Slides for courses based on the textbook
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Eight design methods
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Chapter 1: The Nature of Design

Designers have to:

- **Communicate** - a final design proposal
- **Evaluate** - alternative possible solution concepts
- **Generate** - some solution concepts
- **Explore** - the problem ‘territory’
1 The Nature of Design

Design problems have:

A goal to be achieved
Some constraints within which the goal must be achieved
Some criteria by which a good solution is recognised

Constraints set specific (usually quantitative) targets or limits
Criteria are more flexible and might be used for judging between different design proposals, each of which meets the specific constraint targets.
1 The Nature of Design

Design problems are ill-defined problems

Characteristics of ill-defined problems:

There is no definitive formulation of the problem
Any problem formulation may embody inconsistencies
Formulations of the problem are solution-dependent
Proposing solutions is a means of understanding the problem
There is no definitive solution to the problem
2 Design Ability

Because of the nature of design problems, designers tend to be ‘solution-focused’ (whereas scientists tend to be ‘problem-focused’).

Designers use solution conjectures as ways of exploring and understanding the problem.

Designers actively manage and control the process of design.
2 Design Ability

Experienced designers

Make rapid, controlled exploration of the problem
Move between solution concepts and problem exploration
Maintain a broad view across several sub-solution alternatives
Make designing look easy and ‘intuitive’

Novice designers

Can become ‘bogged down’ in data gathering and analysis
Can become ‘fixated’ on an early solution concept
Can concentrate on exploring single sub-solutions in depth
Need to practice and develop basic techniques
3 The Design Process

Models of the design process

Designers have to:

Explore - the problem ‘territory’

Generate - solution concepts

Evaluate - alternative solution concepts

Communicate - a final proposal
3 The Design Process

Models of the design process

A simple model of the design process, derived from what designers have to do:

- Exploration
- Generation
- Evaluation
- Communication

(iteration)
3 The Design Process

Models of the design process

French’s model:

- Analysis of problem
- Statement of problem
- Conceptual design
- Selected schemes
- Embodiment of schemes
- Detailing
3 The Design Process

Models of the design process

VDI model:

- Overall problem
- Sub-problems
- Partial problems
- Overall solution
- Sub-solutions
- Partial solutions
3 The Design Process

Models of the design process

Cross’s basic model:

Assumes that designers develop the *co-evolution* of problem and solution together, as well as analysing overall problem into sub-problems and synthesising sub-solutions into an overall solution.
4 New Design Procedures

Creative Methods

Brainstorming:

Rules of Brainstorming

No criticism allowed during the session
Large quantity of ideas wanted
Crazy ideas are welcome
Keep ideas short and snappy
Combine and improve on others’ ideas
4 New Design Procedures

Creative Methods

Synectics:

*Uses analogies*

Direct analogies
e.g. biological

Personal analogies
Imagine yourself in the situation

Symbolic analogies
Poetry, metaphors, similes

Fantasy analogies
‘Impossible’ wishes
4 New Design Procedures

Creative Methods

Enlarging the search space:

Transformation
magnify, minify, modify, unify, subtract, add, etc.

Random input
e.g. open a book and choose a word

a string of questions

Counter-planning
thesis + antithesis = synthesis
## 4 New Design Procedures

### Rational Methods: the methods in the book

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4 New Design Procedures
Rational Methods: mapped on to Cross’s model

- Overall problem
  - Clarifying objectives
  - Identifying opportunities
  - Establishing functions
  - Setting requirements
- Sub-problems
  - Improving details
  - Evaluating alternatives
  - Determining characteristics
  - Generating alternatives
- Sub-solutions
- Overall solution
4 New Design Procedures

Rational Methods: exploring overall problem/solution

- Clarifying objectives
  - Objectives tree

- Identifying opportunities
  - User scenarios

- Improving details
  - Value engineering
4 New Design Procedures

Rational Methods: analysing overall problem into sub-problems

- Overall problem
  - Clarifying objectives
    - Objectives tree
  - Establishing functions
    - Function analysis
  - Setting requirements
    - Performance specification
- Sub-problems
4 New Design Procedures

Rational Methods: exploring sub-problems and sub-solutions
4 New Design Procedures

Rational Methods: synthesising sub-solutions into overall solution

- Improving details
  - Value engineering
- Evaluating alternatives
  - Weighted objectives
- Generating alternatives
  - Morphological chart

Overall solution

Sub-solutions
4 New Design Procedures

Rational Methods: the overall model

- Overall problem
- Sub-problems
- Clarifying objectives
- Identifying opportunities
- Improving details
- Evaluating alternatives
- Establishing functions
- Setting requirements
- Determining characteristics
- Generating alternatives
- Overall solution
- Sub-solutions
5 Identifying Opportunities

The User Scenarios Method

Summary
The aim of the user scenarios method is to identify and define an opportunity for a new or improved product.

1. Practice being a user of a product or service.
   Decide which user’s (or users’) point(s) of view to adopt and the variations to the user trip or trips you are going to take.

2. Observe users in action.
   Both experienced and inexperienced users can provide valuable insights.

3. Question users about their experiences.
   This can include the use of formal, structured or unstructured questionnaires, and focused group discussions.

4. Create relevant user personas and scenarios.
   A persona is a well-defined but hypothetical user, and a scenario is a storyline about their use of the product or service.

5. Define the preliminary goal, context, constraints and criteria for a new product opportunity.
   These are the key steps in formulating a good brief for a new product design.
6 Clarifying Objectives

The Objectives Tree Method

Summary
The aim of the objectives tree method is to clarify design objectives and sub-objectives, and the relationships between them.

1. Prepare a list of design objectives. These are taken from the design brief, from questions to the client, and from discussion in the design team.

2. Order the list into sets of higher-level and lower-level objectives. The expanded list of objectives and sub-objectives is grouped roughly into hierarchical levels.

3. Draw a diagrammatic tree of objectives, showing hierarchical relationships and interconnections. The branches (or roots) in the tree represent relationships which suggest means of achieving objectives.
7 Establishing Functions

The Function Analysis Method

Summary
The aim of the function analysis method is to establish the functions required, and the system boundary, of a new design.

1. Express the overall function for the design in terms of the conversion of inputs into outputs. The overall, ‘black box’ function should be broad - widening the system boundary.

2. Break down the overall function into a set of essential sub-functions. The sub-functions comprise all the tasks that have to be performed inside the ‘black box’.

3. Draw a block diagram showing the interactions between sub-functions. The ‘black box’ is made ‘transparent’, so that the sub-functions and their interconnections are clarified.

4. Draw the system boundary. The system boundary defines the functional limits for the product or device to be designed.

5. Search for appropriate components for performing the sub-functions and their interactions. Many alternative components may be capable of performing the identified functions.
8 Setting Requirements

The Performance Specification Method

Summary
The aim of the performance specification method is to make an accurate specification of the performance required of a design solution.

1. Consider the different levels of generality of solution which might be applicable.
   There might be a choice between
   - product alternatives
   - product types
   - product features

2. Determine the level of generality at which to operate.
   This decision is usually made by the client. The higher the level of generality, the more freedom the designer has.

3. Identify the required performance attributes.
   Attributes should be stated in terms which are independent of any particular solution.

4. State succinct and precise performance requirements for each attribute.
   Wherever possible, specifications should be in quantified terms, and identify ranges between limits.
9 Determining Characteristics

The Quality Function Deployment (QFD) Method

Summary
The aim of the quality function deployment method is to set targets to be achieved for the engineering characteristics of a product, such that they satisfy customer requirements.

1. Identify customer requirements in terms of product attributes.
   It is important that ‘the voice of the customer’ is recognised, and that customer requirements are not subject to ‘reinterpretation’ by the design team.

2. Determine the relative importance of the attributes.
   Techniques of rank-ordering or points-allocation can be used to help determine the relative weights that should be attached to the various attributes. Percentage weights are normally used.

3. Evaluate the attributes of competing products.
   Performance scores for competing products and the design team’s own product (if a version of it already exists) should be listed against the set of customer requirements.

continued . . .
9 Determining Characteristics

The Quality Function Deployment (QFD) Method

4. Draw a matrix of product attributes against engineering characteristics. Include all the engineering characteristics that influence any of the product attributes and ensure that they are expressed in measurable units.

5. Identify the relationships between engineering characteristics and product attributes. The strength of the relationships can be indicated either by symbols or numbers; using numbers has some advantages, but can introduce a spurious ‘accuracy’.

6. Identify any relevant interactions between engineering characteristics. The ‘roof’ matrix of the ‘house of quality’ provides this check, but may be dependent upon changes in the design concept.

7. Set target figures to be achieved for the engineering characteristics. Use information from competitor products or from trials with customers.
Summary
The aim of the morphological chart method is to generate the complete range of alternative design solutions for a product, and hence to widen the search for potential new solutions.

1. List the features or functions that are essential to the product. Whilst not being too long, the list must comprehensively cover the functions, at an appropriate level of generalisation.

2. For each feature or function list the means by which it might be achieved. These lists might include new ideas as well as known existing components or sub-solutions.

3. Draw up a chart containing all the possible sub-solutions. This morphological chart represents the total solution space for the product, made up of the combinations of sub-solutions.

4. Identify feasible combinations of sub-solutions. The total number of possible combinations may be very large, and so search strategies may have to be guided by constraints or criteria.
11 Evaluating Alternatives

The Weighted Objectives Method

Summary
The aim of the weighted objectives method is to compare the utility values of alternative design proposals, on the basis of performance against differentially weighted objectives.

1. List the design objectives.
These may need modification from an initial list; an objectives tree can also be a useful feature of this method.

2. Rank order the list of objectives.
Pair-wise comparisons may help to establish the rank order.

3. Assign relative weightings to the objectives.
These numerical values should be on an interval scale; an alternative is to assign relative weights at different levels of an objectives tree, so that all weights sum to 1.0.

4. Establish performance parameters or utility scores for each of the objectives.
Both quantitative and qualitative objectives should be reduced to performance on simple points scales.

5. Calculate and compare the relative utility values of the alternative designs.
Multiply each parameter score by its weighted value - the ‘best’ alternative has the highest sum value; comparison and discussion of utility value profiles may be a better design aid than simply choosing the ‘best’.
12 *Improving Details*

The Value Engineering Method

**Summary**

The aim of the value engineering method is to increase or maintain the value of a product to its purchaser whilst reducing its cost to its producer.

1. List the separate components of the product, and identify the function served by each component.
   If possible, the actual product should be disassembled into its components; exploded diagrams and component-function charts are more useful than parts lists.

2. Determine the values of the identified functions.
   These must be the values as perceived by customers.

3. Determine the costs of the components.
   These must be after fully finished and assembled.

4. Search for ways of reducing cost without reducing value, or of adding value without adding cost.
   A creative criticism is necessary, aimed at increasing the value/cost ratio.

5. Evaluate alternatives and select improvements.
13 Design Strategies

A design strategy provides two things:

1. A *framework* of intended actions.
2. A management *control* function.
# 13 Design Strategies

A possible framework

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13 Design Strategies

Another possible framework

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An appropriate strategy framework depends on the design situation and the design team’s strengths and weaknesses.
13 Design Strategies

Strategy control

Keep your objectives clear

Keep your strategy under review

Involve other people

Keep separate files for different aspects
Design is only one part of a larger process of product development:
**14 Product Development**

Opportunity areas: from low risk to high risk

- **Market Pull**
  - Current market
  - Current technology
  - Product renewal
- **Technology Push**
  - New markets
  - New technology
  - Product development
  - Product innovation

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