Lec 1: Design Process

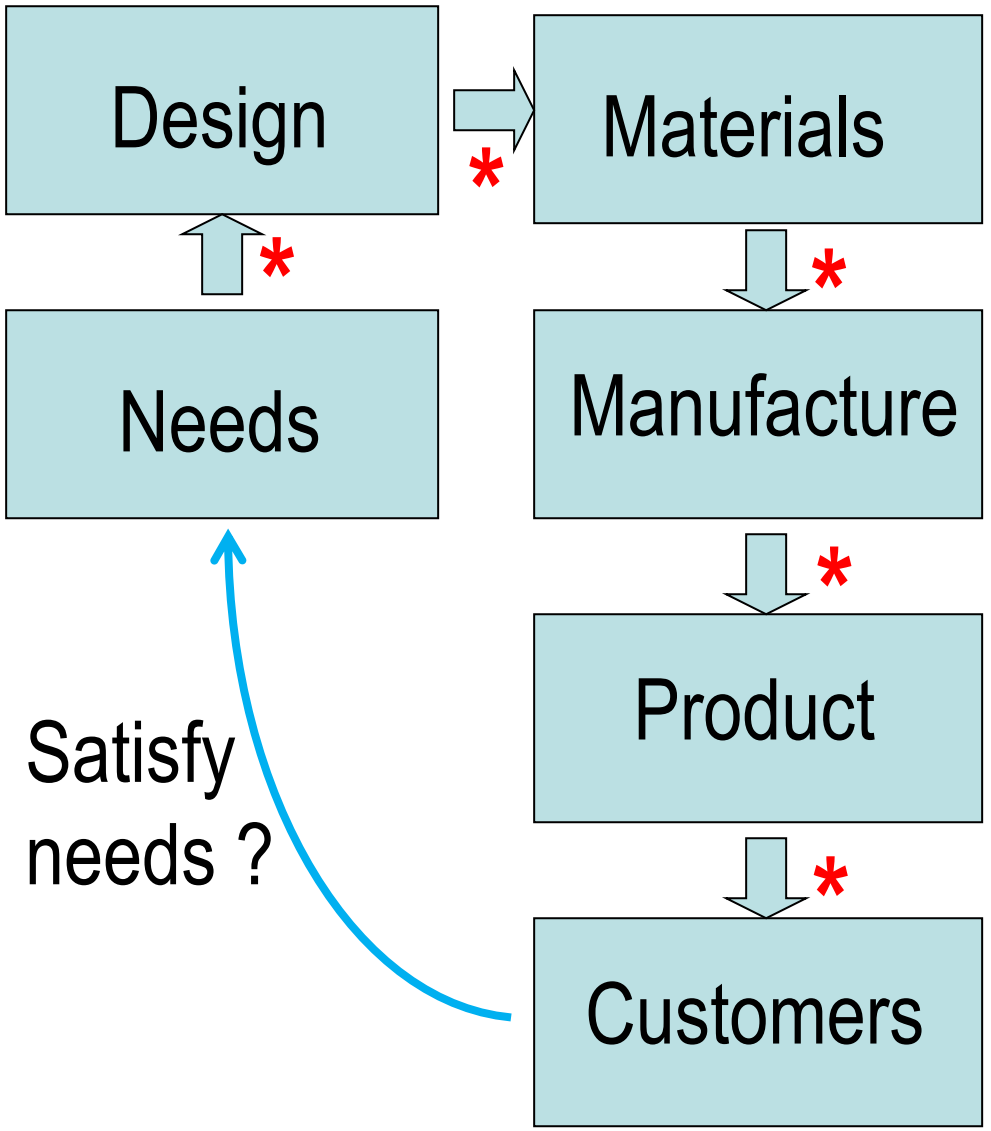
Design process can be applied to:

- ❑ New curriculum development
- ❑ Product design
- ❑ Problem solving

References:

- Nigel Cross, Engineering Design Methods: Strategies for Product Design, 2nd ed. Wiley, 1994.
- Edward Lumsdaine and Monika Lumsdaine, Creative Problem Solving: Thinking Skills for a Changing World, Mc Graw-Hill, 1995.

Engineering Product Design



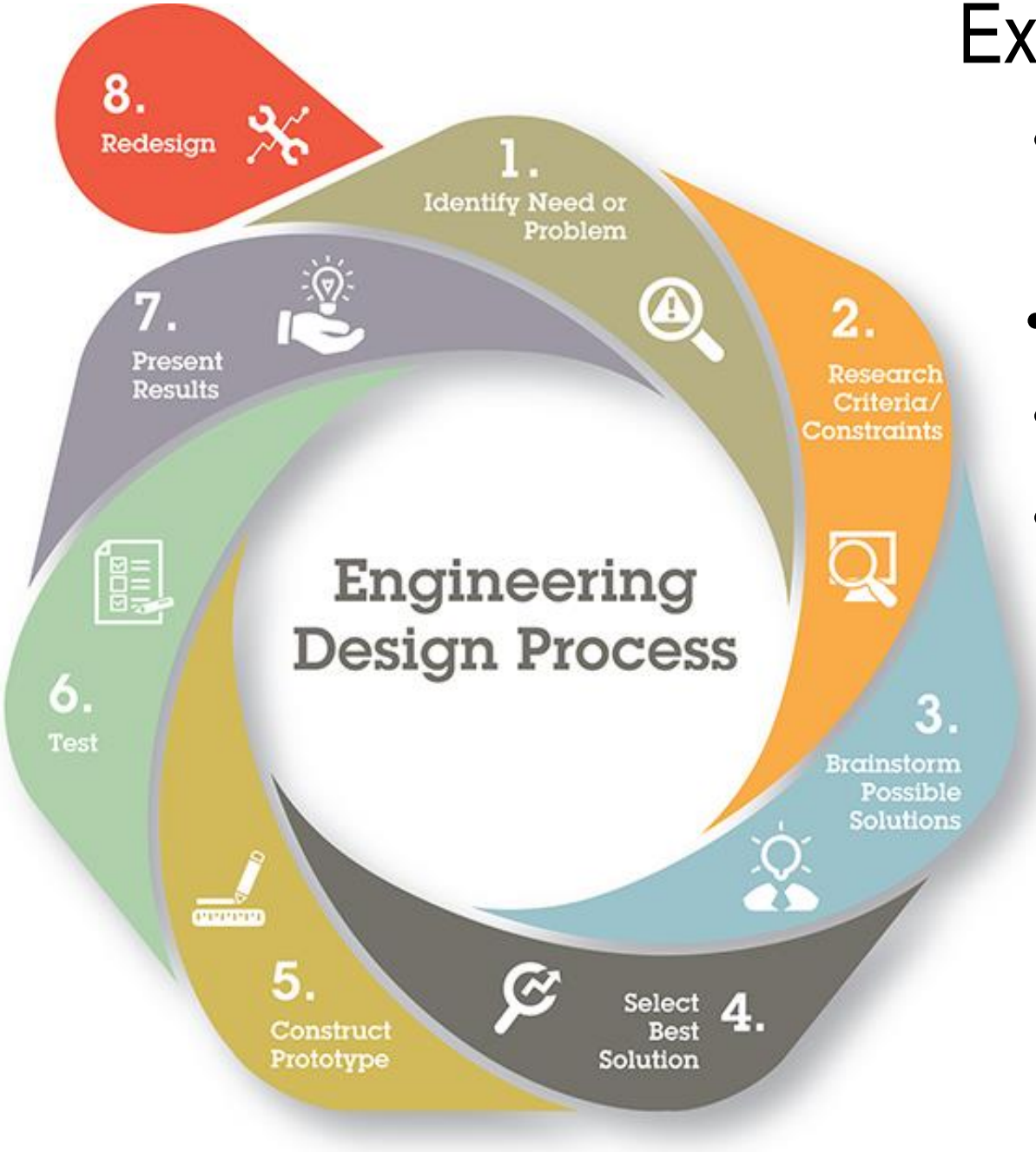
Metal, polymer, ceramic, natural, composite…

Change shape, property, surface…

Production system

Sales & marketing

** Communicate via drawing and document*



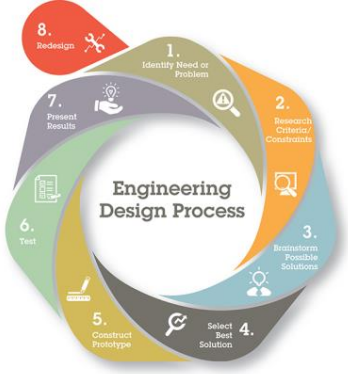
Examples

- Lack of manufacturing talents in Texas
- Cheating in exam
- Computer virus
- Traffic jam during peak hours
- Universal tool for metric and imperial fasteners
- Steak grilling to customer demand
- Etc …

https://www.teachingchannel.org/blog/2015/09/29/rube-goldberg-machines-and-the-engineering-design-process/

More examples:

- Find a solution for student cheating in exam
- Design new robot for state competition
- How to motivate students for STEM?
- A product to replace/block cell phone
- I want to improve my GPA
- Modify my program to attract underrepresented students
- …

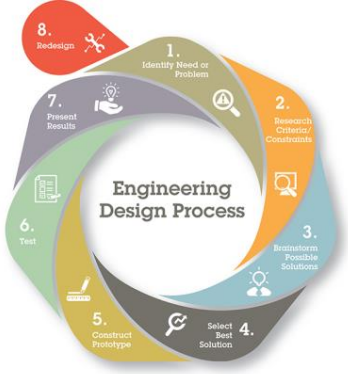


Step 1: Identify need or problem

"Find a solution for student cheating in exams"

Step 1b: Clarify objectives

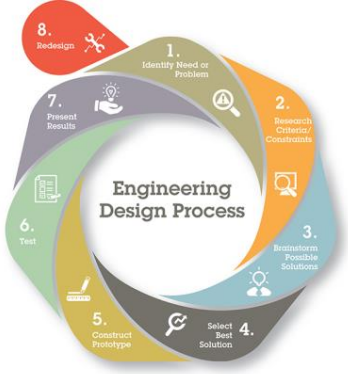
- Test type: quiz, midterm, final, entrance exam, national exam…
- Result: preventive solution, disciplinary or punishing procedure…



Step 2: Research criteria and constraints

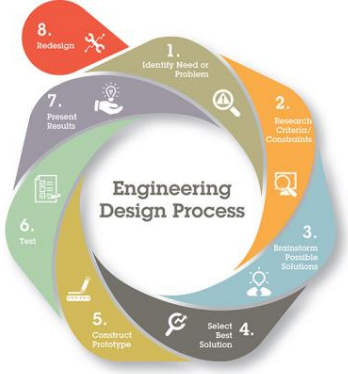
Obtain specific /relevant information…

- Exam types: final, entrance exam, quiz…
- No large classroom available
- Cannot change schedule
- Limited funding to implement
- …



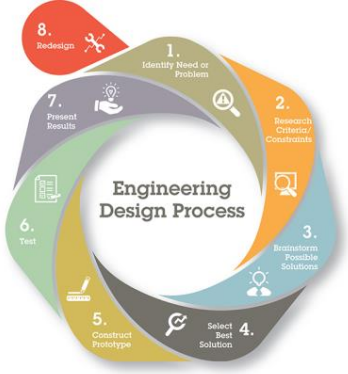
Step 3: Search for possible solutions (Ideation)

- *Brainstorming:* look for lots of ideas from a group
- *Synectics:* find possible solution using analogies
- *Removing mental block*: Find new direction, think outside of a box
- *Morphological chart:* idea for functional requirement
- *Fishbone diagram*: cause and effect



Step 3: Search for possible solutions (Ideation)

- *Brainstorming:* look for lots of ideas from a group
  - Quantity, not quality
  - No criticism
  - Avoid prejudice
  - Combining ideas
  - …



Step 3: Search for possible solutions (Ideation)

- *Synectics:* find possible solution using analogies

  - Similar issues from different fields
  - Solutions to similar problems

Step 3: Ideation Synectics

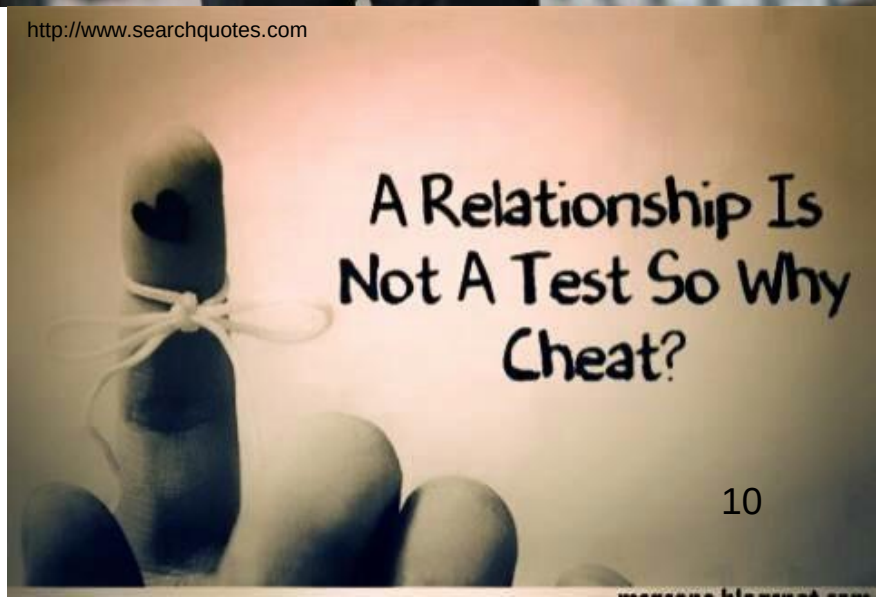
"Find a solution for student cheating in scheduled final exams"

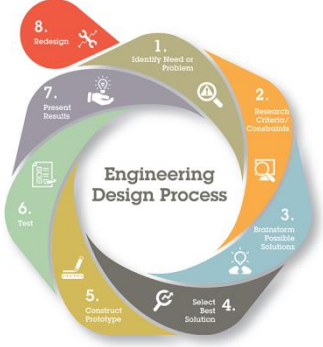
https://wellnessmama.com/15510/cheat-system-diet/

http://waterfordwhispersnews.com/2017/12/08/irelands-final-dole-cheat-to-be-publicly-executed-later-today/

http://www.avonotakaronetwork.co.nz/blog/page/I-cheated-on-my-boyfriend

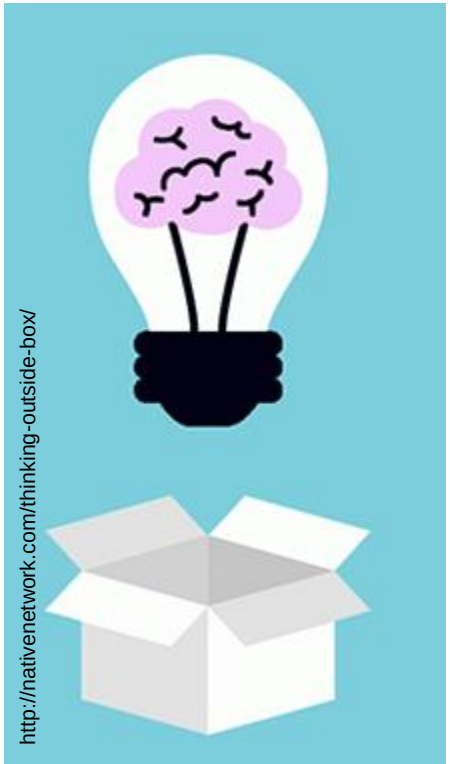
http://www.searchquotes.com





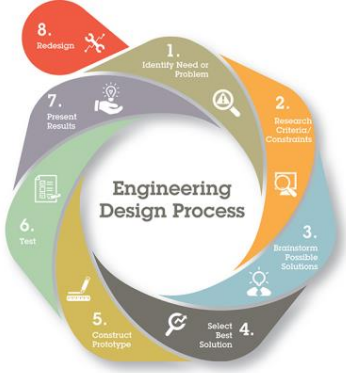
Step 3: Search for possible solutions (Ideation)

- *Removing mental block*: Find new direction, think outside of a box



http://nativenetwork.com/thinking-outside-box/

- Ignore constraints
- No criticism



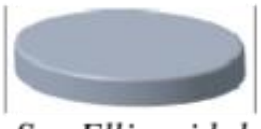
Step 3: Search for possible solutions (Ideation)

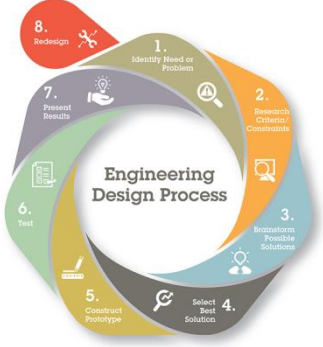
- *Morphological chart:* idea for functional requirement

Morph (verb): to undergo transformation from an image of one object into that of another

- Change shape, support structure, boundary, rule… based on the required function
- Quantity not quality

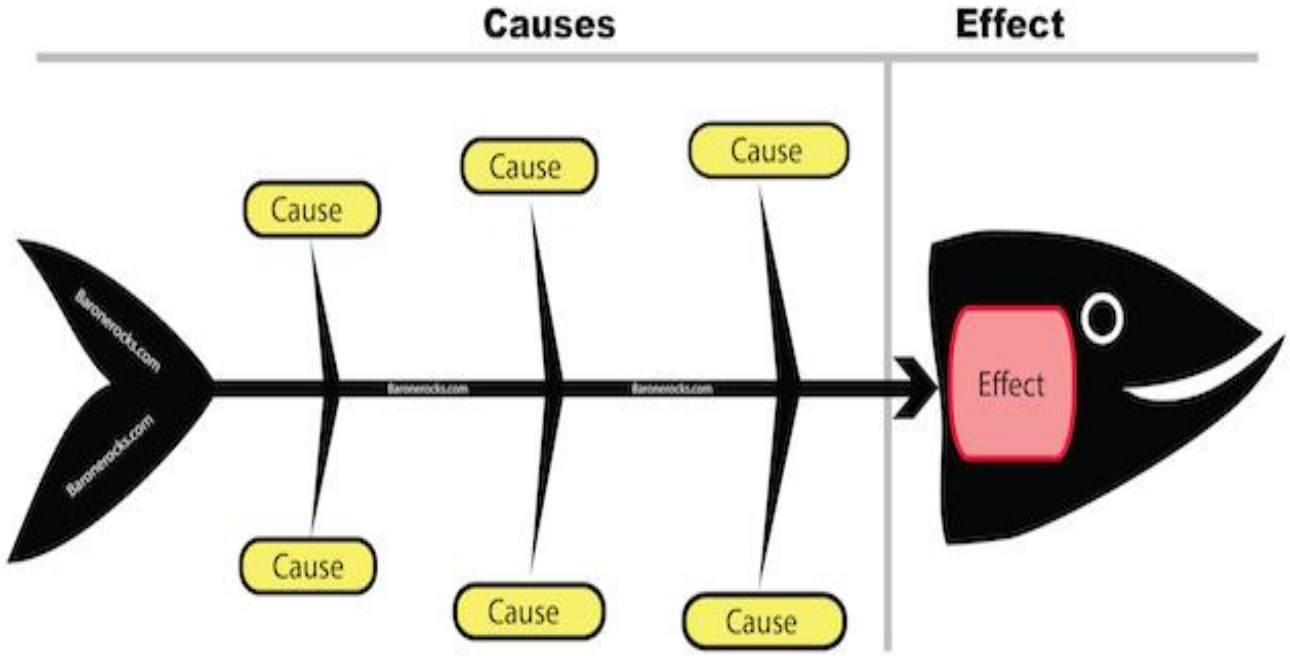
Morphological chart for chair design

Chair components	Physical solutions – S_k				
	1	*2*	*3*	*4*	*5*
Seat	 S_1 - Square	 S_2 – Half round	 S_3 - Rectangle	 S_4 - Round	 S_5 - Ellipsoidal
Back	 S_6 - Square	 S_7– Trapezoidal_a	 S_8 – Trapezoidal_b	 S_9 - Round	 S_{10} - Ellipsoidal
Armrest	 S_{11} – "L" shape	 S_{12} – "T" shape	 S_{13} – "J" shape	 S_{14} - Ellipsoidal	 S_{15} - "U" shape
Stand	 S_{16} – Straight_a	 S_{17} – Straight_b	 S_{18} - Round	 S_{19} – Slant_a	 S_{20} – Slant_b



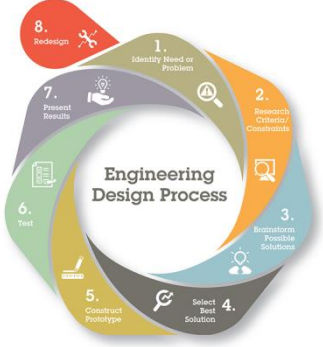
Step 3: Search for possible solutions (Ideation)

- *Fishbone diagram*: cause and effect



- Brainstorm for causes
- Graphical presentation

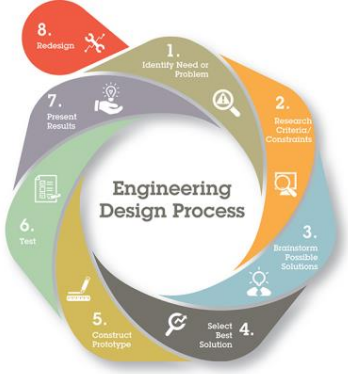
baronerocks.com



Step 4: Select the best solution

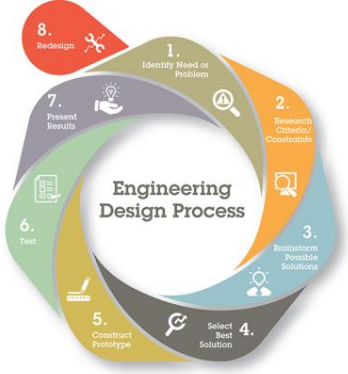
[satisfying all constraints/criteria]

- Top-down instruction
- Weighted criteria



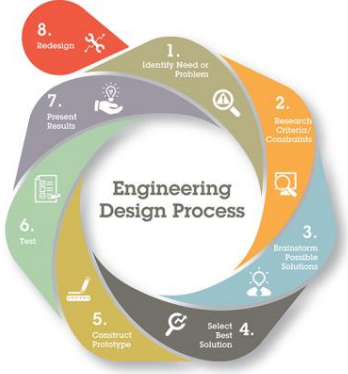
Step 5: Construct prototype

- Draft curriculum
- Fabricate nonfunctional prototype
- Manufacture functional model
- Sketch of solution
- …



Step 6: Test prototype

- Preliminary functional /reliability tests
- Survey
- Professional feedback
- Alpha vs beta tests
- …

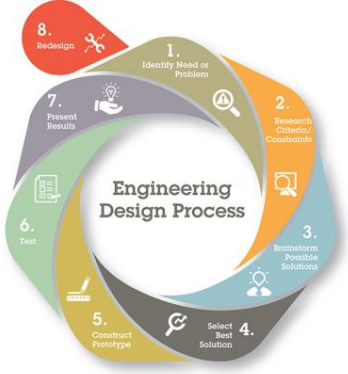


Step 7: Present solution/result

- Submit report
- Presentation of concept
- Show a physical /working model

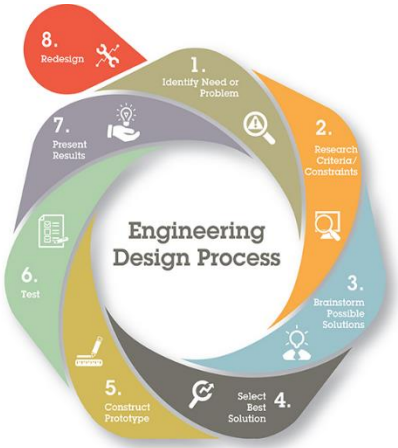
Step 7b: Implement solution/result

- Contingency plan
- Regular feedback. Collect data.



Step 8: Redesign. Modification. Justification.

- Cut cost
- Simplify device
- Automate steps
- Change rules
- Increase effectiveness
- Differentiate Musts vs Wants
- Consider different market /culture
- …

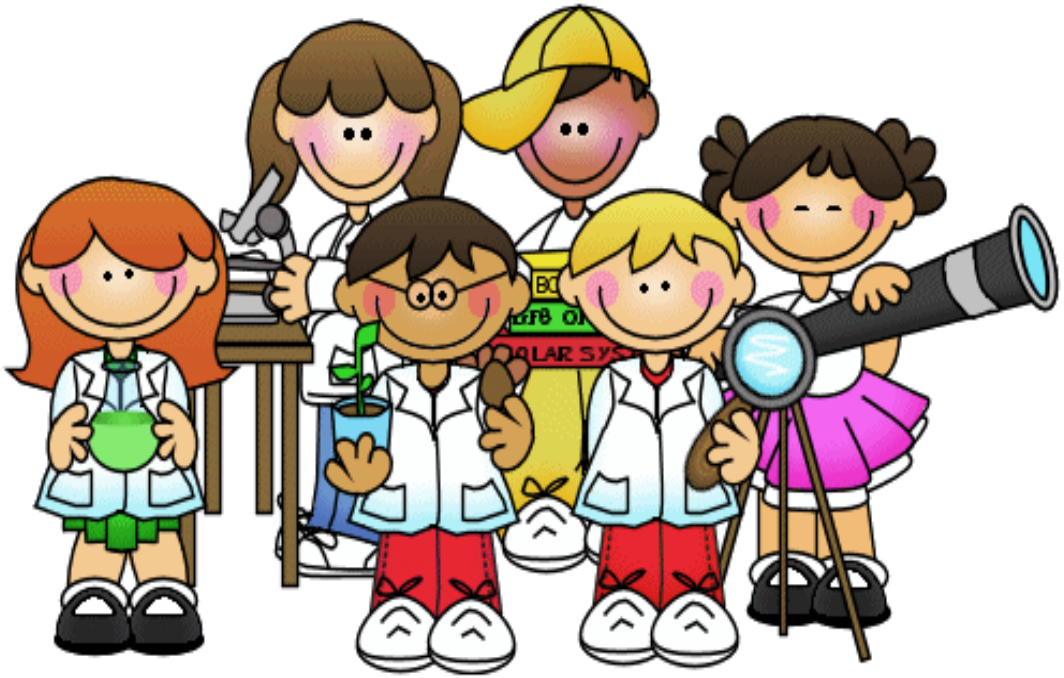


https://www.teachingchannel.org/blog/2015/09/29/rube-goldberg-machines-and-the-engineering-design-process/

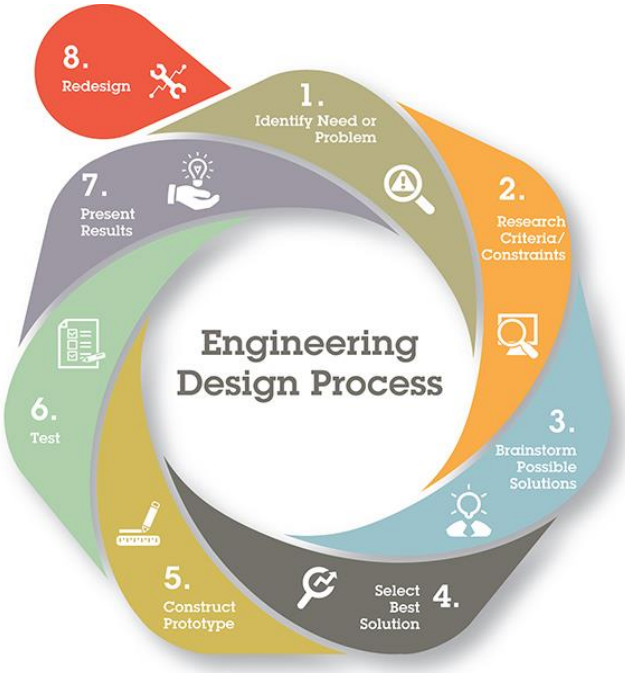
Program outcomes:

1) Design and fabricate a drone attachment to pick and place a paper cup.
2) Design a new curriculum, or
3) Propose plan to implement a new concept /exercise to existing curriculum

https://ericksoninc.com/



http://www.aspire2pass.com/

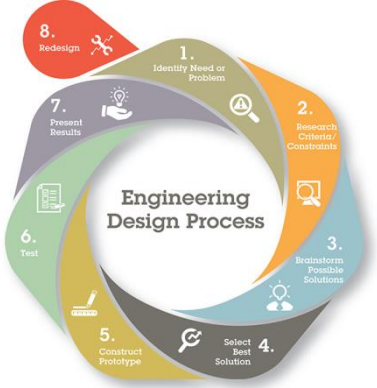


https://www.teachingchannel.org/blog/2015/09/29/rube-goldberg-machines-and-the-engineering-design-process/

Post-program outcome:

Measureable success of new implementation in your class:

- Number of students, certificates, field trips, STEM clubs …
- Participation in competition and awards (if any)
- Additional funding, equipment
- Conference presentation
- Inter-school activities
- …



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Question from the external evaluator:

- Manufacturing and other STEM concepts, state curriculum objectives that will be addressed?
- List of materials and equipment needed and how they will be acquired and maintained?
- Support that the teacher will need from RET team, school administration, or industry

- Reflection component for success after the project is implemented
- How students involve in the various stages of the process, from discovery to evolution?
- How the students' designs, process approach and products will be assessed?

- Problem: exam cheating. Solution?

https://www.youtube.com/watch?v=_5GLG1C0DCs

- Problem: Eating utensil for backpacking. Solution?

https://blog.edexams.com/cheating-in-exams-what-can-you-do-to-prevent-it/

https://home.quymart.com/product/luxury-stainless-steel-gold-plated-cutlery-set/