ECEN 478: Senior Design

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March 3, 2023

Outline

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- Creativity is different from innovation.
- It refers to the ability to develop new ideas. However, innovation is the ability to bring creative ideas to reality
- This chapter addresses creativity, concept generation, and evaluation in design.

Learning Objectives

- Understand the importance of creativity, innovation, concept generation, and concept evaluation in engineering design.
- Be familiar with the barriers that hinder creativity.
- Be able to apply strategies and formal methods for concept generation.
- Be able to apply techniques for the evaluation of design concepts.

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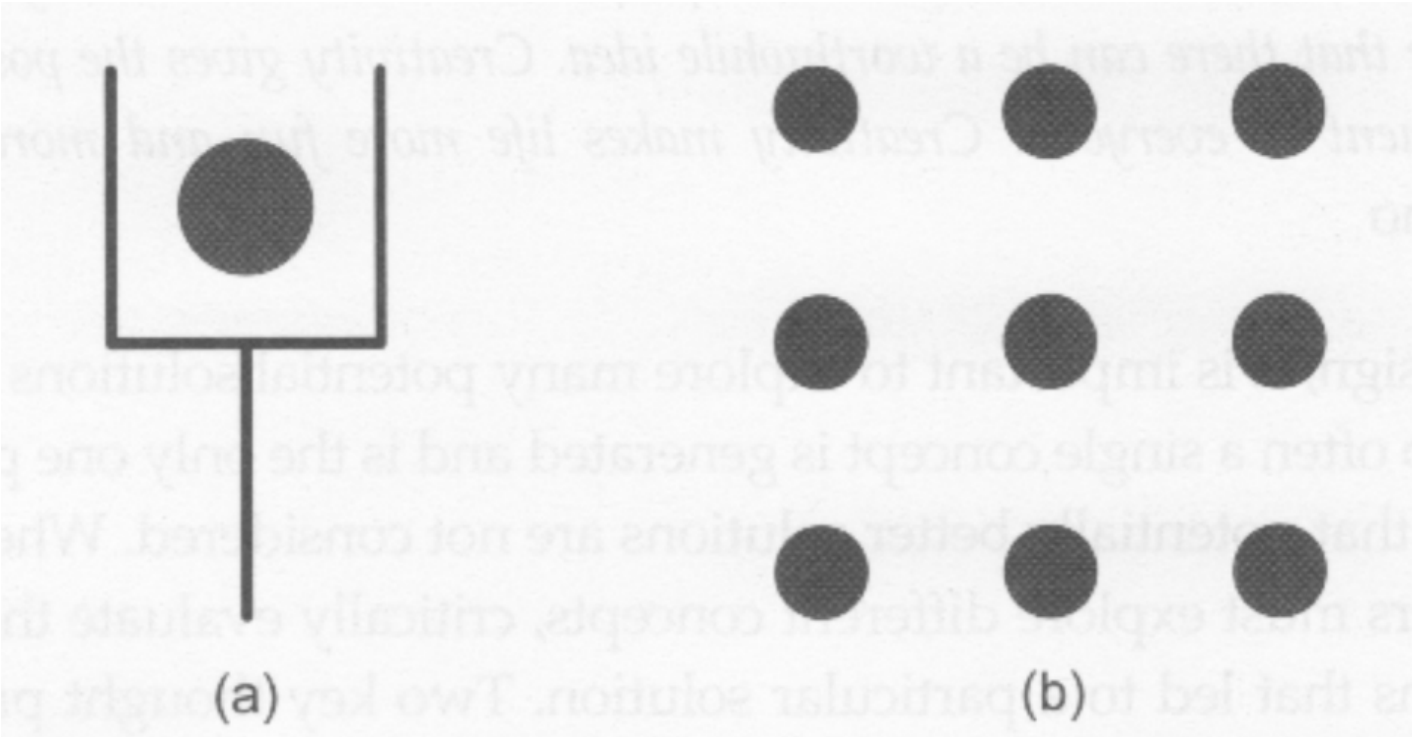

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Barriers to Creativity

James L. Adams, professor at Stanford University, examined the barriers to creativity and classified them into the following Four types:

- Perceptual blocks
- Emotional blocks
- Cultural and environmental blocks
- Intellectual and expressive blocks

Perceptual blocks

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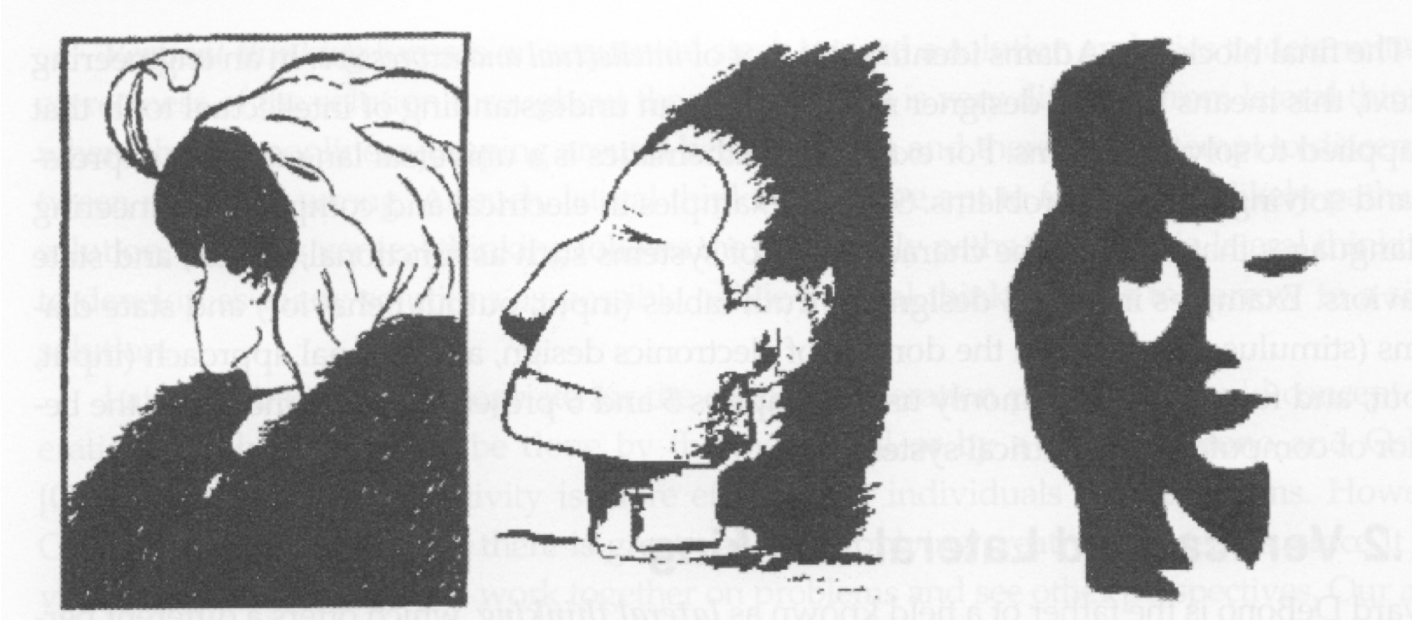

Emotional blocks

- One of the most common emotional blocks is the fear of failure.
- Afraid to receive criticism for incorrect answer.
- Successful product design company the approach in concept generation to "fail early and often" in order to succeed.
- Another emotional block is a fear of chaos and disorganization.
- Tendency to critically judge ideas, rather than generate and build upon them.

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- There are also cultural biases against creativity.

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- Examples in digital design are truth tables (input, output behavior) and state diagrams (stimulus-response).
- In the domain of electronics design, a functional approach (input, output, and function) is commonly used.

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- This is usually based upon experience solving similar problems and conventional tools that are employed in that par- ticular area.

Lateral Thinking

- The objective of lateral (or divergent) thinking is to identify creative solutions.
- It is not about developing a solution, or right or wrong solutions.
- It encourages jumping around between ideas.

Vertical and Lateral Thinking

The vertical thinker says: *'I know what I am looking for.'*

The lateral thinker says: *'I am looking but I won't know what I am looking for until I have found it.'*

Example

A body is discovered in a park in Chicagoin the middle of the summer. It has a damaged skull and many other broken bones, but the cause of death was hypothermia.

Can you develop plausible scenario that describe the situation?

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- The goal in lateral thinking is to develop as many solutions as possible, while vertical thinking tries to narrow to a single solution.
- Thus, lateral thinking is appropriate for the concept generation phase.

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- Think like a beginner.
  - Experience is a double-edged sword

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- **Rearrange or Reverse** Can elements of the system be rearranged differently to work better?

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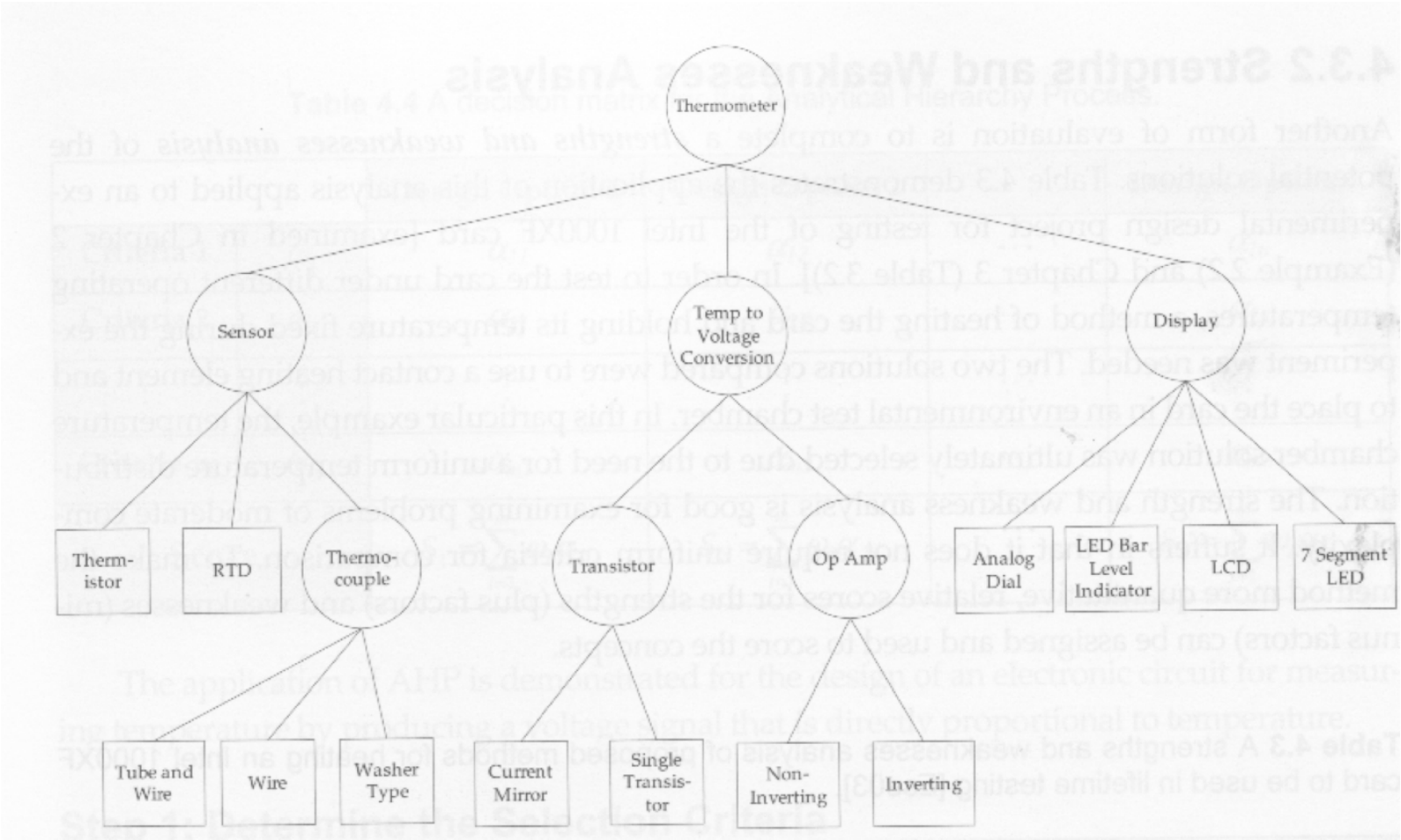
6. Vote.

Outline

Concept Generation Table

User Interface	Display	Connectivity and Expansion	Power	Size
Keyboard	CRT	Serial & Parallel	Battery	Handheld, Fits in Pocket
Touchpad	Flat Panel	USB	AC Power	Notebook Size
Handwriting Recognition	Plasma	Wireless Ethernet	Solar Power	Wearable
Video	Heads-up Display	Wired Ethernet	Fuel Cell	Credit Card Size
Voice	LCD	PCMCIA	Thermal Transfer	Flexible in Shape
		Modem / Telephone		

Concept Generation Fan

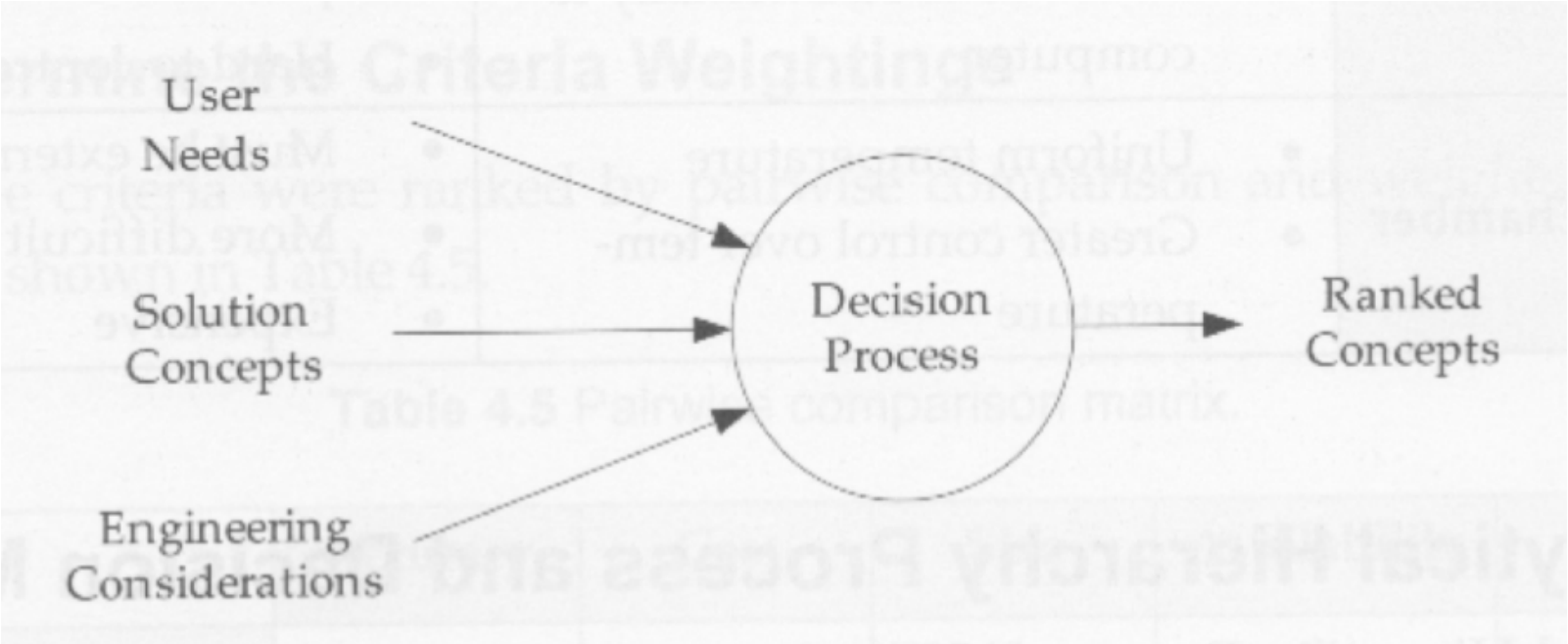


The circles represent the choices to be made and the squares represent potential solutions to the choices.

Outline

Concept Evaluation

- The concepts generated are evaluated to determine which are the most promising to pursue.



Initial Evaluation

- The concepts generated should be initially reviewed and those that are completely infeasible are discarded.
- infeasiblity
  - Cost
  - Too long to develop
  - Too much risk
  - Not meeting user requirements
  - Not meeting engineering requirements

Outline

Strength and Weakness Analysis

Assume we want to compare two experimental design project for testing of the Intel 1000XF card to test performance.

Method	Strengths	Weaknesses
Contact Heating	• Simplest design • Could be used internally to computer	• Does not create uniform temperature • Hard to control temperature
Temperature Chamber	• Uniform temperature • Greater control over temperature	• Must be external to computer • More difficult to design • Expensive

To make the method quantitative, relative scores for the strengths (plus factors) and weaknesses (minus factors) can be assigned

AHB: Decision Making with Analytical Hierarchy Process

AHI is a flexible quantitative and qualitative method, applicable to many problems

- To apply AHP there must be a decision to be made, criteria against which the decision is based, and a set of competing decisions from which one must be selected.
- This process is encapsulated in a decision matrix

		Alternative 1	Alternative 2		Alternative n
Criteria 1	ω_1	α_{11}	α_{12}	$\cdots$	α_{1n}
Criteria 2	ω_2	α_{21}	α_{22}	$\cdots$	α_{2n}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\cdots$	$\vdots$
Criteria m	ω_m	α_{m1}	α_{m2}	$\cdots$	α_{mn}
Score		$S_1 = \sum_{i=1}^{m} \omega_i \alpha_{i1}$	$S_2 = \sum_{i=1}^{m} \omega_i \alpha_{i2}$	$\cdots$	$S_n = \sum_{i=1}^{m} \omega_i \alpha_{in}$

Applying AHP for Car Selection

Steps for AHB:

1. Determine the selection criteria.
2. Determine the criteria weightings.
3. Identify and rate alternatives relative to the criteria.
4. Compute the scores for the alternatives
5. Review the decesion.

Lets apply the AHP for Car Selection

Step 1: Determine the Selection Criteria

Assume that the criteria determined are:

- Purchase cost
- Safety
- Design styling
- Brand-narne recognition

Step 2: Determine the Criteria Weightings

- Pairwise comparison is applied.

1 = equal, 3 = moderate, 5 = strong, 7 = very strong 9 = extreme.

	Purchase cost	Safety	Design	Brand name
Purchase cost	1	1	3	7
Safety	1	1	5	9
Design	1/3	1/5	1	3
Brand name	1/7	1/9	1/3	1

Step 2: Determine the Criteria Weightings

	Purchase cost	Safety	Design	Brand name	Geometric Mean	Weights
Purchase cost	1	1	3	7	2.1	0.37
Safety	1	1	5	9	2.6	0.46
Design	1/3	1/5	1	3	0.7	0.12
Brand name	1/7	1/9	1/3	1	0.3	0.05

$$\text{Geometric mean} = \sqrt[n]{a_1 a_2 \cdots a_n}.$$

$$\sum_i \omega_i = 1.$$

Step 3: Identify and Rate Alternatives Relative to the Criteria

The three competing alternatives to be evaluated are the Honda CR-V, Hyundai Tucson, and Toyota RAV4.

- For fair comparison, it is important that the ratings relative to each criteria be normalized so that their sum is one. if not, the sum of ratings for each criterion will be different.

Lets compute α score for each criteria and each car.

Step 3: Identify and Rate Alternatives Relative to the Criteria (Cost)

The vehicle costs are \$21,026(Honda), \$18,183 (Hyundai), and \$21,989 (Toyota).

$$\alpha = \frac{\text{min[cost]}}{cost}$$

The cost ratings are computed to be $\alpha 1$: 0.86, $\alpha 2 = 1$, and $\alpha 3 =$ 0.83.

The normalized values are $\alpha 1$: 0.32, $\alpha 2 = 0.37$, and $\alpha 3 =$ 0.31.

Step 3: Identify and Rate Alternatives Relative to the Criteria (Safety)

According to US. National Highway Transportation Safety Association the average safety rating for each car on scale of 5-points is $\alpha 1 = 4.8$ (Honda), $\alpha 2$: 4.8 (Hyundai), and $\alpha 3$: 4.6 (Toyota)

The normalized values are computed to be $\alpha 1$: 0.34, $\alpha 2 = 0.34$, and $\alpha 3 =$ 0.32.

Step 3: Identify and Rate Alternatives Relative to the Criteria (Style)

It is subjective so we will return to pairwise comparison.

	Honda CRV	Hyundai Tucson	Toyota RAV4	Design Rating
Honda CRV	1	1/3	1/5	0.11
Hyundai Tucson	3	1	1/2	0.31
Toyota RAV4	5	2	1	0.58

Step 3: Identify and Rate Alternatives Relative to the Criteria (Style)

It is subjective so we will return to pairwise comparison.

	Honda CRV	Hyundai Tucson	Toyota RAV4	Brand name Rating
Honda CRV	1	4	1	0.44
Hyundai Tucson	1/4	1	1/4	0.12
Toyota RAV4	1	4	1	0.44

Step 4: Compute Scores for the Alternatives

The decision matrix is built and the overall weighted scores for the alternatives are computed

		Honda CR-V	Hyundai Tucson	Toyota RAV4
Cost	0.37	0.32	0.37	0.31
Safety	0.46	0.34	0.34	0.32
Design styling	0.12	0.11	0.31	0.58
Brand name	0.05	0.44	0.12	0.44
Score		**0.31**	**0.34**	**0.35**

Step 5: Review the Decision

- if all work is done properly the final scores should sum to one.
- In this case there is not much difference between the scores, and a simple decision based upon the maximum value would lead to selection of the RAV4.

Pugh Concept Selection

1. Select the comparison criteria, usually the engineering or marketing requirements.
2. Determine weights for the criteria.
3. Determine the concepts.
4. Select a baseline concept that is initially believed to be the best.
5. Compare all other concepts to the baseline, using the following scoring method: +1 better than, 0 equal to, —l worse than.
6. Examine each concept to determine if it should be retained, updated, or dropped. Synthe- size the best elements of others into other concepts wherever possible.
7. Compute a weighted score for each concept, not including the baseline.
8. Update the table and iterate until a superior concept emerges.

Pugh Concept Selection

		Option 1 (Reference)	Option 2	Option 3	Option 4
Criteria 1	4	-	0	0	+1
Criteria 2	5	-	+1	−1	0
Criteria 3	2	-	−1	0	+1
Criteria 4	1	-	+1	+1	−1
Score		-	4	−4	5
Continue?		Combine	Yes	No	Combine

Project Application

- Identify different design alternatives (see also Chapters 5 and 6).
  - Search externally
  - Brainstorming sessions.
  - Nominal Group Technique
  - Morphology (Concept Tables and Fans)
- SCAMPER
  - Identify leading concept and justify
  - Strength & Weaknesses Analysis
  - Decision Matrices
  - Pugh Concept Selection

Summary

- Open your mind to creativity
  - Innovation is important
  - There are strategies to apply
- Apply Methods of Concept Generation
  - Search externally: Patents, research, experts
  - Search internally: SCAMPER, Morph Charts,
  - Concept Fans, Brainstorming, Nominal Group Technique
- Evaluate Concepts Critically
  - Strengths/Weaknesses
  - Decision Matrices
  - Pugh Concept Selection

References

- Ford, Ralph Michael Coulston, Chris S - Design for electrical and computer engineers theory, concepts, and practice-McGraw-Hill (2008)

Questions