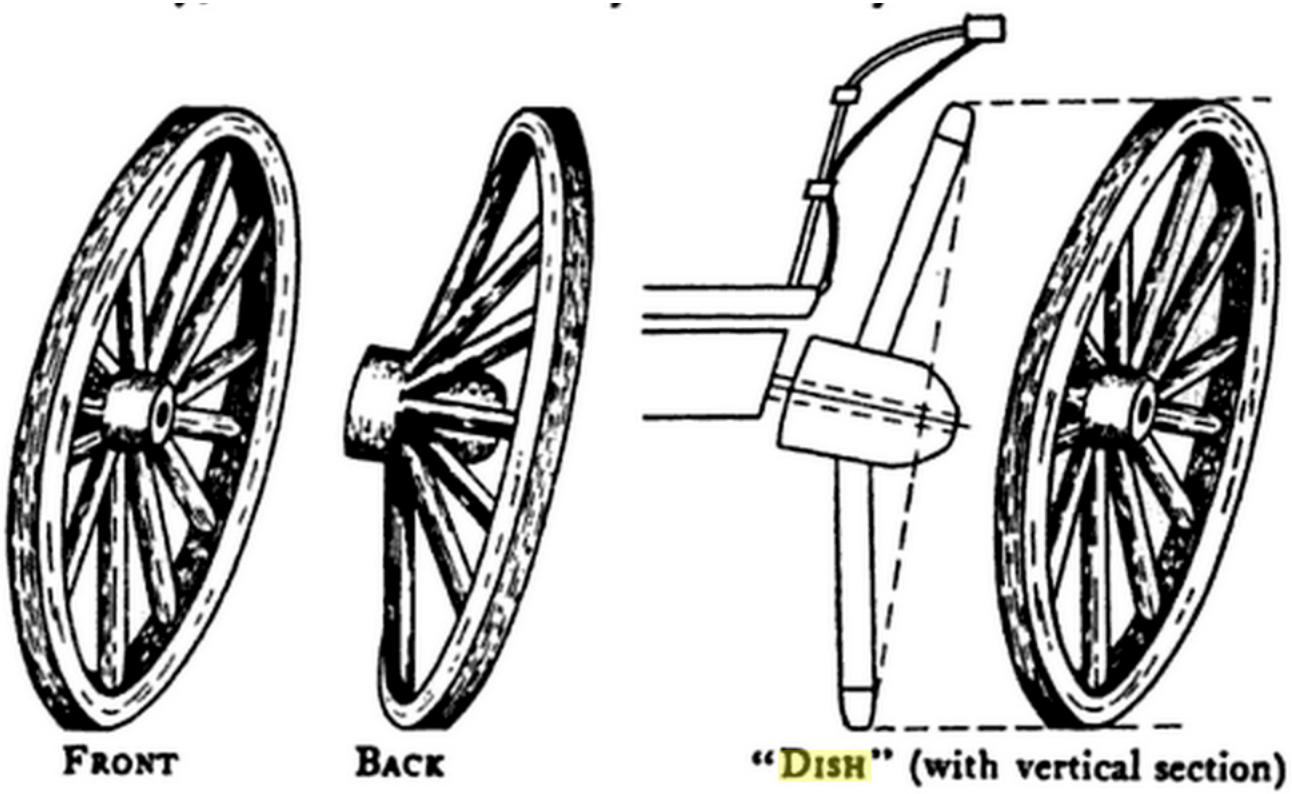
Types

- Vernacular design
- Formal or Selfconscious design
  - in *Ecole des Beaux Arts* design methods meant using classical details from Vitruvius, etc.
  - De Stijl, Le Corbusier, ...

Design products

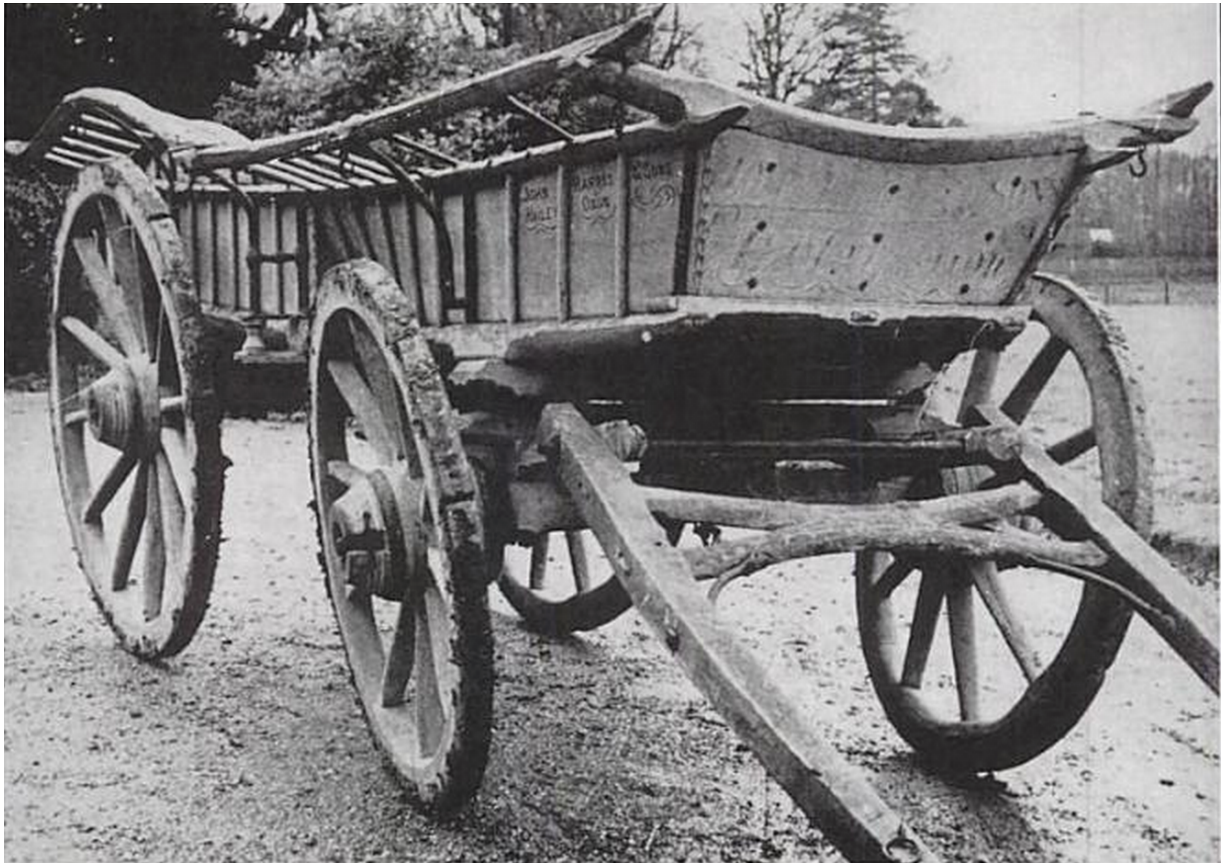
- Buildings, roads, bridges
- Amphora, barrel, container
- Horse cart, boat, gun

George Sturt, The Wheelwright's Shop, Cambridge University Press, 1993 (1923).



J C Jones, *Design Methods*, John Wiley 1970

- Design rationale



Design is ...

- The creation of form

  Christopher ALEXANDER

- Creation of the artificial

  Herbert SIMON

- An ill-defined problem

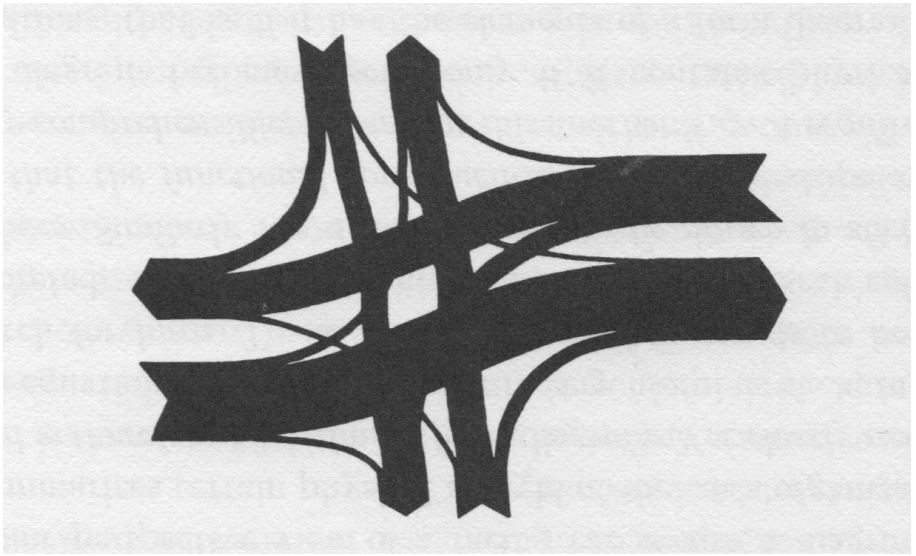
  Walter REITMAN

- A wicked problem

  Horst RITTEL & Melvin WEBBER

Alexander

- Design is the generation of form
- Achieve fitness between form and its context



Alexander

- Why is design hard?
  - When you change one thing everything changes
  - Many to many relationship between *design variables* and *performance variables*
- Unselfconscious process:
  - Adaptation

Alexander's method

Determination of components for an Indian Village

- Misfit variables
  -
  -
- Links
  -
  -

72. Prevent famine if monsoon fails.
73. Conservation of water resources for future.
74. Maintenance of irrigation facilities.
75. Drainage of land to prevent waterlogging, etc.
76. Flood control to protect houses, roads, etc.

Material Welfare

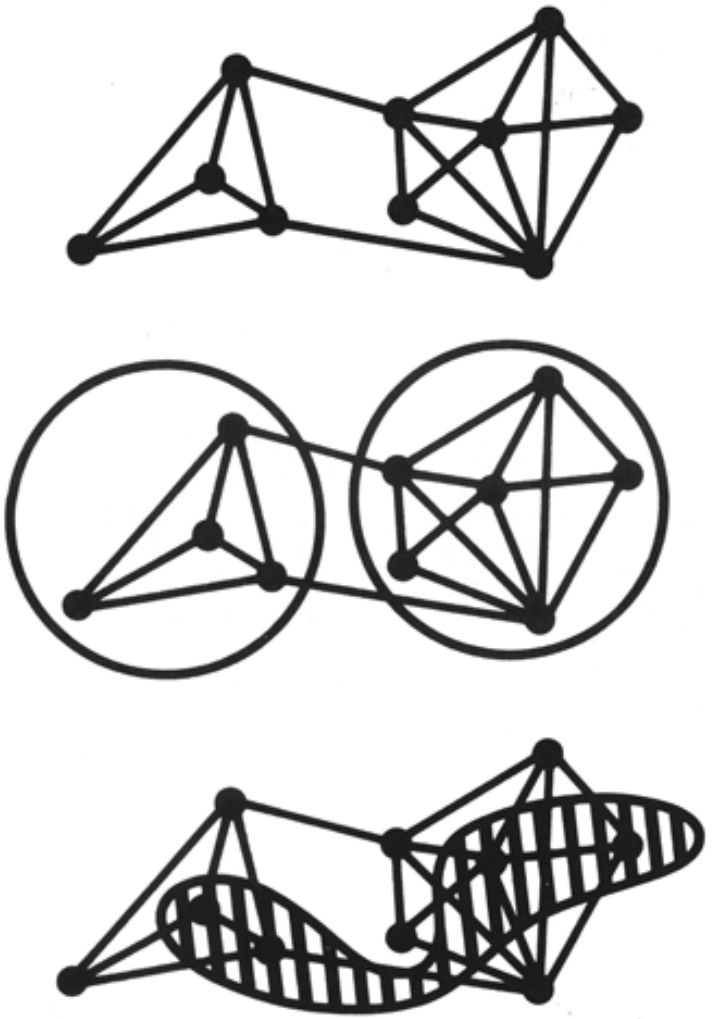
77. Village and individual houses must be protected from fire.
78. Shade for sitting and walking.
79. Provision of cool breeze.
80. Security for cattle.

139

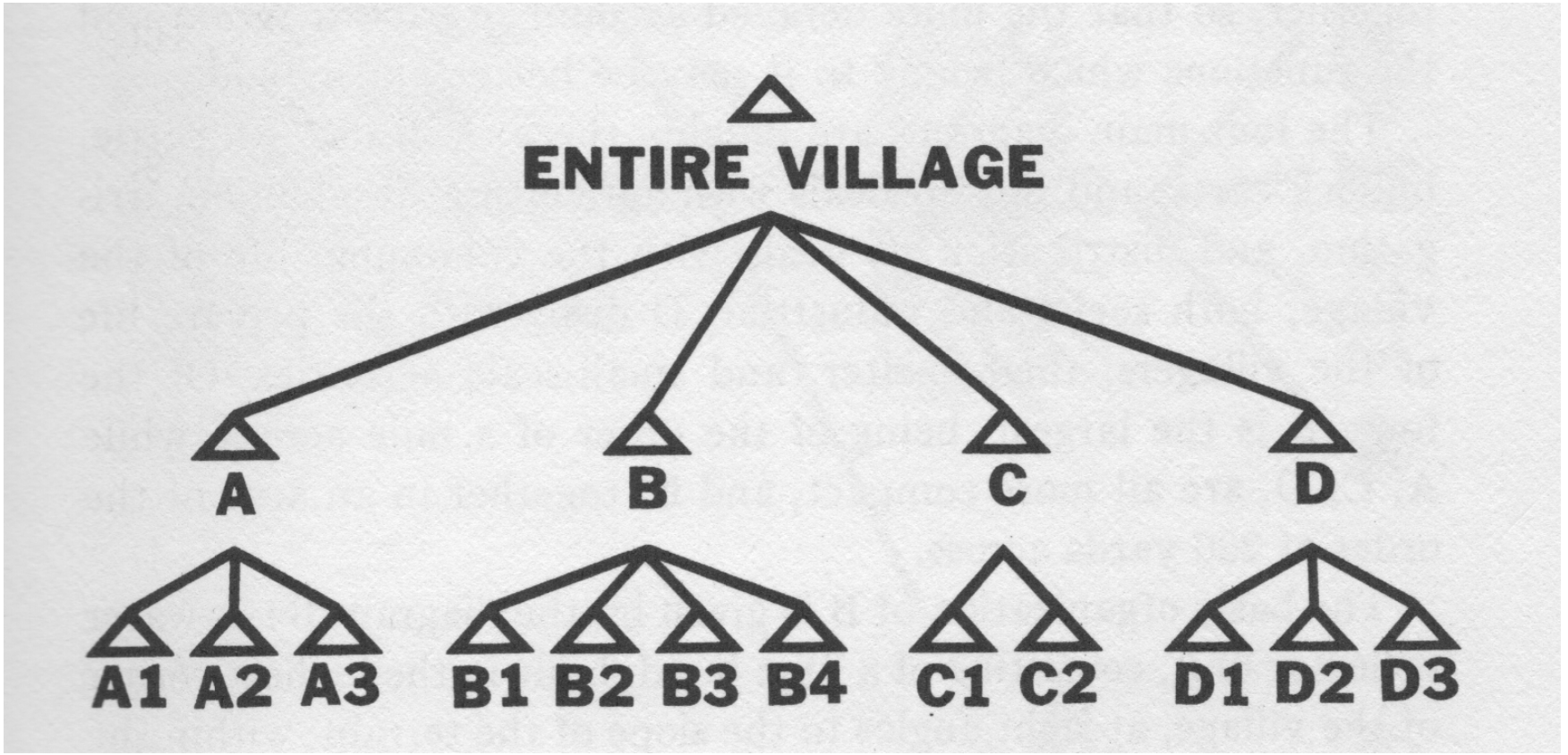
73 interacts with 32, 45, 70, 71, 78, 91, 104, 105, 108, 109, 110.
74 interacts with 4, 18, 22, 28, 32, 33, 34, 45, 61, 69, 105, 107, 109, 110, 127.
75 interacts with 32, 33, 39, 48, 63, 66, 69, 71, 98, 100, 104, 107, 123, 124, 133.
76 interacts with 3, 12, 23, 26, 37, 38, 50, 56, 58, 67, 71, 85, 87, 90, 91, 92, 95, 98, 101, 108, 113, 120, 122, 123, 124, 127.
77 interacts with 1, 18, 50, 51, 79, 83, 86, 90, 93, 103.
78 interacts with 3, 4, 16, 23, 34, 38, 45, 56, 58, 73, 79, 85, 86, 101, 105, 130.

Alexander's method

- Graph G(M,L)
- Hierarchy
- Divide & conquer
  - CAD

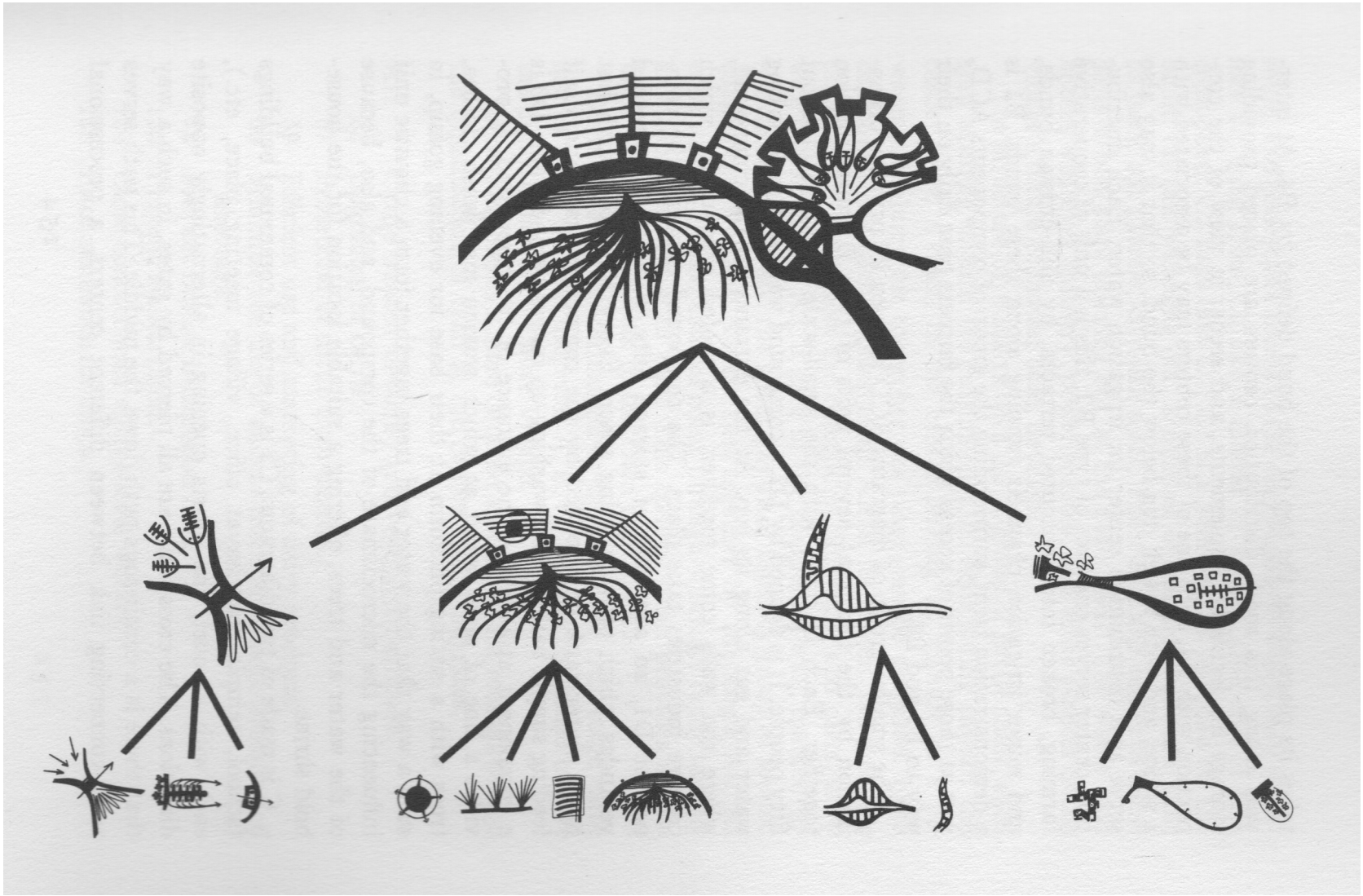


Alexander's Method



Example - The tree of diagrams made during the realization of this program. [©Alexander, Christopher. 1964. *Notes on The Synthesis of Form*. Cambridge, Massachusetts, and London: Harvard University Press, p. 153.]

Alexander's method



Alexander's Claims

- Every reasonable person who studies a design problem will identify the same misfit variables; the process is objective
- Interactions between misfit variables can be identified at the start

Simon

- The *natural* vs. the *artificial* worlds
- Design is creating the artificial
- *Satisficing* as opposed to *optimizing*

Simon, H. A. (1969). *The sciences of the artificial*. Cambridge, MA: MIT Press.

Simon, H. A. (1973). The structure of ill-structured problems. *AI*, 4, 181-201.

Simon, H. A. (1971). Style in design. In J. Archea & C. Eastman (Eds.) EDRA TWO, Proceedings of the 2nd Ann. Environmental Design Research Association Conference, (pp. 1-10). Dowden, Hutchinson & Ross, Inc.

Optimization

- Selection of best alternative from possible alternatives based on economic utility – von Neuman Morgenstern [*vN-M*], Economic Theory of Games.
- Mathematical optimization – selection of best element (maximizing expected utility) from some set of available alternatives

Satisficing

- Find a solution satisfying all constraints
  - binary constraints: [0 , 1] defined by a threshold
- If problem is too easy
  - change threshold to make a constraint harder
  - add a new constraint
- If problem is too hard
  - change threshold to make a constraint easier
  - remove a constraint

Problem

- If we want to achieve something and how to achieve it is not obvious, we have a problem.

Problem

- A problem can be defined by 3 elements
  - initial state *A*
  - goal [state(s)] *B*
  - operators =>
- If all elements are given unambiguously: Well-defined problem
- If one or more elements are undefined: Ill-defined problem

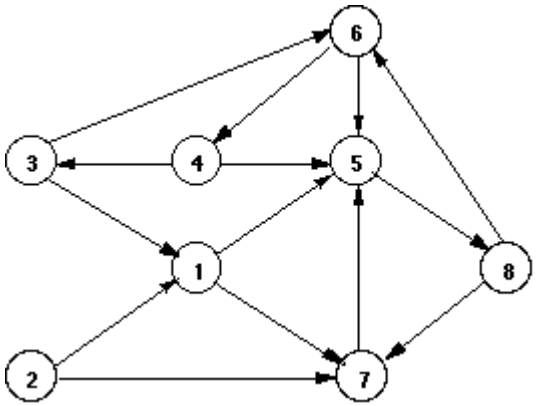
Problem Space

- Problem space

Problem Solving

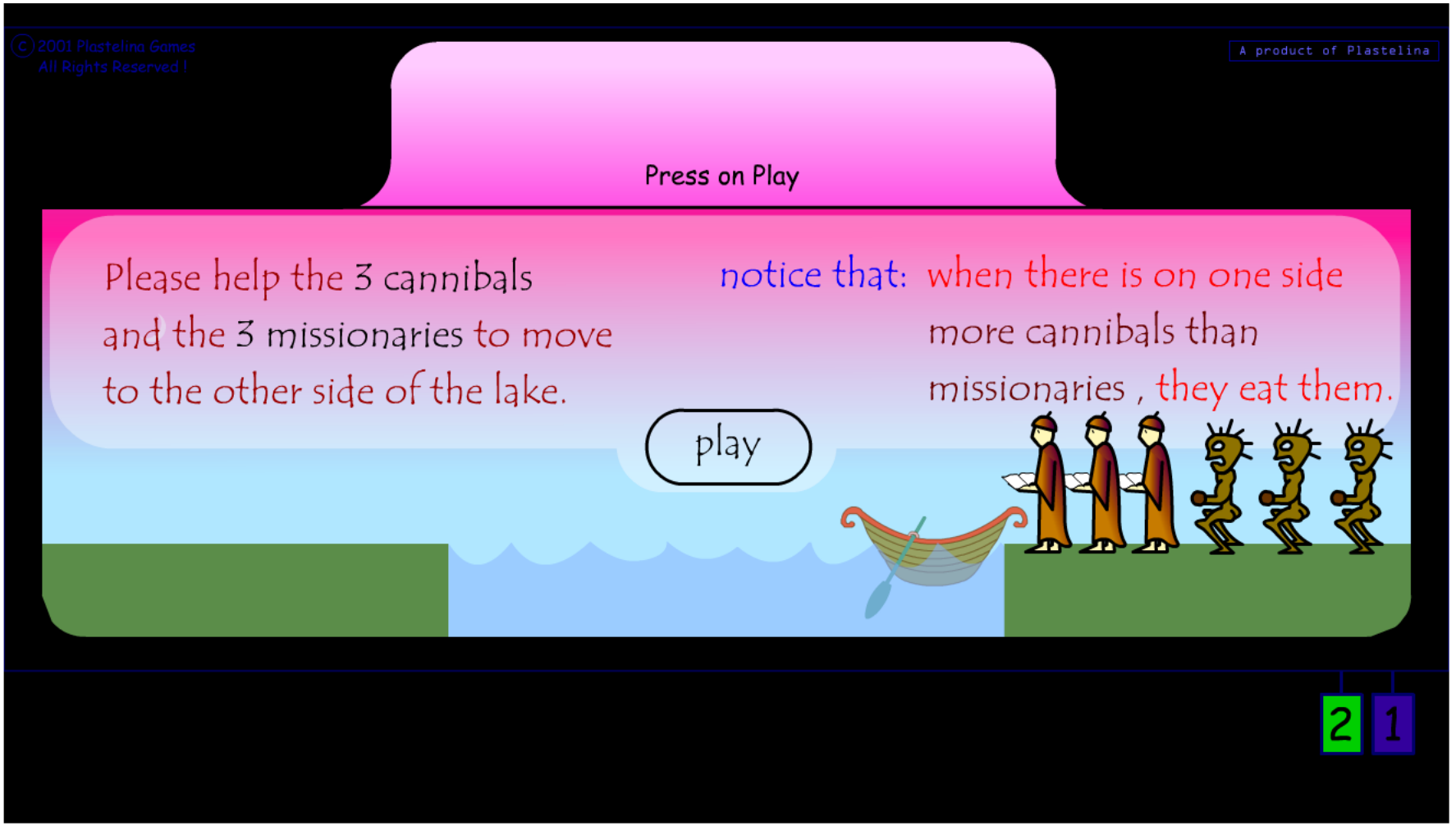
via optimization satisficing or other weak methods

- Problem space
  - States; initial, solution
  - Operators
- Search

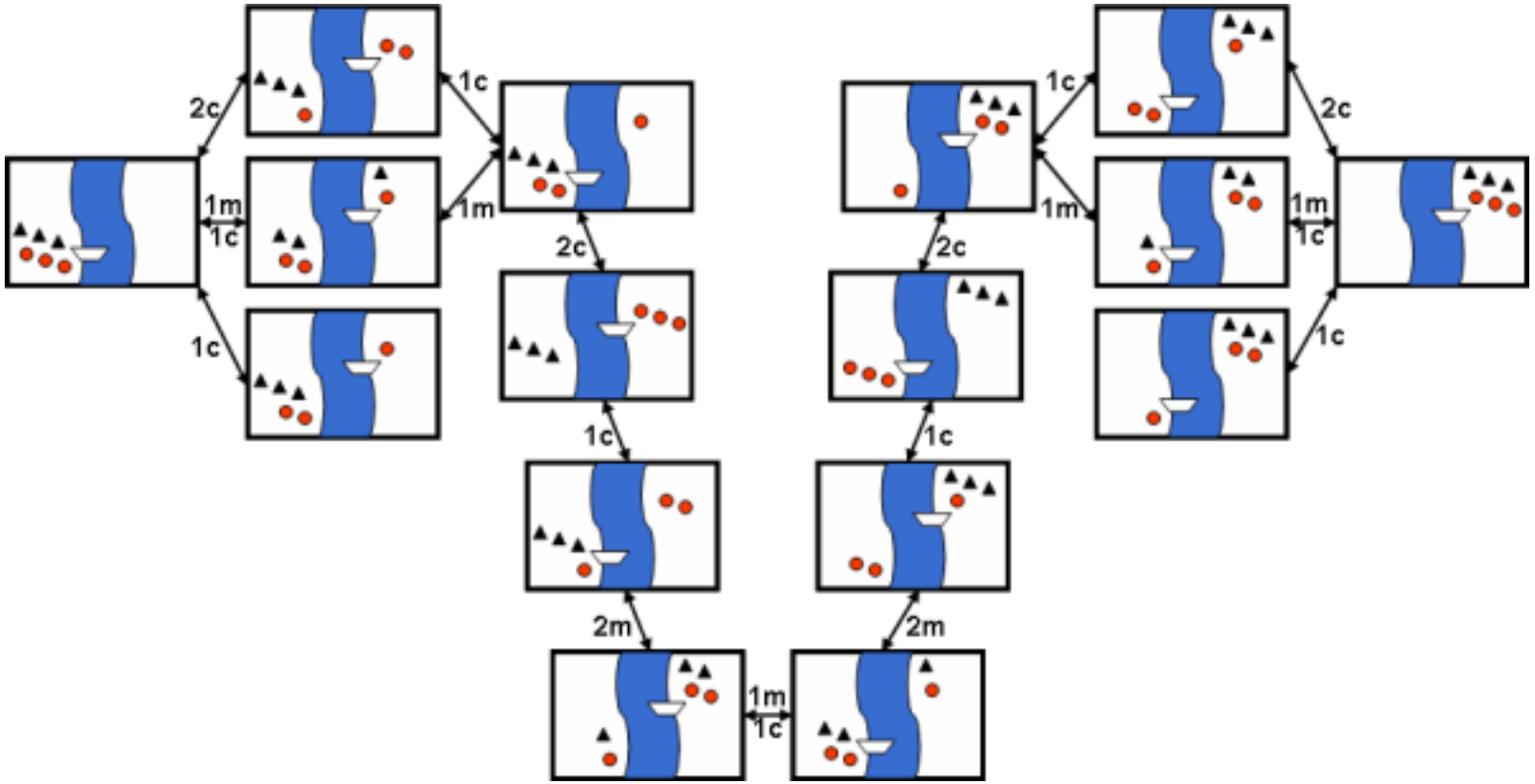


Missionaries & Cannibals Problem

http://www.learn4good.com/kids-games/puzzle/boat.htm

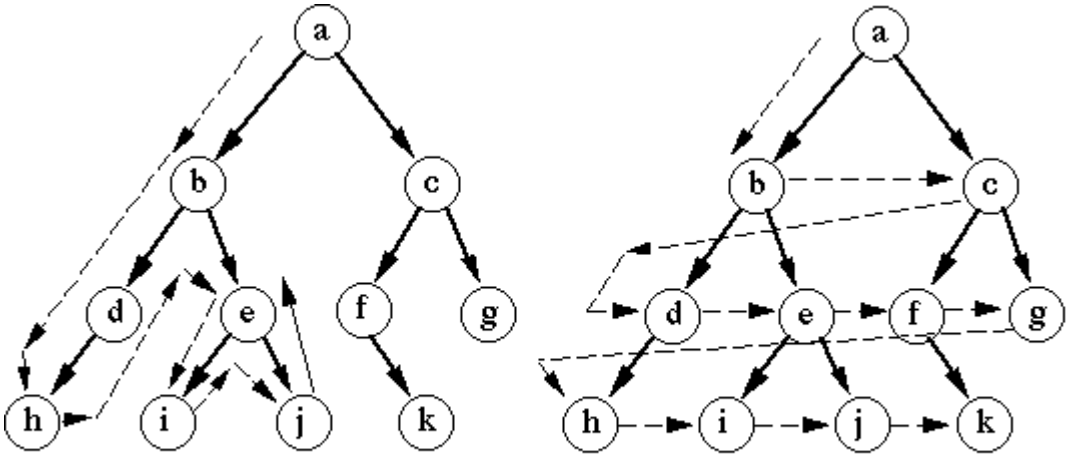


Missionaries and cannibals problem space



Search

- Well-defined problem
- *Methods* select operators & states
- *Heuristics*
- *Intelligence*



Weak vs. Strong Methods

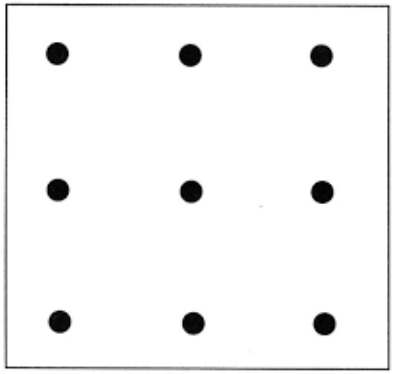
- Strong methods are those designed to address a specific type of problem
- Weak methods are general approaches that may be applied to many types of problems” (Vessey & Glass, 1998).

Heuristic

In computer science, artificial intelligence, and mathematical optimization

- A technique designed for solving a problem more quickly when classic methods are too slow, or for finding an approximate solution when classic methods fail to find any exact solution.
- This is achieved by trading optimality, completeness, accuracy, or precision for speed.
- Not guaranteed to work; sometimes makes finding a solution harder

9 Dots Problem



Problem solving

- Works for well-defined problems
- No mechanism for dealing with ill-defined problems
- Ill-defined problem solved by converting to well-defined [sub]problems
- Domain knowledge needed for this

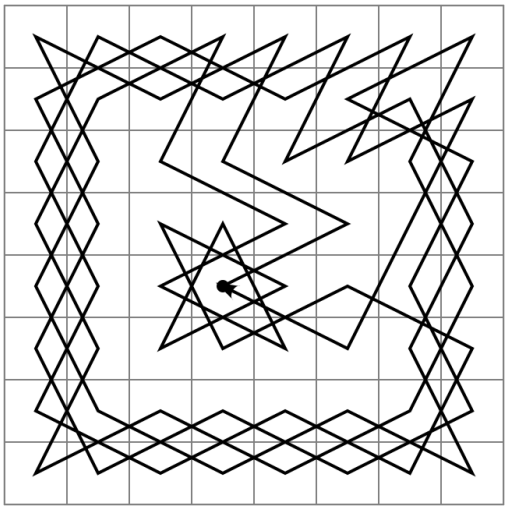
Representation

- What is representation?
  - Art = representation ?
  - In problem solving
- Problem representation inside and outside the mind

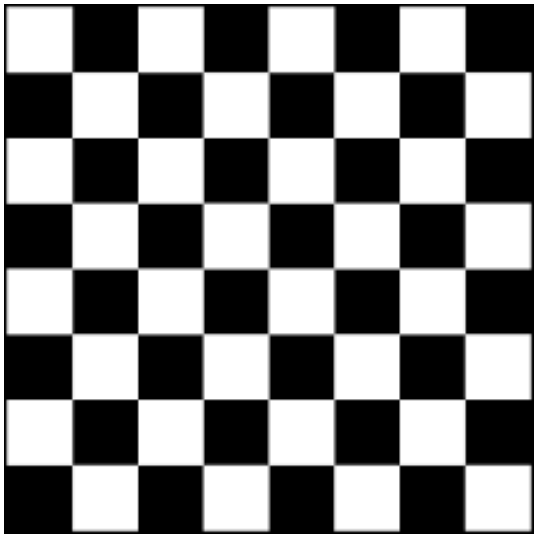
Representation Types

- Acc. to Akın
  - Analogue
  - Symbolic
- Acc. to Ackoff
  - Iconic
  - Analogue
  - Symbolic

Role of Representation in Problem Solving



Role of Representation in Problem Solving



Rittel & Webber

Dilemmas in a general theory of planning

- Wicked problems
  - No definitive formulation
  - No stopping rule
  - Not true-or-false but good-or-bad
  - No test of a solution
  - Every solution one shot
  - No enumerable set of potential solutions
  - Unique
  - Symptom of another problem
  - Can be explained in numerous ways

Types of Design

- Routine or parametric
- Innovative
- Creative

Science

- What is science?
- Kuhn – Paradigm change
- Popper – Falsificationism
- Occam's razor

Design and Science

Cross, ¨Designerly Ways of Knowing: ... ¨

- Scientific Design
  - Uses scientific knowledge
- Design Science
  - Uses scientific methods
  - Design as a scientific activity itself – controversial
- Science of Design
  - Study design scientifically to generate knowledge about principles, practices, procedures of design

Design as a Discipline

Cross, ¨Designerly Ways of Knowing: ... ¨

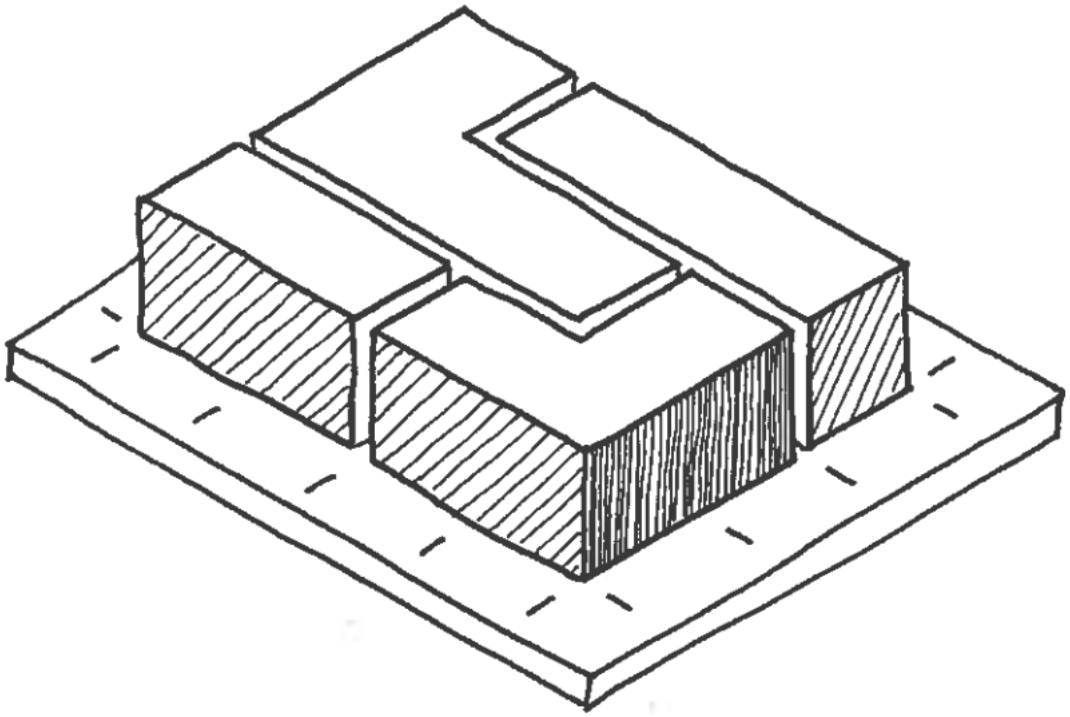
- Knowledge about the artificial world and how to contribute to its creation and maintenance
- Reflective practice is the intuitive processes which some practitioners bring to situations of uncertainty, instability, uniqueness and value conflict
- Science of design based on the reflective practice of design

Science vs Design

- Different aims
  - to generate systematic, reliable knowledge
  - to create the artificial based on human goals
- Different approaches
  - Requires skeptical, critical, questioning approach
  - Requires faith, we have to solve the problems even if we don't know enough

Lawson's experiment

Psychologist, architect and design researcher Bryan Lawson [1972]



Lawson's experiment

Empirical study to investigate if there is a difference between thinking styles of designers [final year architecture students] and scientists [post-graduate science students]

Create one-layer structures from a set of colored blocks. The perimeter of the structure has to be as red or as blue as possible. However, there are hidden rules about which combinations are possible.

Lawson's experiment

- The scientists adopted a technique of trying out a series of designs which used as many different blocks and combinations of blocks as quickly as possible. Thus they tried to maximize the information available to them about the allowed combinations. If they could discover the rule governing which combinations of blocks were allowed they could then search for an arrangement which would optimize the required color around the layout. [problem-focused]

Lawson's experiment

- The architects selected their blocks in order to achieve the appropriately colored perimeter. If this proved not to be an acceptable combination, then the next most favorably colored block combination would be substituted and so on until an acceptable solution was discovered. [solution-focused]
- Nigel Cross concluded that Lawson's studies suggested that scientists problem solve by analysis, while designers problem solve by synthesis.