Lecture 3: Concept Generation & Selection

Casey Hoffman & David Mendonca

iClicker Question

Are you excited for today's lecture?

A. Yes

B. Of course, yes

iClicker Question

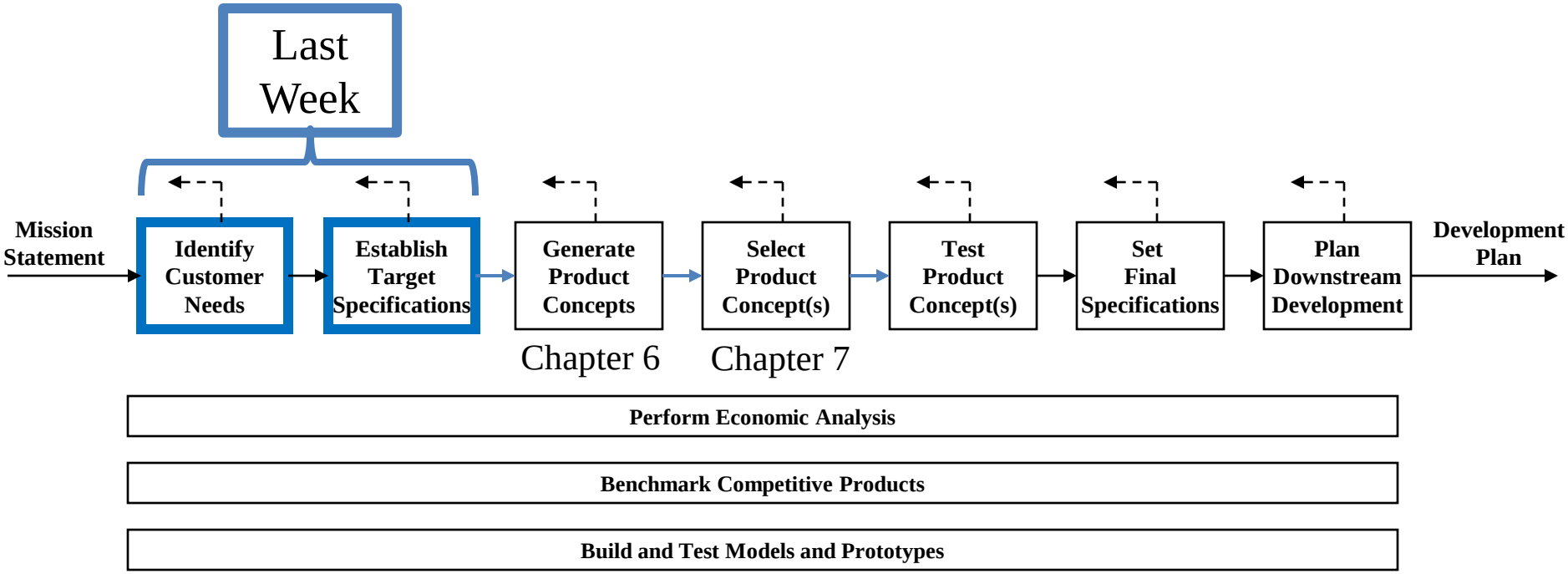
Are you excited for today's lecture?

A. Yes

B. Of course, yes

C,D,E. So excited I plan to retake the course next semester

Concept Development Process
(A systematic approach)



The Concept Development Process, as shown on p. 98 of Ulrich & Eppinger.

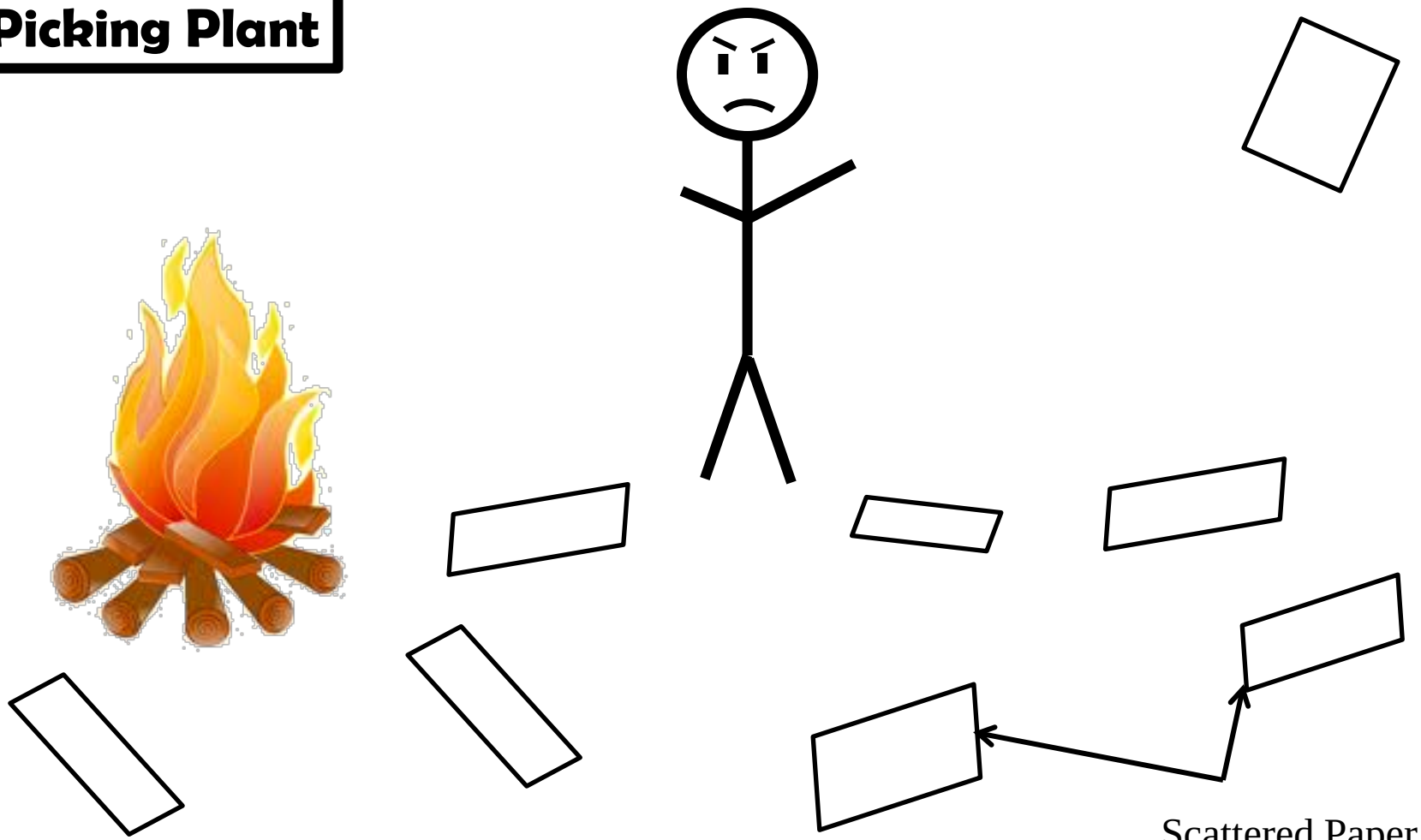
Translating Customer Needs

Cranky Casey's Colosseum

Translating Customer Needs

Cranky Casey's Colossal Conundrum

Pyro's Paper Picking Plant



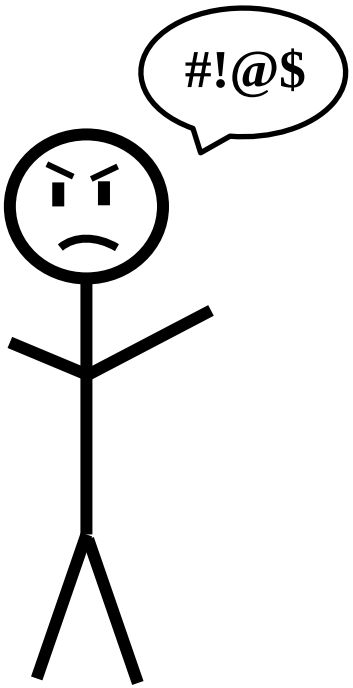
Scattered Paper

Image source: http://www.clker.com/cliparts/N/2/h/B/V/O/campfire-no-shadow.svg , Retrieved 9/10/2013

Translating Customer Needs

Cranky Casey's Colossal Conundrum

"What do you need, Cranky Casey?"



After interviewing with Cranky Casey you find …

1. *He wants a way of getting the paper to the fire quickly without walking to it*
2. *Sometimes paper is closer to the fire, and sometimes it is farther*
3. *The fire is roughly 3 feet in diameter*
4. *He can only pick one paper at a time (Paper Picking Union Regulations)*
5. *He has to do this for hundreds of papers a day*
6. *He can't buy special equipment*

After work area inspection/observation

1. *He averages 480 sheets per 8 hour day (1 sheet/min)*
2. *The room size is 120 ft. diameter*

Cranky Casey's Colossal Conundrum

1. *He wants a way of getting the paper to the fire quickly without walking to it*

   Need to get paper to fire without walking in less than 1 min/sheet

2. *Sometimes paper is closer to the fire, and sometimes it is farther*

   Distance paper travels is not consistent, the further range the better (max distance to fire~60ft)

3. *The fire is roughly 3 feet in diameter*

   Horizontal accuracy needs to be within ±1.5 ft

4. *He can only pick one paper at a time (Paper Picking Union Regulations)*

   Single page limit

5. *He has to do this for hundreds of papers a day*

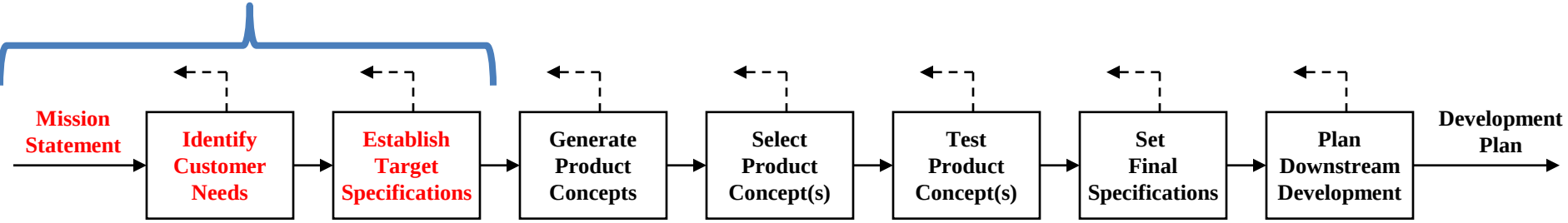
   Needs repeatability (standard deviation of horizontal accuracy)

6. *He can't buy special equipment*

   Can only use random office supplies

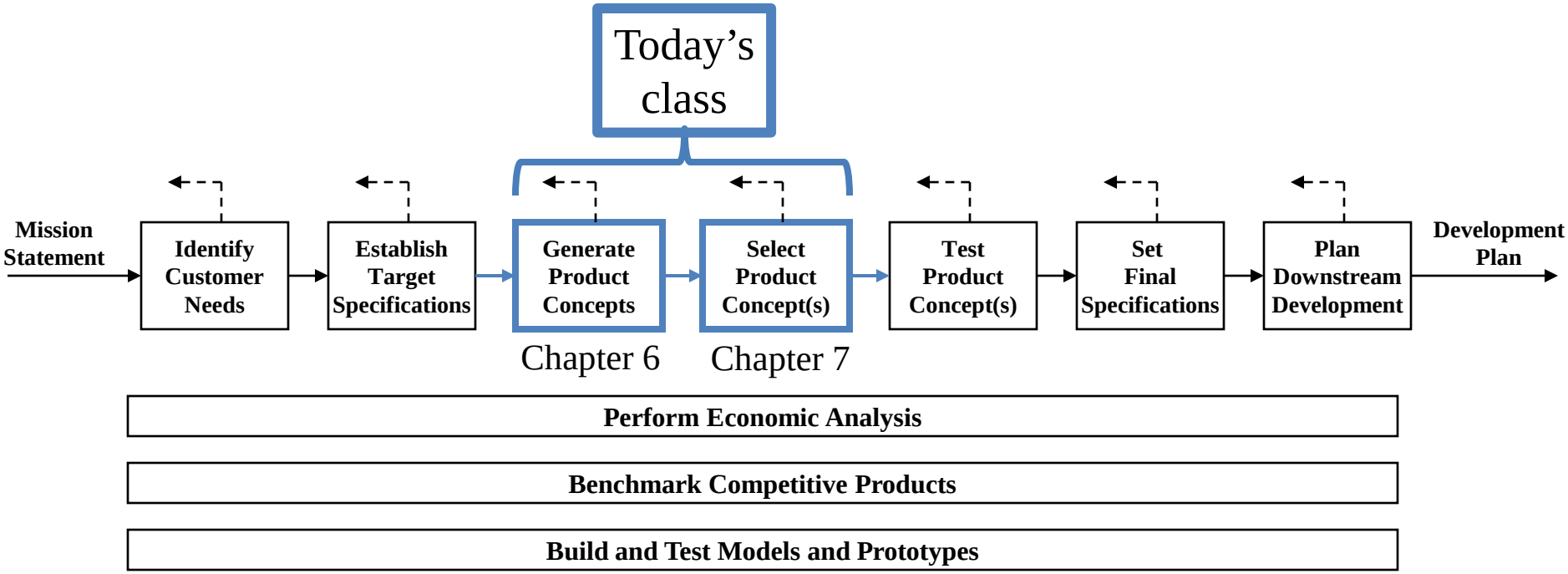
Concept Development Process

We've done this:



The Concept Development Process, as shown on p. 98 of Ulrich & Eppinger.

Concept Development Process
(A systematic approach)



Concept Generation/Selection is a relatively **inexpensive process**, taking typically less than 5% of the budget and 15% of the development time

The Concept Development Process, as shown on p. 98 of Ulrich & Eppinger.

Today's Class

Provide you with tools to use during these steps of the design process

- **Concept Generation (Chapter 6)**
  - Five-step concept generation method (p. 100)
    - Brainstorming (individual & group)
    - Sketching
    - Concept Classification Tree (mind-mapping)
    - Concept Combination Table (3 column)
- **Concept Selection (Chapter 7)**
  - Simple Concept Screening
    - First-thing-we-think-of, External Decision, Product Champion, Intuition, Multi-voting, Pros and Cons, Prototype and Test,
  - Matrix methods:
    - Selection Matrix ("Decision Matrix")
    - Concept Scoring Matrix

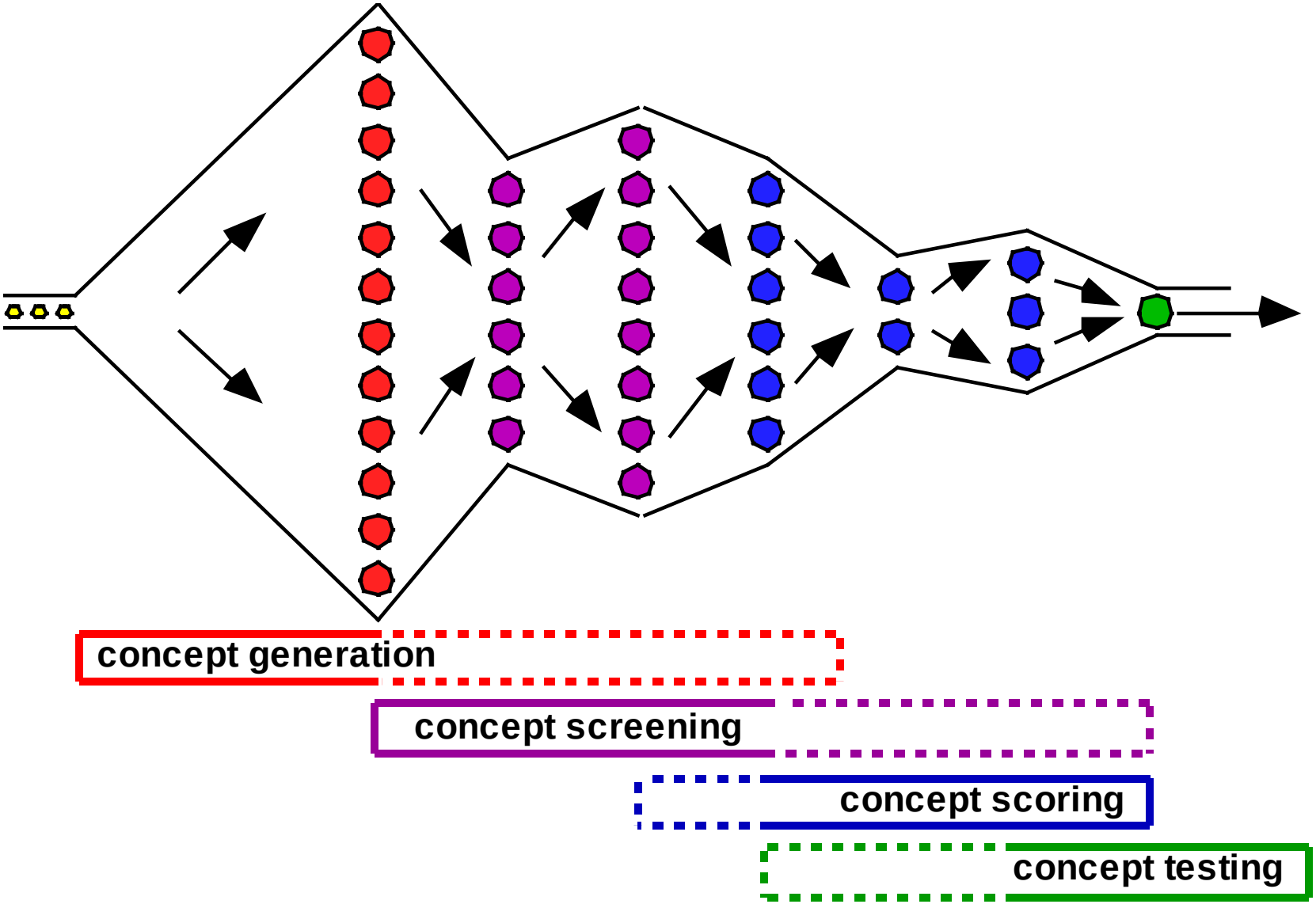
Design is an iterative process …

involving ***unlimited opportunities***

and an ***infinite number of solutions***

It’s open-ended, but ultimately we as engineers need to converge on a unique and unambiguous solution

Concept Development Funnel



From Ulrich & Eppinger, Exhibit 7-4, p. 128

Not Limited to Engineering!

	1	2	3	4
Early Concept				
Final product				

Source: http://screencrush.com/early-movie-concept-art/, Retr. 9/6/2013

Need for an Efficient Design Process


[3]

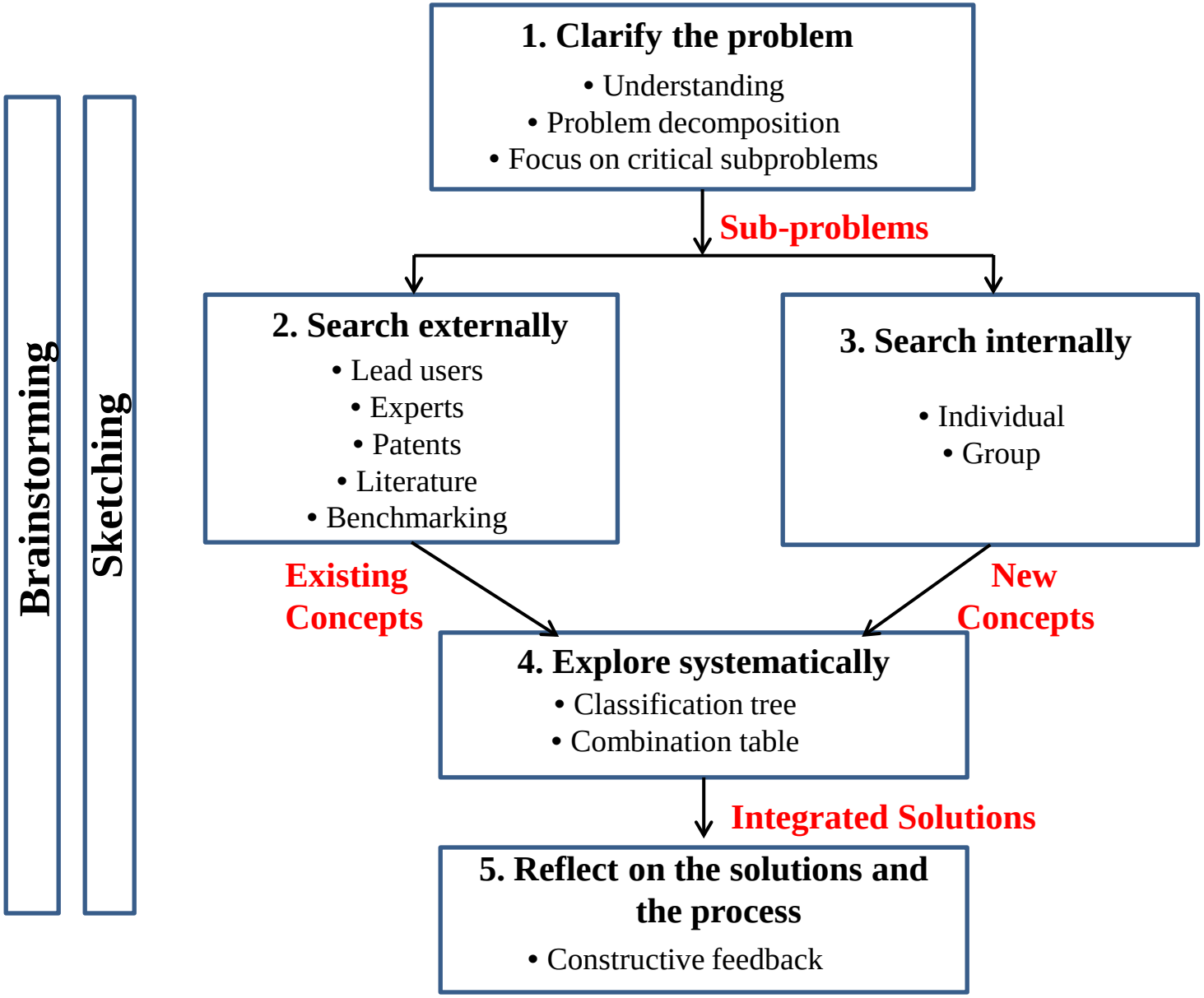
- **The Thomas Edison Light bulb**
  Edison not the first or only one to develop incandescent light bulbs [2]
- Developed **3000** theories to create an effective incandescent lamp. [1]
  - Notable success with fine platinum filament, in an evacuated glass globe. This burned for "a few hours".
- **6000+** more attempts to find "a suitable vegetable growth" to produce a carbonized filament (carbonized cotton thread, lasted ~15 hours)[1]
- **Further development** yielded a 1500 hour life with a 16 watt bulb.[2]

Edison and his assistants tried OVER 9000 times

Clearly we need a better method!

[1] The Franklin Institute: Edison's Lightbulb; http://www.fi.edu/learn/sci-tech/edison-lightbulb/edison-lightbulb.php?cts=electricity; retr: 1/31/2013
[2] Light Bulb History – Invention of the Light Bulb; http://www.ideafinder.com/history/inventions/lightbulb.htm; retr: 1/31/2013
[3] Image Source: http://www.fi.edu/learn/sci-tech/edison-lightbulb/images/Full.jpg; retr: 1/31/2013

5-Step Concept Generation Method



The Five Step Concept Generation Method, Exhibit 6-3 (p. 100) of Ulrich & Eppinger.

Concept Generation

- Product concept: *An approximate description of the technology, the working principles and the form of the product.*

1. Clarify the Problem

- Decomposition: *Divide a complex problem into simpler (sub)problems.*
  - Customer Needs: What needs will product satisfy?
  - Function: What is the product supposed to able to do?
  - Cust/Prod Interaction ("user actions"): How will customer need to interact with product to satisfy needs?

Decomposition	Mini Project	Big Project
Customer Needs	Known	Unknown
Product Function	Known	Unknown
Cust/Prod Interaction	Not applicable	Unknown

“If I have seen further it is because I stood on the shoulders of giants” -Sir Isaac Newton

- Dedication and Hard Work are admirable and noble, but, as the saying goes:

Work Smarter, Not Harder

- A LOT of engineering and science has been done in the past 1000 years. **YOU ARE LUCKY!**
- Hence, you go to Engineering School so you can learn the Tools of the Trade.

Don’t Re-Invent the Wheel–Improve Upon It!

2. Search Externally

- *Find existing solutions to main and/or subproblems.*
  - Ask people: lead users, experts
  - Google (www.google.com/patents)
  - Published literature (GoogleScholar; library.rpi.edu)
  - Benchmark against other products

Line Follower

- Robot
- Optical follower
- Automation

Mousetrap Car

- Spring powered vehicle
- Wind-up toys

Launcher

- Trebuchet
- Catapult
- Nerf Gun

Gallopin' Gertie:
The Tacoma Narrows Bridge (WA)

Footage of Tacoma Narrows Bridge:
https://www.youtube.com/watch?v=XggxeuFDaDU
(Posted to YouTube by britishpathe on June 18, 2013)

http://en.wikipedia.org/wiki/Tacoma_Narrows_Bridge (1940) Retr: 1/31/2013

Gallopin' Gertie: The Tacoma Narrows Bridge (WA)

The failure of the bridge occurred due to a never-before-seen twisting mode produced by winds at a mild 40 mph (64 km/h).

This is a torsional vibration mode, in which the midpoint of the bridge remained motionless while the two halves of the bridge twisted in opposite directions.

Footage of Tacoma Narrows Bridge:
https://www.youtube.com/watch?v=XggxeuFDaDU
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http://en.wikipedia.org/wiki/Tacoma_Narrows_Bridge (1940) Retr: 1/31/2013

The Tacoma Narrows Bridge: Lessons Learned

- ***External Search*:** the right design *for the conditions*
- Always ***analyze/model/test*** your design
- Learn from others' failures (and your own)
  - Documentation!
- A team with multiple sets of expertise can be valuable

3. Search Internally

- *The use of personal and team knowledge and creativity to generate solution concepts.*
- Create multiple solutions to solve a single problem
  - Although this is not the natural way of thinking, judgment must be suspended.
- New and creative ideas
- Any idea is a possibly good idea
  - Don’t only limit yourself to ideas that seem feasible
- Use graphical and physical media to express ideas
  - Sketches, CAD, foam models, etc.

In Fact, Creativity and Teamwork ***generate*** value

- Like an mp3 file, I can share with you my ideas.
- Like multiple mp3 files, you can remix or "mash-up" your idea and my idea, creating:

A NEW IDEA

- Keeping the best parts of multiple concepts leads to **better, more developed ideas**.

iClicker Question

How many concepts did you consider for your mini-project?

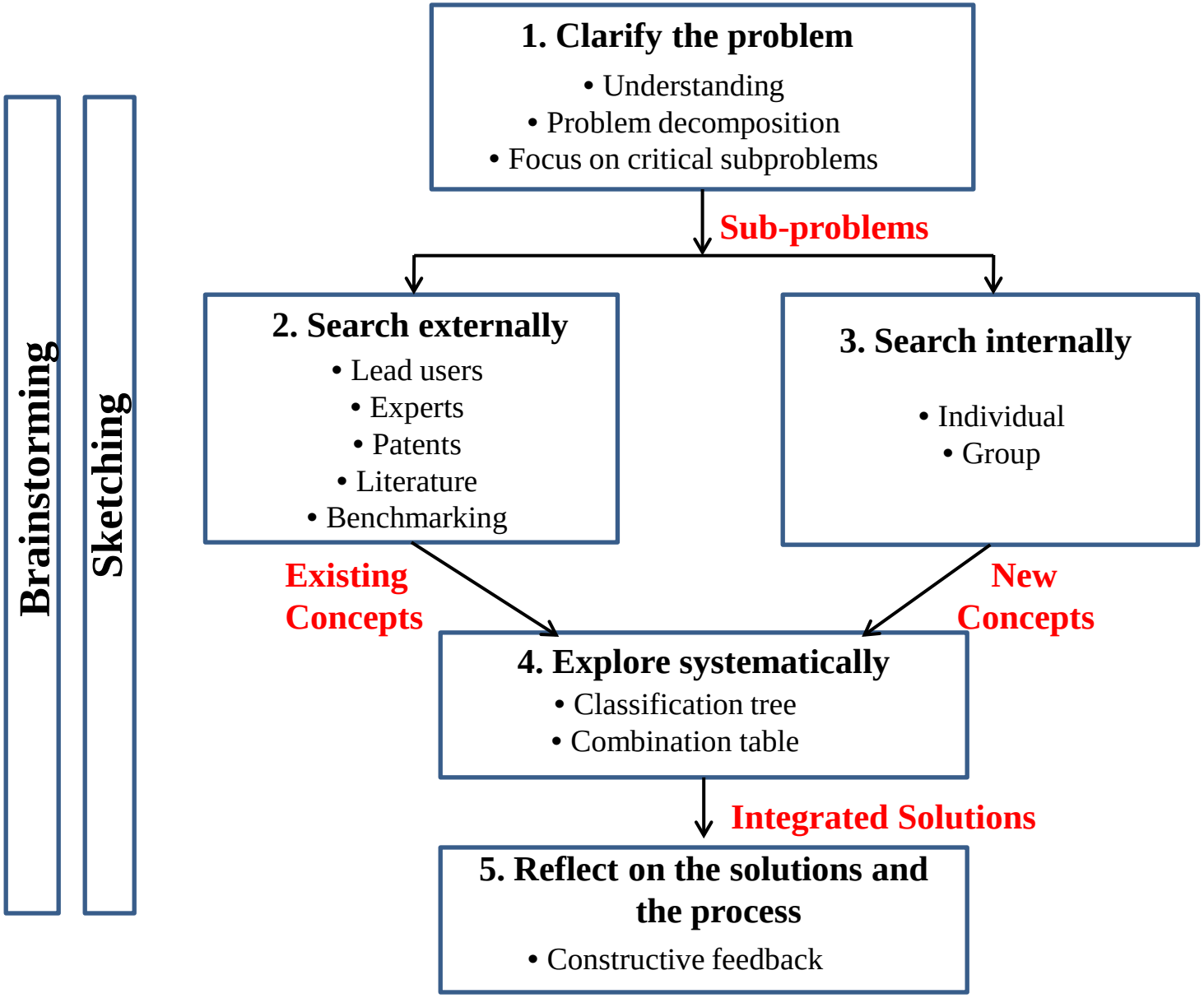
A. One

B. Two

C. Three

D. Four or more

5-Step Concept Generation Method



The Five Step Concept Generation Method, Exhibit 6-3 (p. 100) of Ulrich & Eppinger.

4. Explore Systematically

Concept Classification Tree

FUNCTION OR SUB-PROBLEM

Energy Source

(…one of the possibilities…)

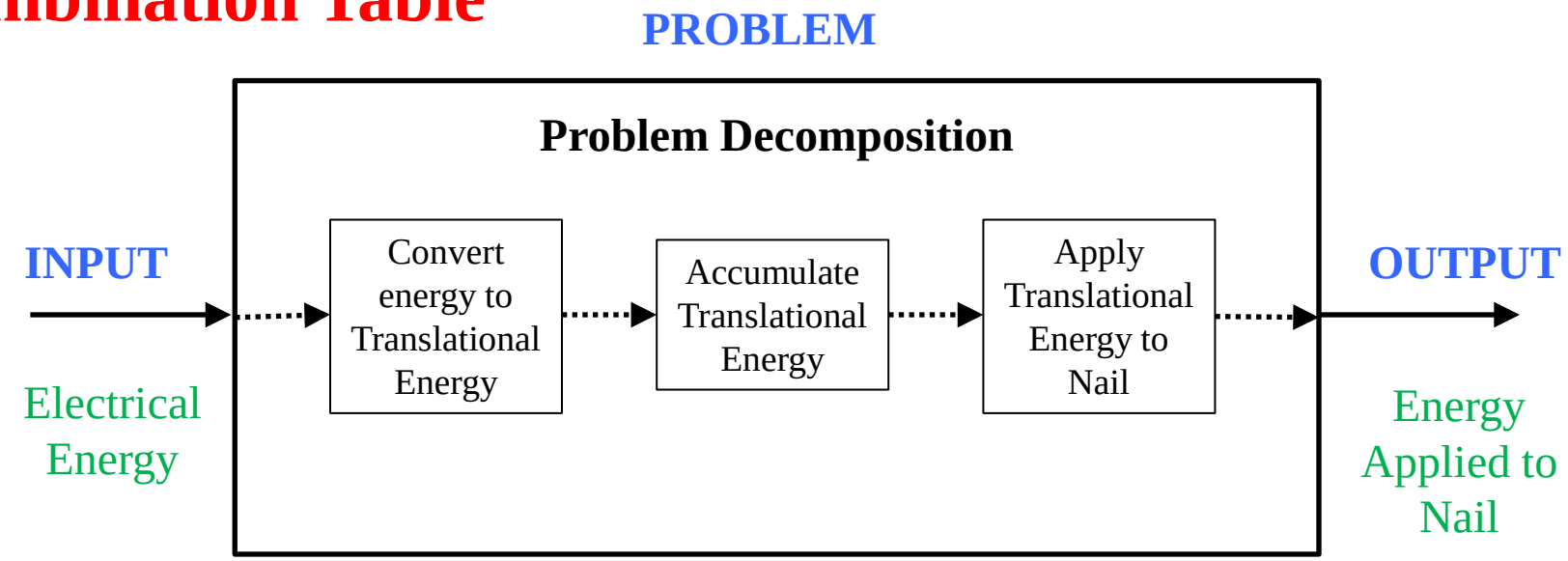
Hand-held nailer

- Pneumatic
- Chemical
- Hydraulic
- Electrical
- Nuclear
- Fuel-Air Systems
- Explosive Systems
- Wall Outlet
- Battery
- Fuel Cell

Concept Classification Tree, as shown on p.112 of Ulrich & Eppinger.

Explore Systematically: The Book's Example

Combination Table

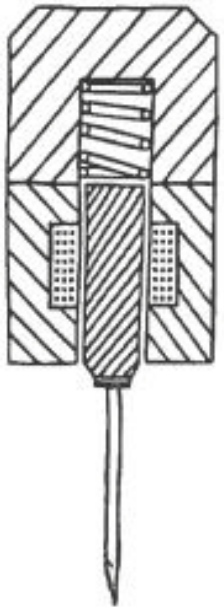


Hand-held electric roofing nailer

Way to consider combinations of solution fragments systematically

Example: Combination Table from p.114 to 118 of Ulrich & Eppinger

Convert Electrical Energy to Translational Energy	*Accumulate Energy*	*Apply Translational Energy to Nail*
Rotary motor with transmission	Spring	Single impact
Linear motor	Moving mass	Multiple impacts
Solenoid		Push nail
Rail gun		



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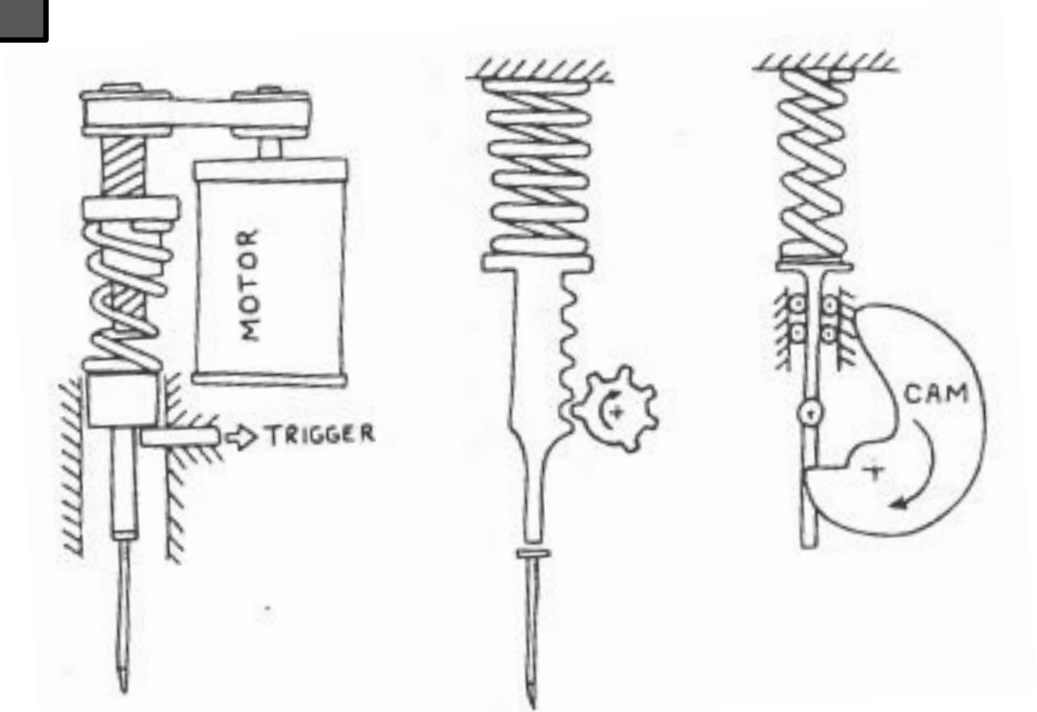

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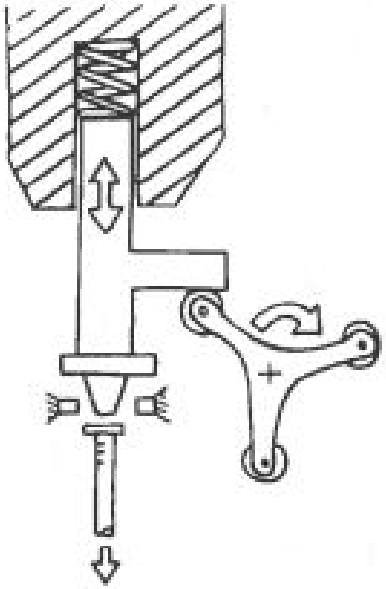

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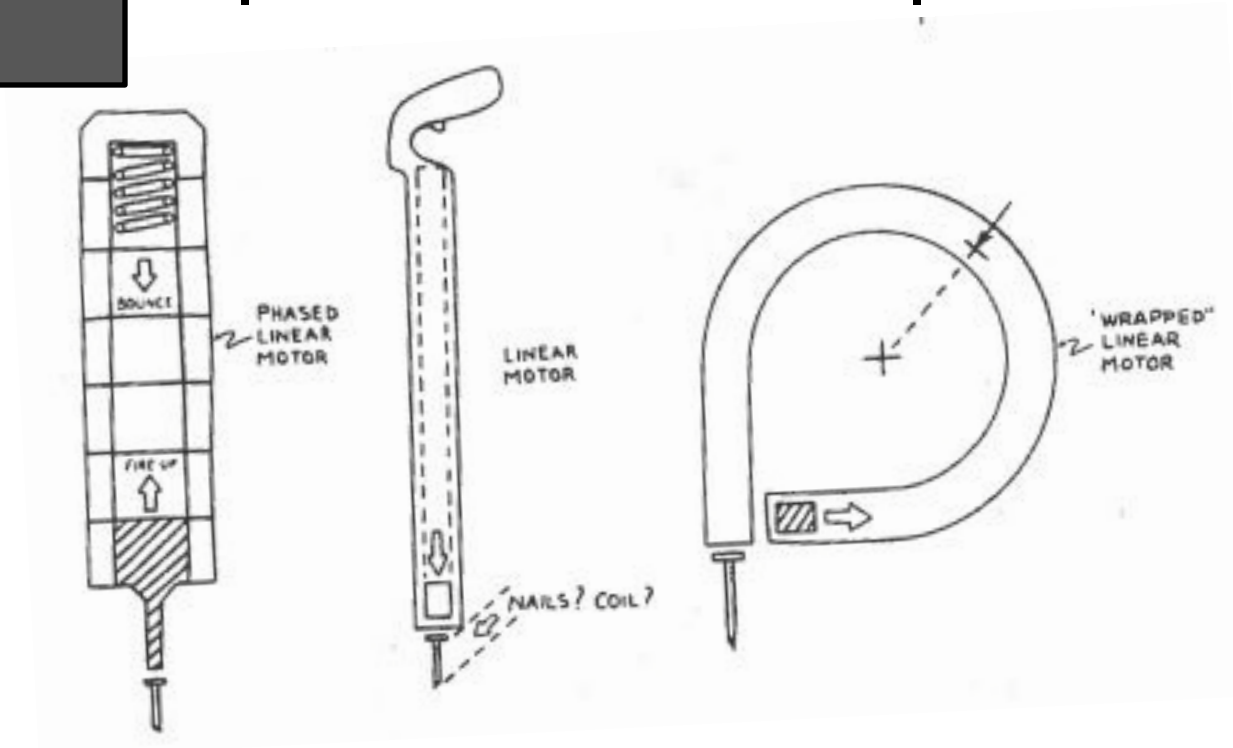
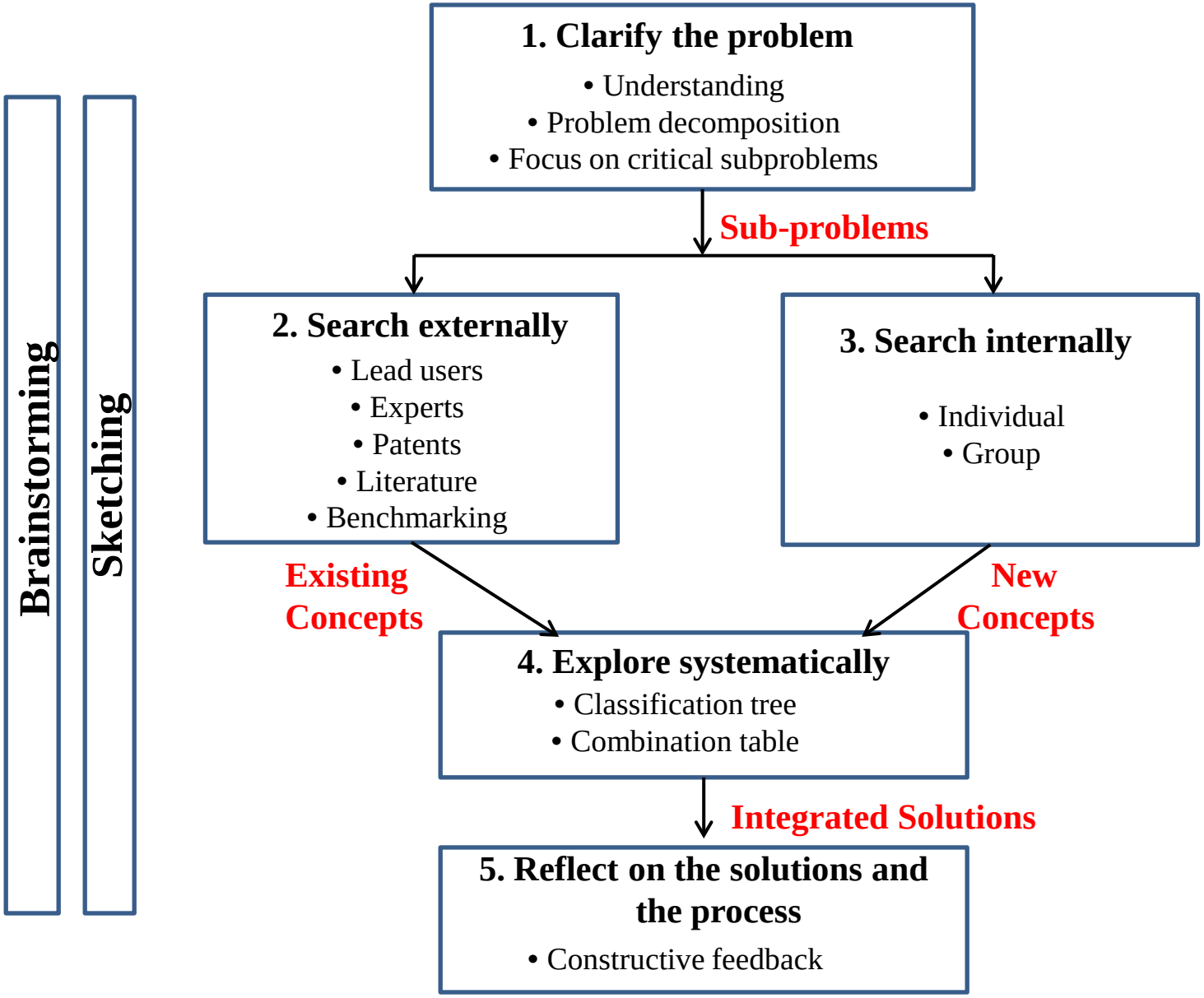


5-Step Concept Generation Method



The Five Step Concept Generation Method, Exhibit 6-3 (p. 100) of Ulrich & Eppinger.

Reflect on Solutions and the Process

Ask yourself the following questions:

1. Is the team confident the solution space is fully explored?

2. Are there alternative function diagrams?

3. Are there alternative ways to decompose the problem?

4. Have external sources been thoroughly pursued?

5. Have ideas from everyone been accepted and integrated?

Cranky Casey's Colossal Conundrum

Pyro's Paper Picking Plant

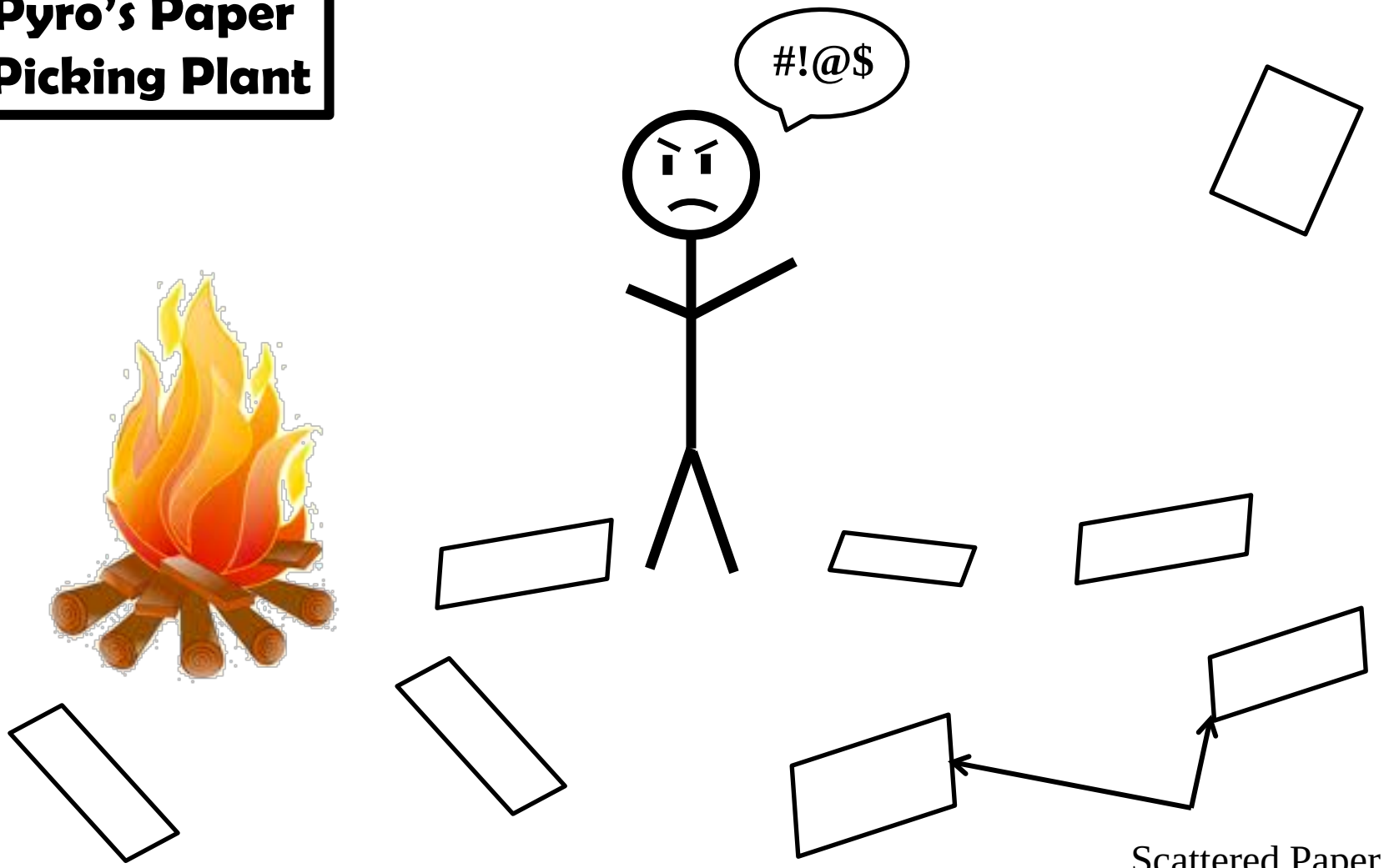


Image source: http://www.clker.com/cliparts/N/2/h/B/V/O/campfire-no-shadow.svg , Retrieved 9/10/2013

GROUP WORK

Cranky Casey's Colossal Conundrum

Working in groups of 3-5, use the target specifications to develop multiple concepts to solve "*Cranky Casey's Colossal Conundrum*"

TARGET SPECIFICATIONS

- **Need to get paper to fire in less than 1 min/sheet**
- **The further range the better (<60ft)**
- **Horizontal accuracy needs to be within ± 1.5 ft**
- **Single page limit**
- **Needs repeatability (standard deviation)**
- **Only has office supplies**

iClicker Question

Do you think we should have the instructors form a team to participate?

A. Yes

B. Of course, yes

Image Source: http://blog.dmtraining.net/Portals/227987/images/three_superheros_400_clr_6467%20(1)-resized-600.png/, Retr. 9/6/2013

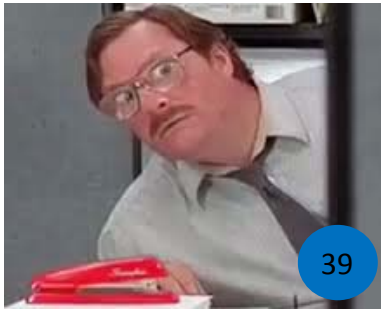
GROUP WORK

Cranky Casey's Colossal Conundrum

Working in groups of 3-5, develop multiple concepts to solve our "*Colossal Conundrum*"

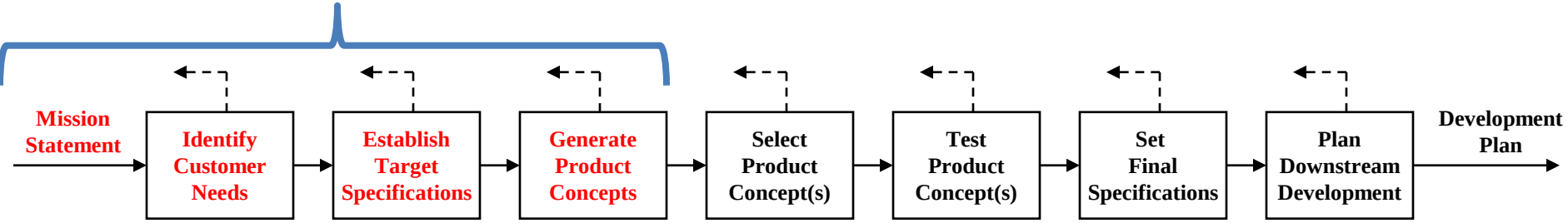
TARGET SPECIFICATIONS

- **Need to get paper to fire in less than 1 min/sheet**
- **The further range the better (<60ft)**
- **Horizontal accuracy needs to be within ± 1.5 ft**
- **Single page limit**
- **Needs repeatability (standard deviation)**
- **Only has typical office supplies**



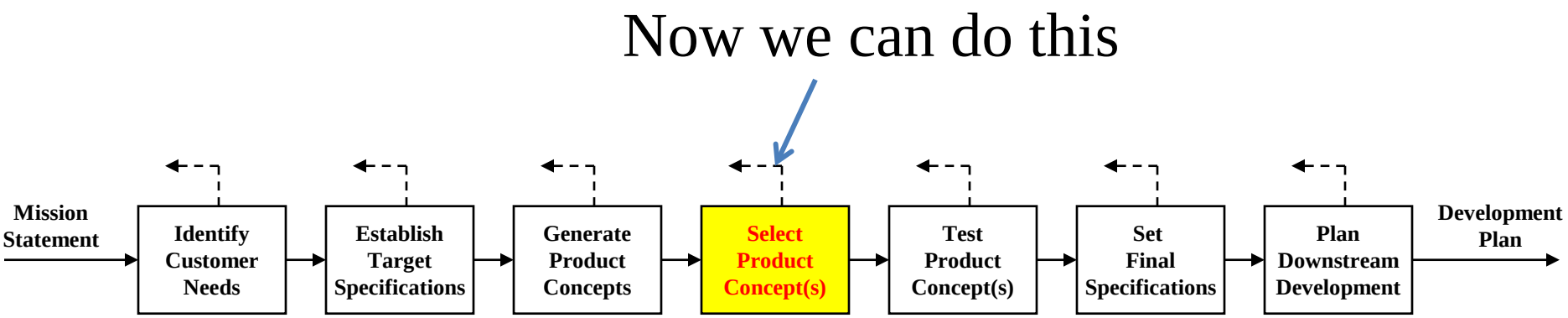
Concept Development Process

We've done this:



The Concept Development Process, as shown on p. 98 of Ulrich & Eppinger.

Concept Development Process



The Concept Development Process, as shown on p. 98 of Ulrich & Eppinger.

Methods for Concept Selection:

All teams use some method for choosing a concept.

You may have used the following methods for your Mini-Project

- External Decision
- Product Champion
- Intuition
- Multi-voting
- Pros and Cons
- Prototype and Test
- Decision Matrices or Selection Matrix

Simple Methods

- External Decision (concepts turned over to the customer)
- Product Champion (personal preference)
- Intuition ("seems" better)
- Multi-voting (votes for several concepts)

More Complex Methods:

- Pros and Cons (group opinion on strengths and weaknesses)
- Prototype and Test (test data)
- Decision Matrix or Selection Matrix (specified selection criteria)

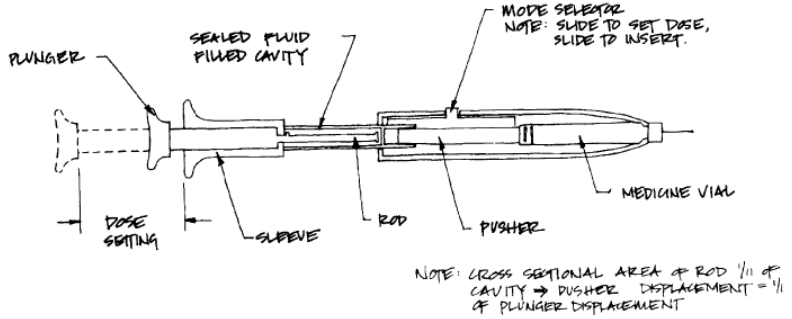
These structured methods base decisions on objective criteria and minimize influence of personal factors

They also provide documentation of the decision process

Choosing a Concept: Re-usable Syringe

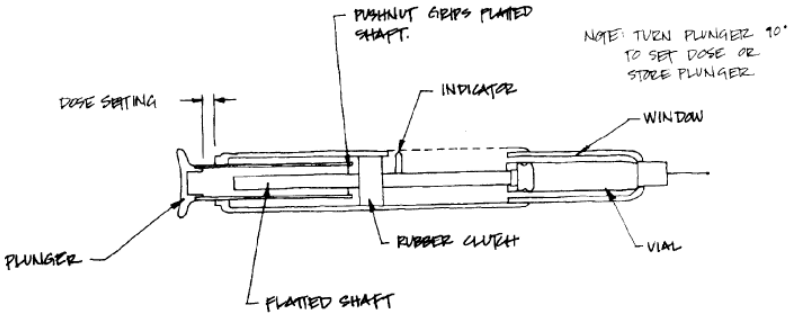
A.

Concept A:
Master Cylinder



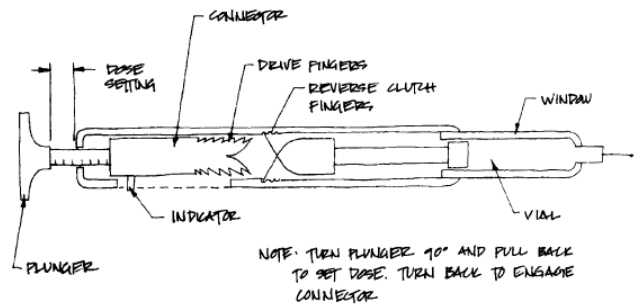
B.

Concept B:
Rubber Brake



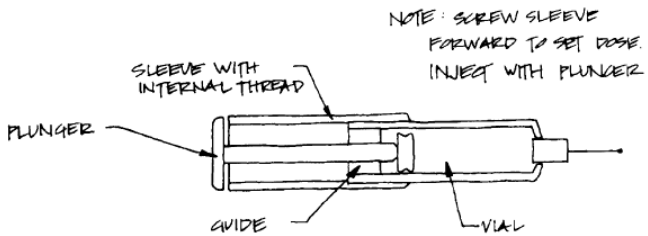
C.

Concept C:
Ratchet



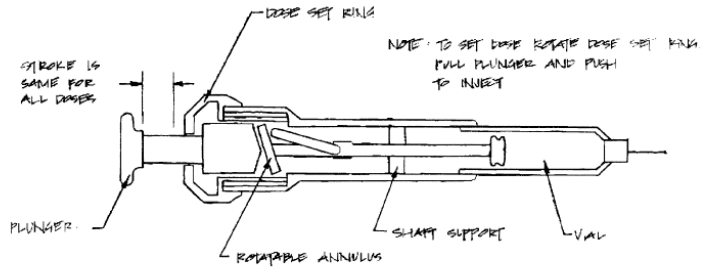
D.

Concept D:
Plunge Stop



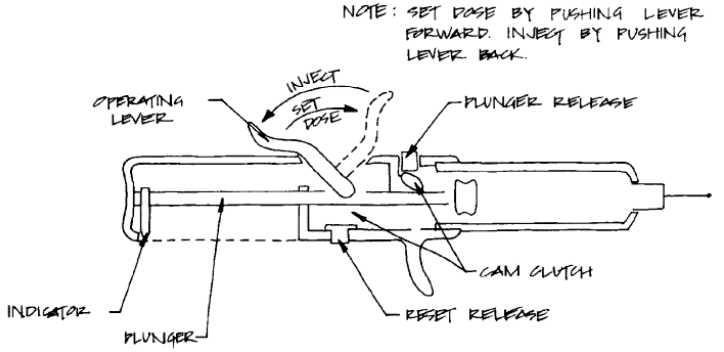
E.

Concept E:
Swash Ring



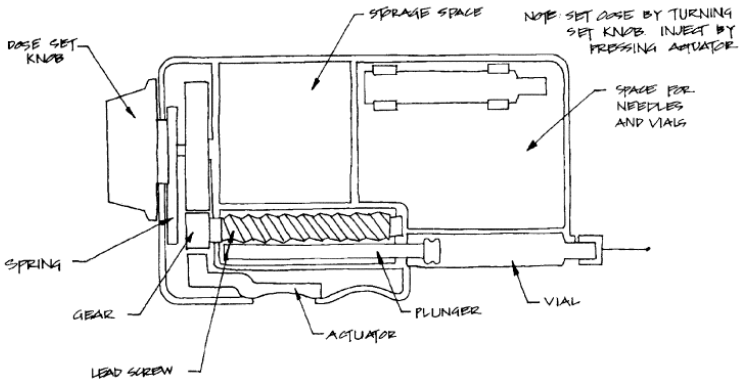
F.

Concept F:
Lever Set



G.

Concept G:
Dial Screw



From *Product Design and Development* by Karl Ulrich and Steven Eppinger (McGraw-Hill/Irwin)

From *Product Design and Development* by Karl Ulrich and Steven Eppinger (McGraw-Hill/Irwin)

Selection Matrix Method

	Concepts						
Selection Criteria	**A Master Cylinder**	**B Rubber Brake**	**C Ratchet**	**D (Reference) Plunge Stop**	**E Swash Ring**	**F Lever Set**	**G Dial Screw**
Ease of handling	0	0	–	0	0	–	–
Ease of use	0	–	–	0	0	+	0
Readability of settings	0	0	+	0	+	0	+
Dose metering accuracy	0	0	0	0	–	0	0
Durability	0	0	0	0	0	+	0
Ease of manufacture	+	–	–	0	0	–	0
Portability	+	+	0	0	+	0	0
Sum +'s	2	1	1	0	2	2	1
Sum 0's	5	4	3	7	4	3	5
Sum –'s	0	2	3	0	1	2	1
Net Score	2	–1	–2	0	1	0	0
Rank	1	6	7	3	2	3	3
Continue?	Yes	No	No	Combine	Yes	Combine	Revise

GROUP WORK

Cranky Casey's Colossal Conundrum

1. Save Time (30%)

		A		B		All Stars	
Selection Criteria	**Weight**	**Rating**	**Wtd**	**Rating**	**Wtd**	**Rating**	**Wtd**
Save Time	30%						
Repeatability	30%						
Horizontal Accuracy	25%						
Range	15%						
	Total Score						
	Rank						

4. Range (15%)

Based upon the given selection criteria and their weights, choose which of your team's concepts is best!

GROUP WORK

Cranky Casey's Colossal Conundrum

In your team of 3-5 select a concept and reflect on the process. Are you confident you have fully explored the options and have made the best decision?

We need two groups to volunteer to present their concept generation/selection method!

iClicker Question

Which concept do you like best?

A. Group A

B. Group B

C. All-Stars

Image Sources

- http://www.ebaumsworld.com/video/watch/80965997/
- http://www.ishmael.org/Education/Writings/environdesign/slide03.jpg
- http://mothergoosejuice.wordpress.com/2010/12/16/scotch-tape-and-schnitzel-with-noodles/
- http://therebuttalfromuranus.files.wordpress.com/2011/08/rubber-bands-02.jpg
- http://2.bp.blogspot.com/_ZhOxxbFUEzU/TGrhvLyNxWI/AAAAAAAAAHM/uHHtquOBBEQ/s1600/duct%2Btape.jpg
- http://www.rpi.edu/dept/cis/web/laptops/images/backpack.2006.jpg

- *Write to EXPRESS, not IMPRESS.*

- *Write to COMMUNICATE, not CONFUSE.*