ENGR 13x2
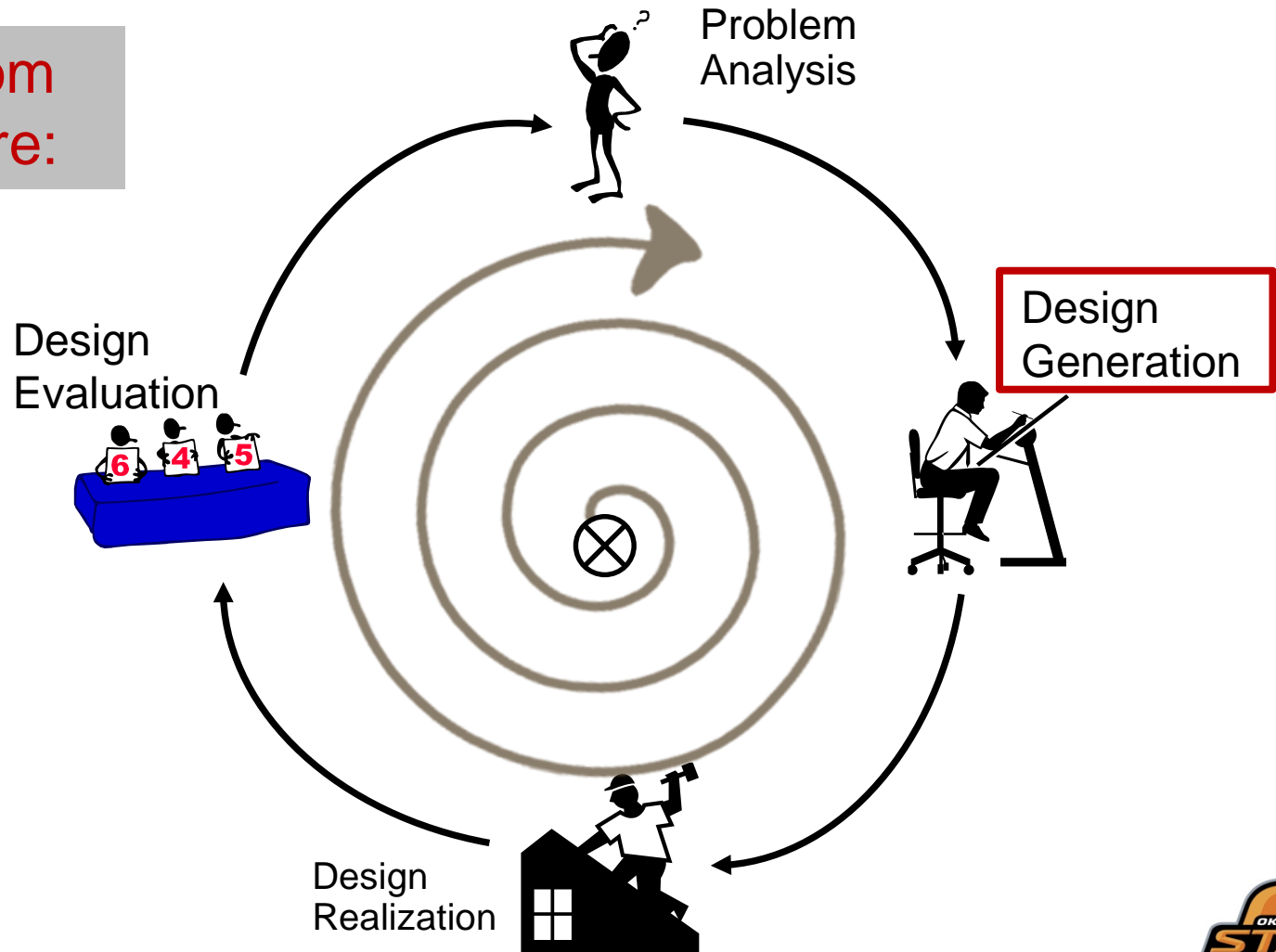# Engineering Design with CAD

Creativity & Analytical Decision Making Tools

The Design Cycle

Recall from last lecture:

Problem Analysis

Design Generation

Design Evaluation

6   4   5

Design Realization

OKLAHOMA STATE UNIVERSITY

Agenda

- Creativity

- Generating creative ideas

- Evaluating ideas
  - SWOT analysis
  - Weighted decision matrix
  - Paired Comparison analysis

Creativity . . .

- Not limited to music, art, and literature
- Critical to the design process
  - Separates design from analysis and replication
  - You can't make the necessary changes in the design cycle without it
- Feels difficult sometimes
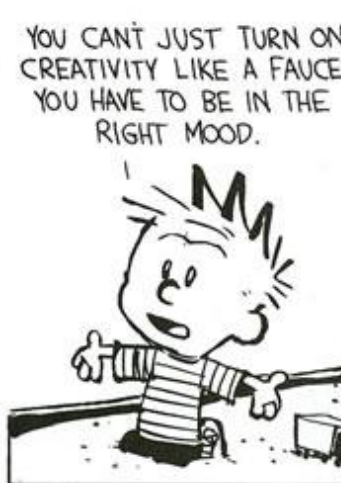
Barriers to creativity

- Internal factors
  - Fear of rejection / failure / risk
- Pre-conceived notions
  - "I'm just not a creative person"
- Failure to look past an obvious first solution
  - "Good is the enemy of Great" – Jim Collins
- Pre-judging ideas
- Time crunch

Generating creative ideas

- Informal brainstorming
  - Ideas are contributed randomly by any group member
  - Ideas are collected, reviewed, and discussed by the group
- Allows members to play off one another
- Can generate a large number of ideas in a short period of time
- Done effectively, can break down barriers to creativity
- Better for small groups

Ground rules

○ Absolutely necessary for success!

○ Each group sets their own – some guidelines:
  - No holding back – any idea, any time
  - No boundaries – no idea is "too crazy"
  - No criticizing – don't critique until the final discussion
  - No dismissing – don't discount an idea
  - No limit – one more idea is always good
  - No restrictions – draw from any field of experience
  - No shame – no one should ever be made to feel embarrassed about an idea

Let's try an example…

PROBLEM – There is a large squirrel population at OSU. Many squirrels are killed each semester by cars traveling on University Street. How can we prevent the death of these poor, innocent creatures?

Formal brainstorming

- Works better in large or unfamiliar groups
  - Keeps 1 or 2 from dominating the discussion
    - Don't want anyone to check out of the process
  - Draws in all group members
  - Avoids a chaotic environment where ideas cannot be captured and creativity is inhibited
    - Fill a cup with a fire hose . . .
  - Provides an opportunity for people to think
- Requires someone to serve as facilitator
  - Run the session and enforce the "rules"

Two methods

- Brainwriting
- Idea Trigger

- There are MANY others . . . .

Brainwriting

- Each member writes down an idea on a piece of paper
- After a given period of time, everyone passes their paper to the next participant
- Next participant can build on this idea or write a new one
- Continue until the papers make their way back to the beginning
- Compile and review ideas

Idea Trigger

- Phase 1 – Idea Generation
    - Each member has a paper divided into four or five columns
    - Design issue is summarized by the facilitator
    - Each participant writes, in column one, as many ideas as possible
        - 2 minutes, break, 1 minute
    - Encourage the trivial and the ridiculous
    - No talking during this phase
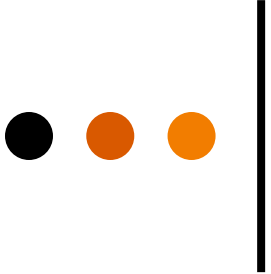
Idea Trigger

- Phase 2 – Idea Trigger
  - Take turns reading ideas from column 1
  - Other members cross out duplicates
  - Write new ideas in column 2
  - Repeat with column 2, 3, etc. until ideas are exhausted
  - 2nd and 3rd column are usually the most creative

Idea Trigger

- Phase 3 – Compilation
  - Facilitator generates a master list of all ideas generated
  - Discuss all ideas, decide which ones to keep for further consideration

What next?

- Once we have brainstormed ideas, we need strategies for narrowing down and selecting which idea(s) to pursue further.

SWOT Analysis

- A structured way of identifying a potential design's
  - <u>S</u>trengths
  - <u>W</u>eaknesses
  - <u>O</u>pportunities
  - <u>T</u>hreats

Weighted Decision Matrix

○ To make confident and rational decisions when you have multiple options and multiple factors to take into account.

- Step 1: List each option as a column heading and each factor/criteria as a row.

- Step 2: Assign a "weight" to each criteria based on its relative importance.

- Step 3: Work through the table, giving a *raw score* to each option for each criteria.

- Step 4: Multiply raw scores by weights.

- Step 5: Add up the *weighted scores* for each option and look for the highest.

Decision Matrix Example

Weighted Decision Matrix Example

Criteria	Concept Weight	A Raw	A Wtd	B Raw	B Wtd	C Raw	C Wtd	D Raw	D Wtd	E Raw	E Wtd
I	1										
II	1.5										
III	1										
IV	2										
V	3										
Totals:											

Scale for Weight Values:

4   Critical importance

3   High importance

2   Medium importance

1   Low importance

0   Minimum importance

Decision Matrix Example

Weighted Decision Matrix Example

Concept		A		B		C		D		E	
Criteria	Weight	Raw	Wtd	Raw	Wtd	Raw	Wtd	Raw	Wtd	Raw	Wtd
I	1	2		3		1		0		2	
II	1.5	1		1		3		3		3	
III	1	4		4		3		4		2	
IV	2	2		2		4		2		3	
V	3	1		2		1		4		2	
Totals:											

Scale for Weight Values:

4   Critical importance

3   High importance

2   Medium importance

1   Low importance

0   Minimum importance

Scale for Raw Scores:

4   Far exceeds requirement

3   Exceeds requirement

2   Meets requirement

1   Minor deficiencies

0   Does not meet requirement

Decision Matrix Example

Weighted Decision Matrix Example

Concept		A		B		C		D		E	
Criteria	Weight	Raw	Wtd	Raw	Wtd	Raw	Wtd	Raw	Wtd	Raw	Wtd
I	1	2	2	3	3	1	1	0	0	2	2
II	1.5	1	1.5	1	1.5	3	4.5	3	4.5	3	4.5
III	1	4	4	4	4	3	3	4	4	2	2
IV	2	2	4	2	4	4	8	2	4	3	6
V	3	1	3	2	6	1	3	4	12	2	6
Totals:		14.5		18.5		19.5		24.5		20.5	

Scale for Weight Values:

4   Critical importance

3   High importance

2   Medium importance

1   Low importance

0   Minimum importance

Scale for Raw Scores:

4   Far exceeds requirement

3   Exceeds requirement

2   Meets requirement

1   Minor deficiencies

0   Does not meet requirement

Another Example

	A	B	C	D	E	F	G	H
1	Options (Alternatives)							
2	Citeria	Weighting	Vehicle A		VehicleB		Vehicle C	
3			Rating	Total	Rating	Total	Rating	Total
4	Purchase Price	5	6	30	4	20	3	15
5	Fuel Consumption	6	3	18	4	24	2	12
6	Reliability	4	4	16	4	16	5	20
7	Available Space	3	3	9	4	12	5	15
8	Engine Power	2	2	4	4	8	6	12
9	Total			77		80		74

Weighted Decision Matrix

source: https://www.infonautics.ch/blog/decision-matrix/

Another Example

A decision matrix for a self-administered syringe

Selection Criteria	Weight	CONCEPTS					
		A (reference) Master Cylinder		DF Lever Stop		E Dial Screw	
		Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Ease of Handling	5	3	0.15	3	0.15	4	0.2
Ease of use	15	3	0.45	4	0.6	4	0.6
Readable settings	10	3	0.3	3	0.3	5	0.5
Dosage accuracy	25	3	0.75	3	0.75	2	0.5
Durability	15	3	0.45	5	0.75	4	0.6
Manufacturability	20	3	0.6	3	0.6	2	0.4
Portability	10	3	0.3	3	0.3	3	0.3
Total Score			3.00		3.45		3.10
Rank			3		1		3
Continue?			No		Yes		No

source: http://deseng.ryerson.ca/~fil/t/oldT/concept/evaluation1.html

What if the relative importance of the criteria is not easy to choose?

Paired Comparison Analysis can help.

Option	A	B	C	D	E	F	G	H
A								
B								
C								
D								
E								
F								
G								
H								

- List options as both Row *and* Column headings.
- Block out cells on the diagonal and below.
- In blank cells, compare the Row option with the Column option and write in the more important one.
- Optional: Score the difference in importance (2x, 3x, etc.)
- Consolidate the results by adding up the values for each option.

An Example

A philanthropist is choosing between several different nonprofit organizations that are asking for money.
The Paired Comparison Analysis helps her rank their "importance."

	A: Overseas Development	B: Local Educational	C: University	D: Disaster Relief
A: Overseas Development		A, 2	C, 1	A, 1
B: Local Educational			C, 1	B, 1
C: University				C, 2
D: Disaster Relief				

source: https://www.mindtools.com/pages/article/newTED_02.htm

Result:
- A = 3 (37.5 percent)
- B = 1 (12.5 percent)
- C = 4 (50 percent)
- D = 0