The Design Process

Built for resident interaction and adaptability, Gehry says the building “looks like a party of drunken robots got together to celebrate.” With the Disney Hall in LA and the Millennium Park Music Pavilion in Chicago, Gehry is leaving an original imprint on several major U.S. cities. Visit MIT.
Design Process requires:

- Problem definition
- Idea searches
- Solution development
- Solution sharing

Thus there are multiple solutions to each design.

Algorithm

- A set of instructions to solve a task.
- A precise step-by-step plan for a computational procedure that begins with an input value and yields an output value in a number of steps.
- WSR–88D radars (NEXRAD) employ algorithms to analyze radar data and automatically determine storm motion, probability of hail, VIL, accumulated rainfall, and several other parameters.
Design Algorithm

1. Identify the problem or design objective.
2. Define Goals and identify constraints.
3. Research and gather information.
4. Create potential design solutions.
5. Analyze the viability of the solutions.
6. Choose the most appropriate solution.
7. Build or implement (prototype).
8. Test and evaluate the design.
9. Repeat steps until success.

Design Algorithm

1. Identify the problem or design objective.

Design is multifaceted thus multiple solutions

Decide on a solution that meets the most important objectives.
Design Algorithm

Define the problem (problem definition pg59)

Define terms

Talk to the constituencies, stakeholders (users, clients) for feedback (IDEO)

“Construct a residential structure that meets LEED certification.

Sustainability

- Meets the needs of the present without compromising the ability of future generations to do the same.
- Energy usage vs pollution
- Large projects require consideration of multiple issues
- Chocolate and tequila and water usage (in some states) are not sustainable
Design Algorithm

3. Brainstorm, Problem Solve,
4. Define the Goals and Identify constraints
5. Typical Constraints
   - Movement
   - Size
   - Form
   - Energy use
   - Cost

Deciding – *What’s Important?*

- Define the Goals and Identify Constraints
- Generate a set of Criteria (page 63 Fill in CC 3–1)
- Generate a set of Constraints

Typical Constraints
- Movement
- Size
- Form
- Energy use
- Cost
Deciding – What’s Important?

- Criteria must be clearly understood
- *Must* Criteria – Constraints
- *Should* Criteria – preferences or options

- Separate the *wants* (criteria) from the *needs* (requirements)
- Requirements can be imposed legally (CAFÉ regulations)
- Page 64

Design Algorithm

3. **Research and gather Information** (David Kelly)
   - Internet searches
   - Build & test preliminary ideas
   - Interview experts
   - Library
   - Data bases
4. **Create a potential design solution**

Build Prototype(s)
- Page 66

5. **Analyze the viability of solutions**

- Test the ideas
  - Collect and evaluate data
  - See experimental design

6. Select the best idea
Brainstorming – Rules

- Project manager leads
- Everyone gives their ideas – all heard from
- No discussion at this point
- Quiet time – think about ideas
- Discussion time – discuss ideas not people
- Consensus
- Action

Design Algorithm

- 7. Build the Prototype
  - Bill of materials
  - Specifications
  - Tooling
  - Financing
  - Budgeting
  - Contractors
Design Algorithm

8. Test the Prototype
   • Measurement specifications
   • Performance specifications
   • Safety

9. Did it meet specification?
   • Yes – go to market – done with design.
   • No – re-iterate
   • Go back and keep on until successful or out of resources (time, money)
Engineering Design Algorithm

1. **Identify** the problem or design objective.
2. **Define** the goals and identify the constraints. (limitations)
3. **Research** and gather information.
4. **Create** potential design solutions.
5. **Analyze** the viability of solutions.
6. **Choose** the most appropriate solution.
7. **Build** or implement the design.
8. **Test and evaluate** the design.
9. **Repeat** ALL steps as necessary.

6 Choosing – Constraints

*Limits that are placed* on the design problem. For example, a constraint might be that the final design should not cost more than \$X or weigh more than \(Y \text{ pounds}\).
Comparing Design Solutions

- Pairwise Comparison page 65
- Weighted Benefit Analysis page 66
- Scoring Rubric

Comparing Designs, Deciding

- Eliminate any solution that doesn’t meet minimum requirements
- Voting by team members
- Pairwise Comparison for one criteria
  - Table to compare each option in the row with
  - Other options in the columns (page 65)
  - Create a rating scale (0–2)
  - 0 = that column is worse than the row
  - 1 = that column is equal than the row
  - 2 = that column is better than the row
  - Add columns – Highest score is best choice
Pairwise Comparison

- Table 3–1 is for criterion “Safety”
- Use the Options Seatbelt, Airbag, crash Bumper.
- 0 = column worse than row
- 1 = column equal to row
- 2 = column better than row

*Create a pairwise comparison for three snack foods*

Cc 3–2 fuel–efficient Auto Safety criteria comparison

<table>
<thead>
<tr>
<th>safety</th>
<th>Airbag</th>
<th>Seatbelt</th>
<th>Crash bumper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airbag</td>
<td>–</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Seatbelt</td>
<td>2</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Crash bumper</td>
<td>2</td>
<td>1</td>
<td>–</td>
</tr>
</tbody>
</table>

0 column is worse than the row
1 column is same as row
2 column is better than row
Comparing Design Options

- Weighted Benefit Analysis
  - Add weight to more important options
  - Score options against criterion
  - First column contains the Criteria
  - Second column contains the weights
  - Other columns contain options
  - Weight X rating = score
  - Add columns down – highest score is most favorable choice

Weighted Benefit Analysis

- Table 3-2 Each option is scored against the criteria where some criteria is more important than others
- Ratings are from 0 to 10
- Weights x Score = Rating
- Columns are added for each Options and scored.
Weighted benefit Analysis

<table>
<thead>
<tr>
<th></th>
<th>Weight</th>
<th>Fiesta</th>
<th>Aro</th>
<th>Smart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wow</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Each design score is rated from 1 to 10
The score is multiplied by the Weight to get the weighted value.
The scores are added and the highest is the selected design

Pairwise comparison

- Rates row against column

<table>
<thead>
<tr>
<th>Safety</th>
<th>Yellow zone</th>
<th>Kill switch</th>
<th>Blade guard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blade guard</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Kill switch</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Yellow zone</td>
<td></td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Max column number best choice
Comparing Design options

- Scoring rubric
- Create a defined scale
- How well does the option meet the criteria?

<table>
<thead>
<tr>
<th>Score</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not Satisfactory</td>
</tr>
<tr>
<td>1</td>
<td>Barely applicable</td>
</tr>
<tr>
<td>2</td>
<td>Fairly good</td>
</tr>
<tr>
<td>3</td>
<td>Good</td>
</tr>
<tr>
<td>4</td>
<td>Very Good</td>
</tr>
</tbody>
</table>

Design example: The Cell phone

- The engineer guy cell phone design– constraints
- Compactness verses usability– size constraints
- Consumer constraints
- Energy constraints
- Economic constraints
- Material constraints Knowledge of materials (plastics)
- Societal constraints
- Cultural constraints
What is a Prototype? IDEO

- The original or model on which something is based or formed.
- Modern manufacturing procedures employ the use of techniques that allow engineers to go directly from drawing to prototype using say, stereo lithography hence “rapid prototyping”.

Brainstorming –rules

- Project manager leads
- Everyone gives their ideas – all heard from
- Quantity vs. quality
- No discussion at this point
- Quiet time – think about ideas
- Discussion time – discuss ideas not people
- Consensus
- Action
Group Presentations *include* slides for–

- How did the Team brainstorm?
- Style – How does this group work together?
- What works in this group?
- What needs to be improved?
- Show and tell –

Experimental Measurements

- Independent variable
- Dependent variable
  - Actual value measured
  - Data collection instrument
  - Level of uncertainty
Ideo

- Brainstorming
- The deep dive
- Observe the process >>>
- No "experts"
- They know –How to innovate–

IDEO Design Process

The IDEO Process is made up of 5 steps:

1. **Step 1** Understand and Observe
   - Scope the project
   - Learn first-hand about people and contexts of use

2. **Step 2** Synthesize
   - Translating research insights into opportunities for design

3. **Step 3** Visualize
   - Creating visible and tangible experiences

4. **Step 4** Prototype, evaluate, and refine
   - Improving designs ideas by making these physical, so users can interact with them

5. **Step 5** Implement
   - Supporting resolution of human issues in the first design
What is IDEO?

IDEO is a widely admired, award-winning design and development firm in Palo Alto, California. For founder David M. Kelley and his colleagues, work is play, brainstorming is a science, and the most important rule is to break the rules. The Wall Street Journal dubbed their offices "Imagination's Playground," and Fortune.

IDEO has brought the world the Apple mouse, Polaroid's Zone instant camera, the Palm handheld, the Crest Neat Squeeze tube with its one-twist cap and hundreds of other cutting-edge products.

- Problem Solving
- One approach – Design Thinking
- [http://youtu.be/a7sEoEvT8I8](http://youtu.be/a7sEoEvT8I8)
- Stanford Design Thinking Crash Course
- [https://www.youtube.com/watch?v=-FzFk3E5nxM](https://www.youtube.com/watch?v=-FzFk3E5nxM)
### Consensus

- Brainstorming decisions require consensus
- Consensus – all agree on the solution

### Build

- Use materials, tools, and machines to implement the design
- MIT
Test and Evaluate

- Apply analytical techniques to evaluate the effectiveness of the design.
- Does the design meet specifications?
  - Safety?
  - Reliability?
  - Cost analysis?
  - Functionality?
  - Aesthetics?

Repeat process

- If the design falls short of the predefined specifications the design team goes back to work to redesign, rebuild and retest (reiterates) until the design meets specification.
Practical Design Process

Team Design Problem
Page 81 ICA 3–3

- Team 1 – b
- Team 2 – c
- Team 3 – d
- Team 4 – e