Lecture 4: Concept Generation

Outline:

- PROCEDURAL TECHNIQUES FOR CONCEPT GENERATION
- BRAINSTORMING
- MORPHOLOGICAL CHARTS
- MIND MAPS
- 6-3-5 METHOD
- BARRIERS TO CREATIVE THINKING
- OTHER TECHNIQUES FOR GENERATING ALTERNATIVES
The “General” Design Process Model

Identify Need
- Talk with Client
- Project Goals
- Information Gathering

Problem Definition
- Problem Statement
- Information Gathering
- Design Objectives (quantifiable/measurable)

Conceptualization
- Brainstorming
- Drawing/Visualization
- Functional Decomp.
- Morphologic Chart

Preliminary Design & Planning
- Prelim. Specifications
- Prelim. Analysis
- Decision Making
- Gantt Charts & CPM

Detailed Design
- Detailed Analysis
- Simulate & Optimize
- Detail Specifications
- Drawings, GD&T

Prototyping
- Prototype Fabrication
- Concept Verification

Testing/Evaluation
- Evaluate Performance
- Are Objectives Met?
- Iterate Process Steps 2 - 7 as needed

Report/Deliver
- Oral Presentation
- Client Feedback
- Formal Design Report

Quotes on Creativity

“Creativity is the power to connect the seemingly unconnected”, [William Plomer]

“Any activity becomes creative when the doer cares about doing it right, or doing it better,” [John Updike]

“A hunch is creativity trying to tell you something,” [Frank Capra]

“Making the simple complicated is commonplace; making the complicated simple, awesomely simple, that is creativity,” [Charles Mingus]

“Genius is one percent inspiration and ninety-nine percent perspiration”, [Thomas A. Edison]
Concept Generation:

This is a creative phase of the design process, where several ideas or concepts are generated. It is the divergent phase where many possibilities are considered without too much judgement.

For a typical design project, at least three conceptual design alternatives should be generated. These concepts should be well documented, using sketches and descriptions.

There is no formula or set of rules to generate ideas out of thin air! Rather, a set of practical strategies to help designers to enhance their inherent creativity, and to facilitate the generation of new ideas, are presented next:

Concept Generation Strategies:

Strategy 1) Study and review existing design examples on a periodic basis. Creativity cannot occur in a vacuum of knowledge! It often comes from exposure to many other ideas, previous experience, and practical lessons.

Strategy 2) Illustration and drawing is an important way to generate new ideas and record them. Some designers are abstract thinkers while others are visual and spatial thinkers. By preparing a drawing, limitations can be revealed, or ideas can be built upon.

Strategy 3) Work within a team environment to generate new ideas. In this case, techniques such as: Brainstorming, or the 6-3-5 method, can be an effective group activity for the generation of new ideas.
**Concept Generation Strategies:**

- **Strategy 4)** Morphological Analysis is a technique that encourages a designer to consider the combination of two seemingly unrelated concepts. Morphological analysis often leads to impractical ideas, however, those ideas may eventually lead to practical ones.

- **Strategy 5)** Allow ample time for Reflection on ideas, and allow for iteration. Creativity cannot be rushed, and setting a strict time-line for the creative phase may limit the best solutions from emerging. Iteration is important, since often the original concept leads to a better idea. Sometimes an idea suddenly emerges for a design solution, while the designer is in the midst of another unrelated activity. This is sometimes referred to as an “Ah-ha moment”, which is more likely to occur when the creative process is given ample time.

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**Brainstorming for Concepts**

- Designate a group leader/facilitator

- Optimal group size 5-10

- Brainstorm for 30-45 minutes

- Do not confine the group to experts in the area

- Plan the session in advance, and ask members to prepare by bringing a few of their own ideas to the session

- Avoid hierarchically structured groups
Rules of Brainstorming

Find a comfortable meeting environment

Appoint one person to record the ideas that come from the session. These should be noted in a format that everyone can see and refer to. Depending on the approach you want to use, you may want to record ideas on flip charts, whiteboards, or computers with data projectors.

Define the problem you want solved clearly, and lay out any criteria to be met. Make it clear that the objective of the meeting is to generate as many ideas as possible.

Give people plenty of time on their own at the start of the session to generate as many ideas as possible.

Ask people to give their ideas, making sure that you give everyone a fair opportunity to contribute.

Encourage people to develop other people's ideas, or to use other ideas to create new ones.

Encourage an enthusiastic, uncritical attitude among members of the group. Try to get everyone to contribute and develop ideas, including the quietest members of the group.

Ensure that no one criticizes or evaluates ideas during the session. Criticism introduces an element of risk for group members when putting forward an idea. This stifles creativity and cripples the free running nature of a good brainstorming session.

Let people have fun brainstorming. Encourage them to come up with as many ideas as possible, from solidly practical ones to wildly impractical ones. Welcome creativity!

Ensure that no train of thought is followed for too long. Make sure that you generate a sufficient number of different ideas, as well as exploring individual ideas in detail.

In a long session, take plenty of breaks so that people can continue to concentrate.

[From: www.mindtools.com]
Example of Brainstorming

Creation of a Foldable, Rapidly Deployable, Emergency Shelter

[Image from: www.theorangeengineer.com/dp1.htm]

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Example of Brainstorming

Follow the rules of brainstorming to come up with a “New Olympic Winter Sport.”
Morphological Analysis

Morphological Analysis is a technique that encourages a designer to consider the combination of two seemingly unrelated concepts.

The technique is best implemented by creating a Morphological Chart, with two axes of information. Each axis describes an attribute, design objective or some function of the design.

The information in the two axes should be relatively independent, to help with the generation of interesting ideas.

Each function or attribute is assigned a dimension in an array:

```
Dimension 1

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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Dimension 2

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</tbody>
</table>
```
### Morphological Analysis

Consider the “Product” of one Function “times” another Function

<table>
<thead>
<tr>
<th>Function or Attribute</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td>4</td>
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<td>4 x B</td>
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<td>5</td>
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<td>6</td>
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<td>7</td>
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<td></td>
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<tr>
<td>8</td>
<td></td>
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<td>8 x C</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### Example 1 of Morphological Chart

Example of Designing an Power Generation Plant

<table>
<thead>
<tr>
<th>Resource Available</th>
<th>Conversion Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thermal</td>
</tr>
<tr>
<td>Fossil Fuel</td>
<td>X</td>
</tr>
<tr>
<td>Nuclear</td>
<td>X</td>
</tr>
<tr>
<td>Wood</td>
<td>X</td>
</tr>
<tr>
<td>Wind</td>
<td></td>
</tr>
<tr>
<td>Solar</td>
<td>X</td>
</tr>
<tr>
<td>Hydro</td>
<td></td>
</tr>
<tr>
<td>Tidal</td>
<td></td>
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<tr>
<td>Wave</td>
<td></td>
</tr>
<tr>
<td>Geothermal</td>
<td>X</td>
</tr>
</tbody>
</table>

[Fig. 6.22 from Engineering Design Textbook]
### Example 2 of Morphological Chart

Create a Morphological chart to come up with a “New Olympic Sport”. In one dimension use environment/terrain. In the other dimension, use equipment.

<table>
<thead>
<tr>
<th>Environment/Terrain</th>
<th>Hill</th>
<th>Water</th>
<th>Field</th>
<th>Sky</th>
<th>Snow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment</td>
<td>Skis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guns</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Ball</td>
<td></td>
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<td></td>
<td>Body Pads</td>
<td></td>
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<td></td>
<td>5</td>
<td></td>
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<tr>
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<td>6</td>
<td></td>
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</tbody>
</table>

### Example 3 of Morphological Chart

Create a Morphological chart for “New Vibration/Motion Energy Harvester”. In one dimension use location of use. In the other dimension, use transduction mechanism.

<table>
<thead>
<tr>
<th>Location of Use</th>
<th>Water</th>
<th>Animal</th>
<th>Sky</th>
<th>Automobile</th>
<th>Ship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transduction Mechanism</td>
<td>Rotational Wheel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Linear Motion</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>See-Saw Lever</td>
<td></td>
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<tr>
<td></td>
<td>Gears</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td></td>
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</tbody>
</table>

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Example of Illustration and Drawing

Creation of a Foldable, Rapidly Deployable, Emergency Shelter

[images from: www.theorangeengineer.com/dp1.htm]

Mind Maps

A graphical or visual way of organizing ideas stemming from a single word.

The ideas branch radially outward from a single word, into various sub-sections which can branch out further as necessary.

Considered to be a more intuitive/natural/organic way to record ideas, allowing for the creator to revisit different branches, and add as necessary as new ideas grow from existing ones.

References:
http://en.wikipedia.org/wiki/Mind_maps
http://images.google.com/ search for: ‘mind map’
http://www.youtube.com/watch?v=MlabrWv25qQ
Example: Memory (Mind) Maps

[Image from: http://live-the-solution.com/mindmaps/]

Example: Memory (Mind) Maps

[Image from: http://www.markchannon.com/thoughts/mind-mapping-at-the-future-of-web-apps/]

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C-Sketch/6-3-5 Method

A systematic way to generate ideas

Involves 6 people, who each write down 3 ideas within 5 minutes, on a piece of paper.

Next, everyone passes their paper of ideas to their neighbor.

With the new paper in hand, everyone attempts to further develop the idea from their neighbor, or vary that idea, or if necessary add a new idea.

The sheets pass through all people (i.e. 5 exchanges) to create up to 108 ideas!

Advantages:

- Easy to Do/Use method
- No moderator required
- All participants are fully active (out-spoken and soft-spoken)
- Ideas receive systematic evaluation and development by all members

Disadvantages:

- Time limit creates pressure to develop ideas
- No group discussion of ideas

References:

- http://www.youtube.com/watch?v=TR1i1PPd8ZU
Barriers to Creative Thinking

Types of Barriers:

- Cultural Barriers: ______________________________
- Environmental Barriers: ___________________________
- Emotional Barriers: ______________________________
- Intellectual Barriers: ______________________________
- Perceptual Barriers: (see next pages)

Perceptual Barriers

Types of Perceptual Barriers:

- Patterns: Many designs involve incremental developments/improvements over a long history. As a result, patterns develop, which frame the thinking and development of future ideas.

  - Example: Consider the ‘internal combustion engine’

  - One way to ‘break out of a pattern’ is to go back and carefully consider the ‘original basic need’ for the design/product.
Types of Perceptual Barriers:

**Boundaries**: People will sometimes impose artificial ‘pre-assumptions’ or ‘boundaries’ to frame the scope of a problem, where in fact those boundaries or assumptions do not exist. These perceived constraints can severely limit the possibilities for creative solutions.

**Illusions**: Perceiving objects (visual), or even conceptually (glass half empty, glass half full, etc...) can skew interpretation of the situation. Example:_________________________

**Lenses/Filters**: Perceiving objects with an inappropriate field of view, or focus (visual) or conceptually focused (briefing session, prior knowledge) can skew interpretation of the situation. Example:_________________________

Lesson learned: If we act too quickly on our first impression/perception of an object or situation, we may misinterpret the situation, or might ignore alternative explanations, and hence the scope of the creative solutions.
Types of Perceptual Barriers:

**Meanings:** This arises out of our habit of adopting conventional roles for objects or situations. Hence, we limit the available options by failing to consider alternative roles for those same objects or situations.

**Example:** ______________________________
_____________________________
_____________________________

Other Techniques for Generating Alternatives

- Lateral Thinking
- Perseverance
- Mental Push-ups

Note: Chapter 6 in the textbook provides more information and refers to these techniques.
Techniques for Generating Alternatives

**Lateral Thinking:** The broad search for multiple design concepts/ideas

During the concept generation phase:
- Generate a large number of concepts from the beginning.
- Resist the urge to pursue any one of the concepts in detail.
- Avoid critiquing any of the concepts

In other words, make sure that during your design process, you clearly separate Step 4 (Concept Generation) from Step 5 (Evaluating Concepts).

Lateral thinking can be hard to do, and requires will power and discipline, since as engineers, we tend to do ‘vertical thinking’, i.e. an in-depth examination of one alternative in progressively greater detail.

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**Perseverance:**

- Don’t give up on an idea too quickly. Give yourself time to reflect.
- Most great ideas are a result of long, deliberate thought and gradual evolution.
- Quotation: “Genius is one percent inspiration and ninety-nine percent perspiration” [Thomas Edison]

**Mental Push-ups:**

- Keep your creative skills and mind in top shape at all times.
  - Make Lists
  - Word Games
  - Solving Puzzles