

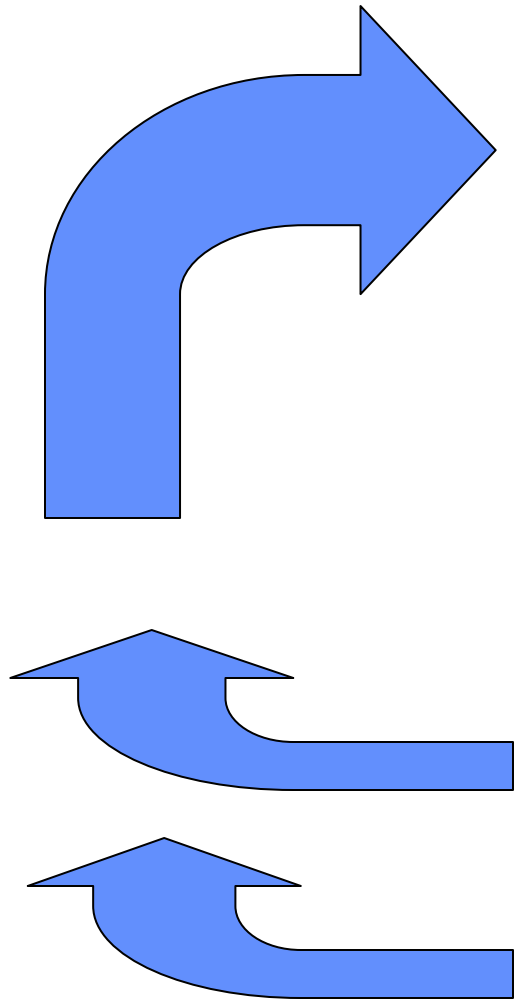
WELCOME !

TO THE THIRD LECTURE ME 401 - ENGINEERING DESIGN

CONTENTS:

- Decomposition
- Functional decomposition
- Idea Generation
 - Morphological charts
 - Brainstorming
 - TRIZ

STEPS OF THE DESIGN PROCESS



- Problem identification
- Problem definition
 - Objective
 - Constraints
 - Criteria
- Problem decomposition
- Solution generation – IDEAS
- Decision making
- Prototyping
- Embodiment or detail design

PROBLEM DECOMPOSITION

- **FUNCTIONAL**

- Provide power
- Support
- Control motion



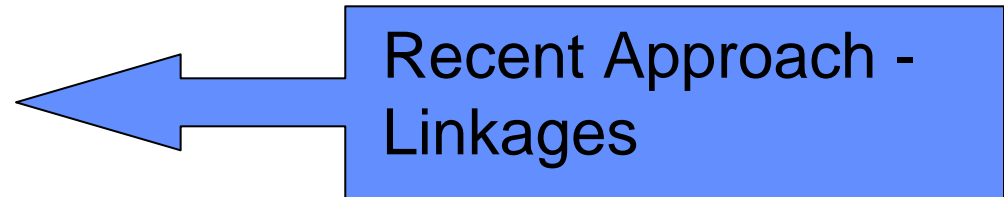
- **DISCIPLINARY**

- Fluids
- Dynamics
- Structure



- **OBJECT**

- Chassis
- Engine
- Body



FUNCTION BASED DESIGN



| | |
|----------------|--|
| Motion | Rotary, Linear, Oscillatory, Other Create, Convert, Modify, Dissipate, Transmit Flexible, Rigid |
| Control | Power, Motion, Information Continuous, Discrete Modification, Indication User-supplied, Internal Feedback |
| Power | Store, intake, Expel, Modify, Transmit, Dissipate Electrical, Mechanical, Other |
| Enclose | Cover, View, Protect Removable, Permanent Support, Attach, Connect, Guide, Limit |

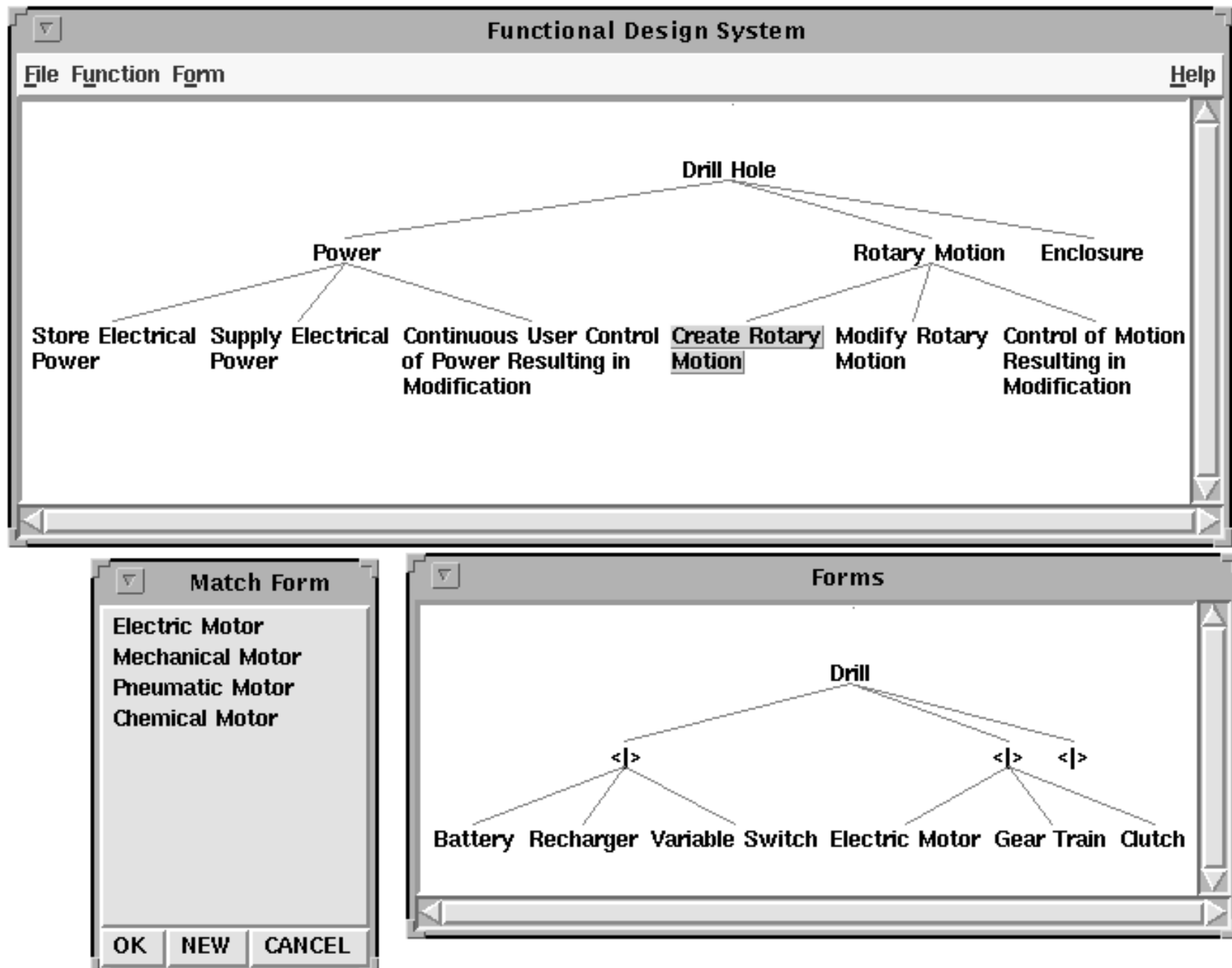
Store
Intake
Expel
Modify
Transmit
Dissipate

Electrical
Mechanical
Other

Power/Matter

Control
to Heat
Move

FUNCTION BASED DESIGN



FUNCTION BASED DESIGN

- Form independent description
- Size independent description
- Ability to generate more solutions
- Possibility to identify commonalties (Product families)
- Difficult to identify form that can accomplish multiple functions (Desirable?)
- Linkages?
- Capture of design intent

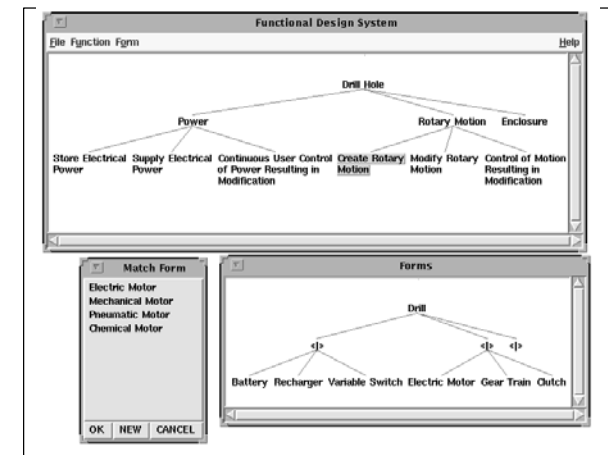
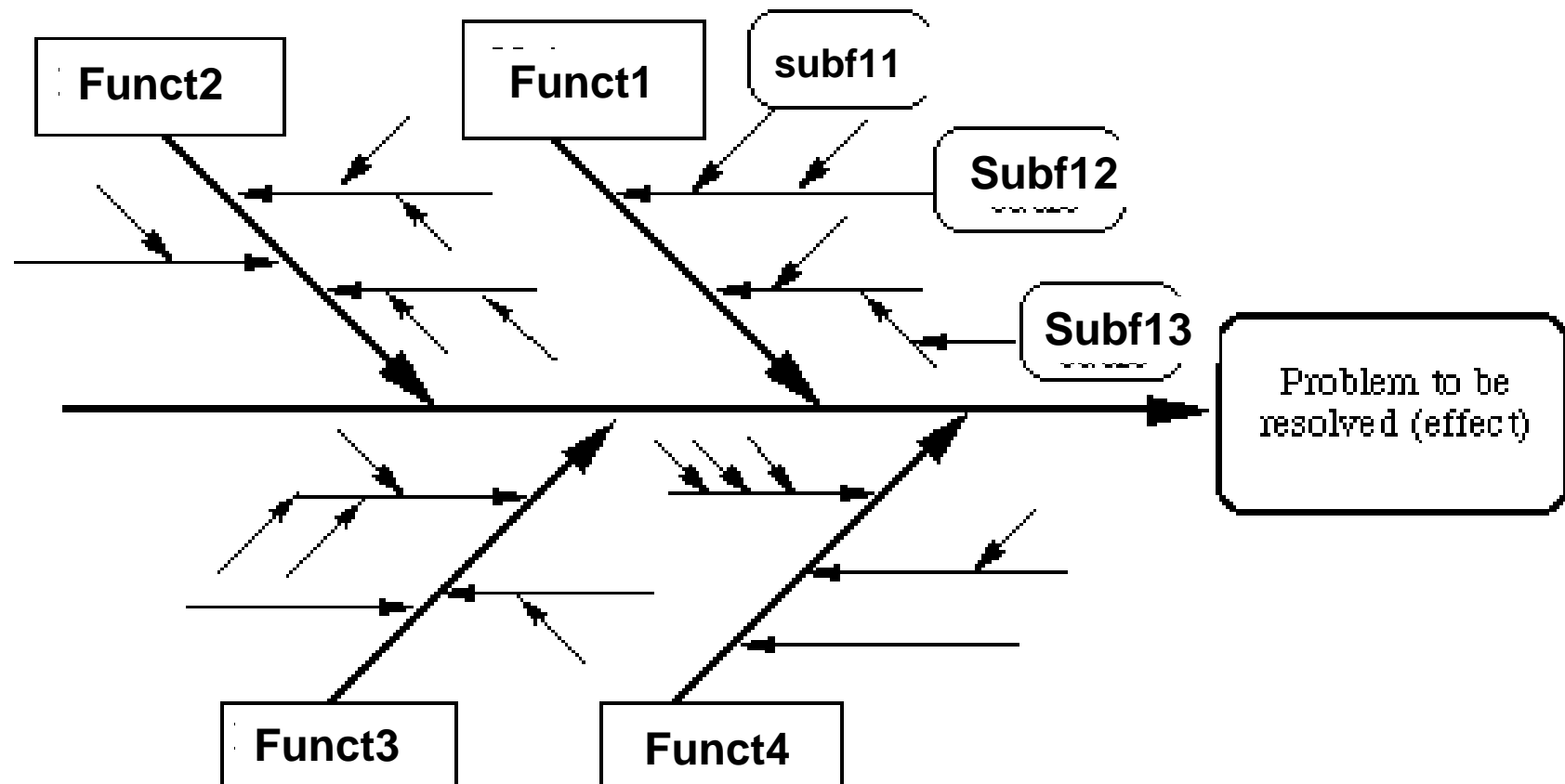


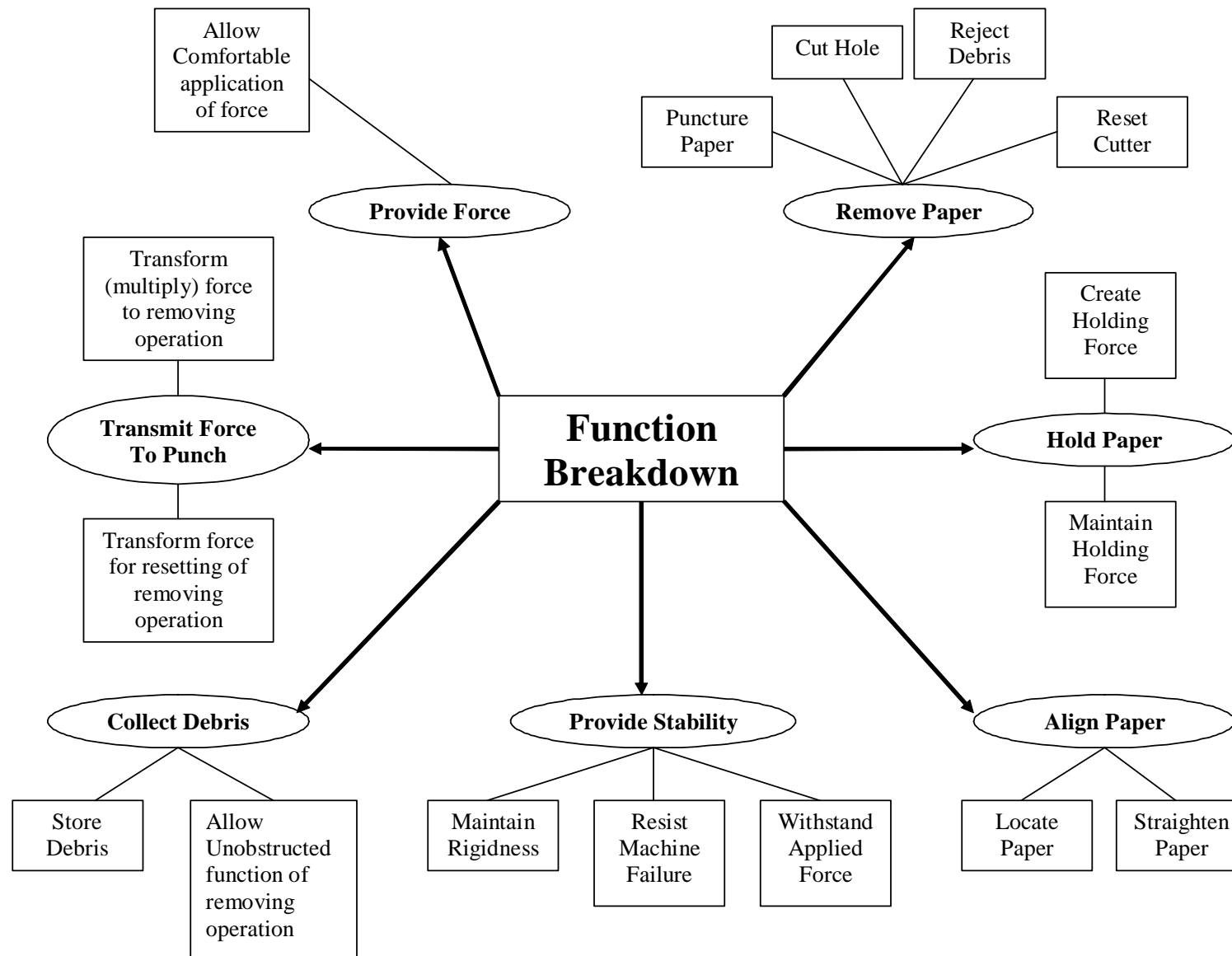
Figure 13. Form Selection.

FISHBONE DIAGRAM

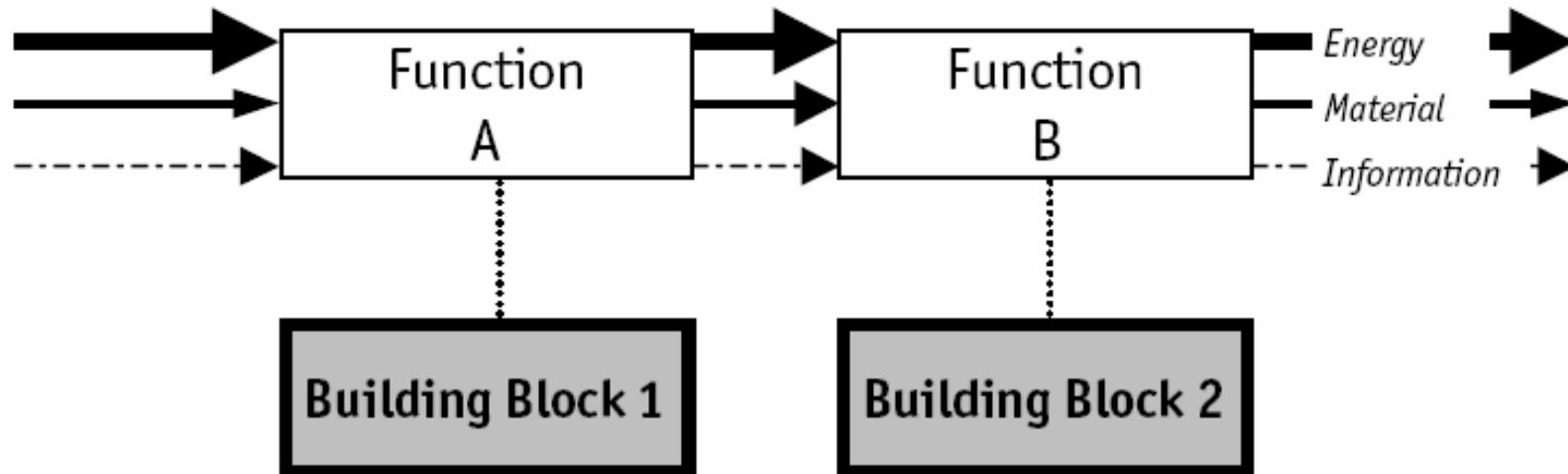
Cause and Effect Diagram, Fishbone, Ishikawa diagram



Objectives Tree



Pahl and Beitz Functional Approach

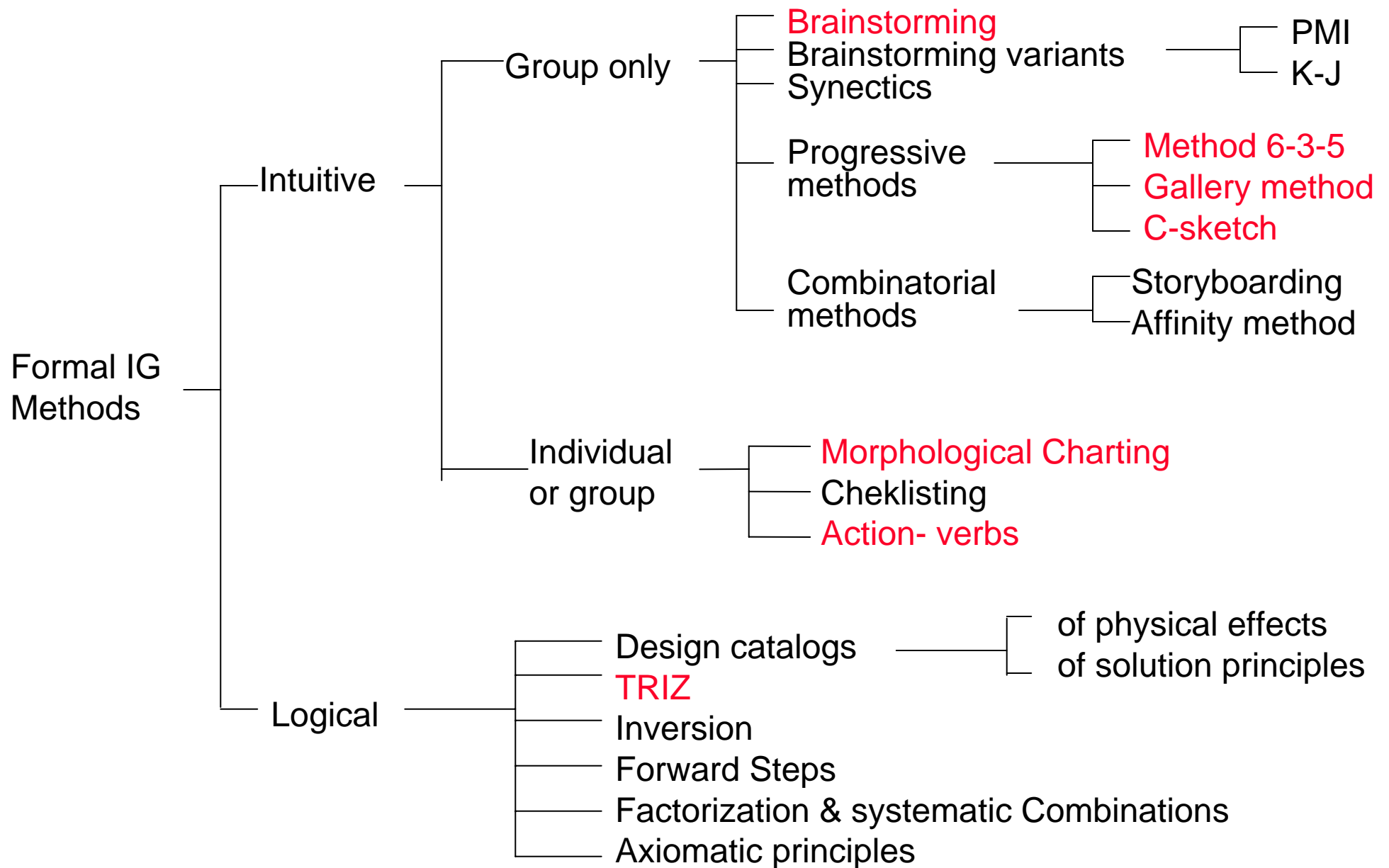


Functional taxonomy (Otto, Wood, Stone, ...)

| Class | Secondary | Tertiary | Correspondents | |
|-----------|------------|-----------------------------|--|--|
| Branch | Separate | | Isolate, sever, disjoin | |
| | | Divide | Detach, isolate, release, sort, split, disconnect, subtract | |
| | | Extract | Refine, filter, purify, percolate, strain, clear | |
| | | Remove | Cut, Polish, Sand, Drill, Lathe | |
| Channel | Distribute | | Diverge, Scatter, Disperse, Diffuse, Empty, Absorb, Dampen, Dispel, Resist, Dissipate | |
| | Import | | Input, Receive, Allow, Form Entrance, Capture | |
| | Export | | Discharge, Eject, Dispose, Remove | |
| | Transfer | Transport | Lift, Move | |
| | | Transmit | Conduct, Convey | |
| | Guide | | Direct, shift, switch, Straighten, Steer | |
| | Guide | Translate | Move, relocate | |
| | | Rotate | Turn, Spin | |
| Allow DOF | | Constrain, Unlock, unfasten | | |
| Connect | Couple | | Associate, connect | |
| | | Join | Assemble, fasten | |
| | | Link | Attach | |
| Control | Mix | | Combine, Blend, Add, Pack, Coalesce | |
| | Actuate | | Enable, Start, Initiate, Turn on | |
| Magnitude | Regulate | | Control, equalize, Limit, maintain | |
| | | Increase | Allow, open | |
| | | Decrease | Close, delay, interrupt | |
| | Change | | Adjust, modulate, clear, demodulate, invert, normalize, rectify, rest, scale, vary, modify | |
| | | Increment | Amplify, enhance, magnify, multiply | |
| | | Decrement | Attenuate, dampen, reduce | |
| | | Shape | Compact, Crush, Compress, Pierce, deform, form | |
| | | Condition | Prepare, adapt, treat | |
| | Stop | | End, halt, pause, interrupt, restrain | |
| | | Prevent | Disable, turn off | |
| | | Inhibit | Shield, insulate, protect, resist | |
| | Convert | Convert | | Transform, Liquefy, Solidify, Evaporate, Condense, Integrate, Differentiate, Process |
| | Provision | Store | | create, decode, encode, generate, digitize |
| | | | | Accumulate |
| | | | Contain | Capture, enclose |
| Signal | Supply | Collect | Absorb, consume, fill, reserve | |
| | | | Provide, Replenish, retrieve | |
| | | | Feel, determine | |
| | Sense | Detect | Discern, perceive, recognize | |
| | | Measure | Identify, locate | |
| | Indicate | | Announce, show, denote, record, register | |
| | | Track | Mark, time | |
| | | Display | Emit, expose, select | |
| Support | Process | | Compare, calculate, check | |
| | Stabilize | | Steady | |
| | Secure | | Attach, Mount, Lock, Fasten, Hold | |
| | Position | | Orient, Align, Locate | |

- **You now have many functions. You need to generate solutions – forms – to accomplish these functions.**
- **Use engineering problem solution approach**
 - Simplify problem, approximate, and use the time and tools at your disposal to get estimates of solutions
 - Sketch possible solutions – list issues, positives, negatives
 - Use idea generation techniques

IDEA GENERATION - METHODS CLASSIFICATION



MORPHOLOGICAL CHARTING

- Once you have decomposed the problem into many functions, list the functions in the right hand column of a table, and fill in each row as many solutions as possible to accomplish this function.

| | | | | | | |
|--------------------------|---|----------------------------|--------------------|-----------------------|----------------|-------------------|
| Store Energy | Battery | Capacitor | Water pump storage | Hydraulic compression | flywheel | Chemical reaction |
| Convert energy to motion | Electric motor | Hydraulic motor | Hydraulic turbine | Gas turbine | Impulse engine | |
| Control motion | Flow regulator | Digital Electronic control | Analog control | Resistance | | |
| Transmit motion | Chain | Linkage | Hose | Cam | Screw | Gear |
| | | | | | | |
| | In this example, over $6 \times 5 \times 4 \times 6 = 720$ solutions! | | | | | |

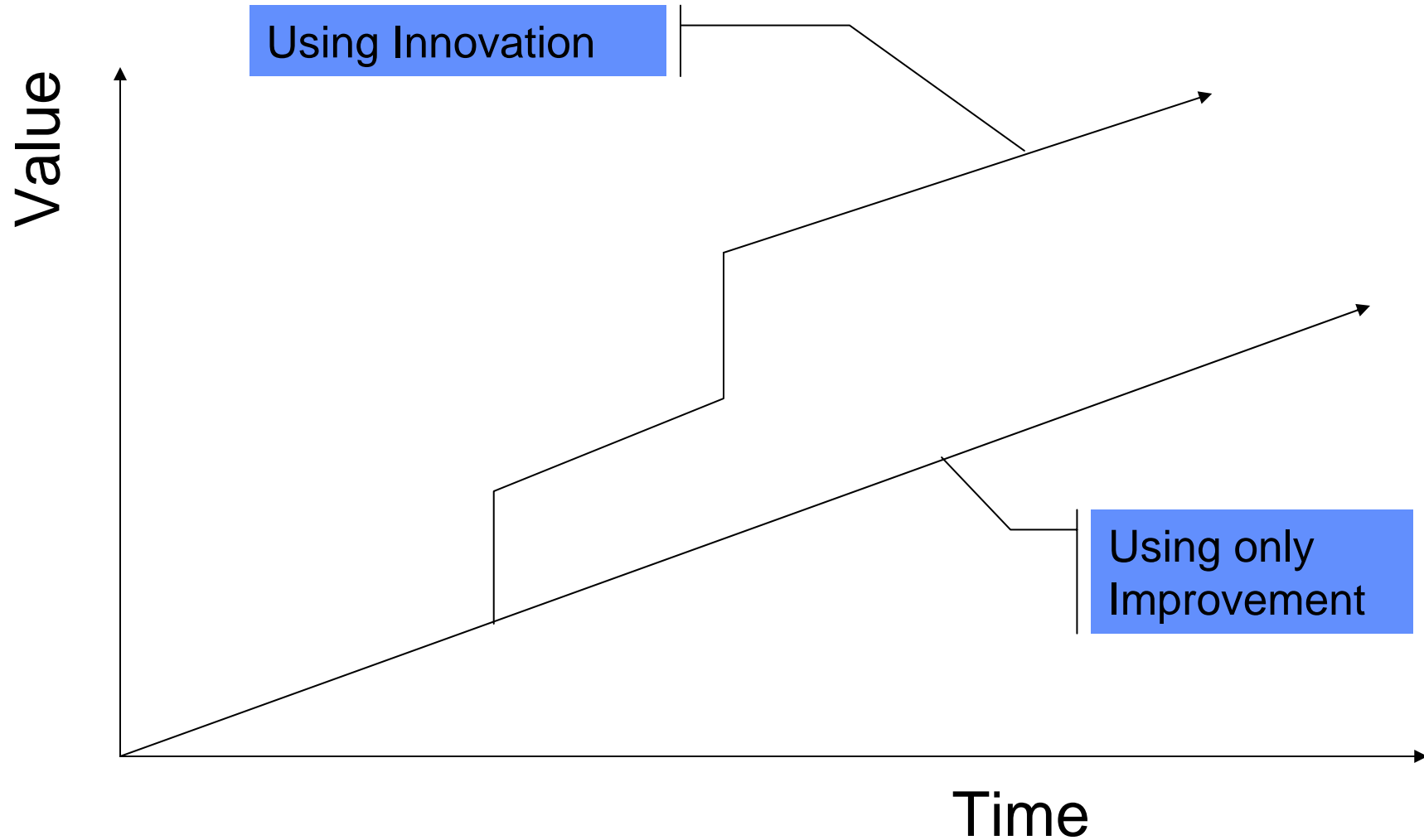
- Method 6-3-5
 - 6 participants - 3 ideas - 5 rotations
 - timed event
 - ideas expressed in keywords/phrases - no sketches
 - No other communication permitted
- C- Sketch
 - Variation of 6-3-5
 - One concept as a sketch
 - smaller group sizes
 - no other communication

- Brainstorming
 - Give topic
 - Warm-up exercise
 - Rules:
 - No critique nor judgment
 - Wild ideas encouraged
 - As many as possible
 - Timed exercise
 - Jump-start

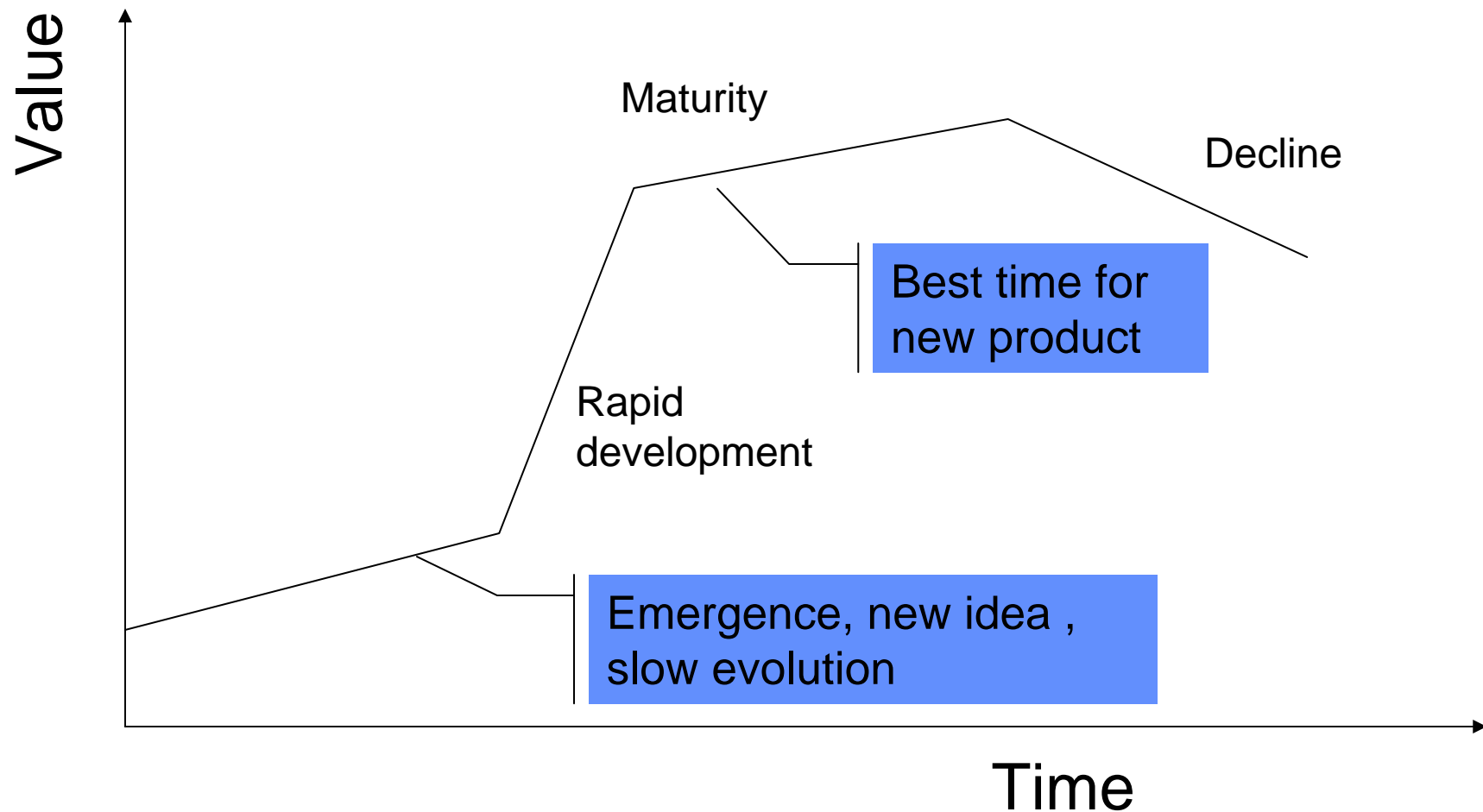
- TRIZ
- SIT
- C-K theory

- Invention Machine Corporation
- TRIZ = Russian acronym for Theory of Inventive Problem Solving
- Invented by Mr. Genrich Altshuller (1946)
- Based on patents study
- Observation that problems repeat across sciences
- Evolution of products follow certain rules
- Problems usually already solved

CREATIVE DESIGN METHODOLOGY - TRIZ



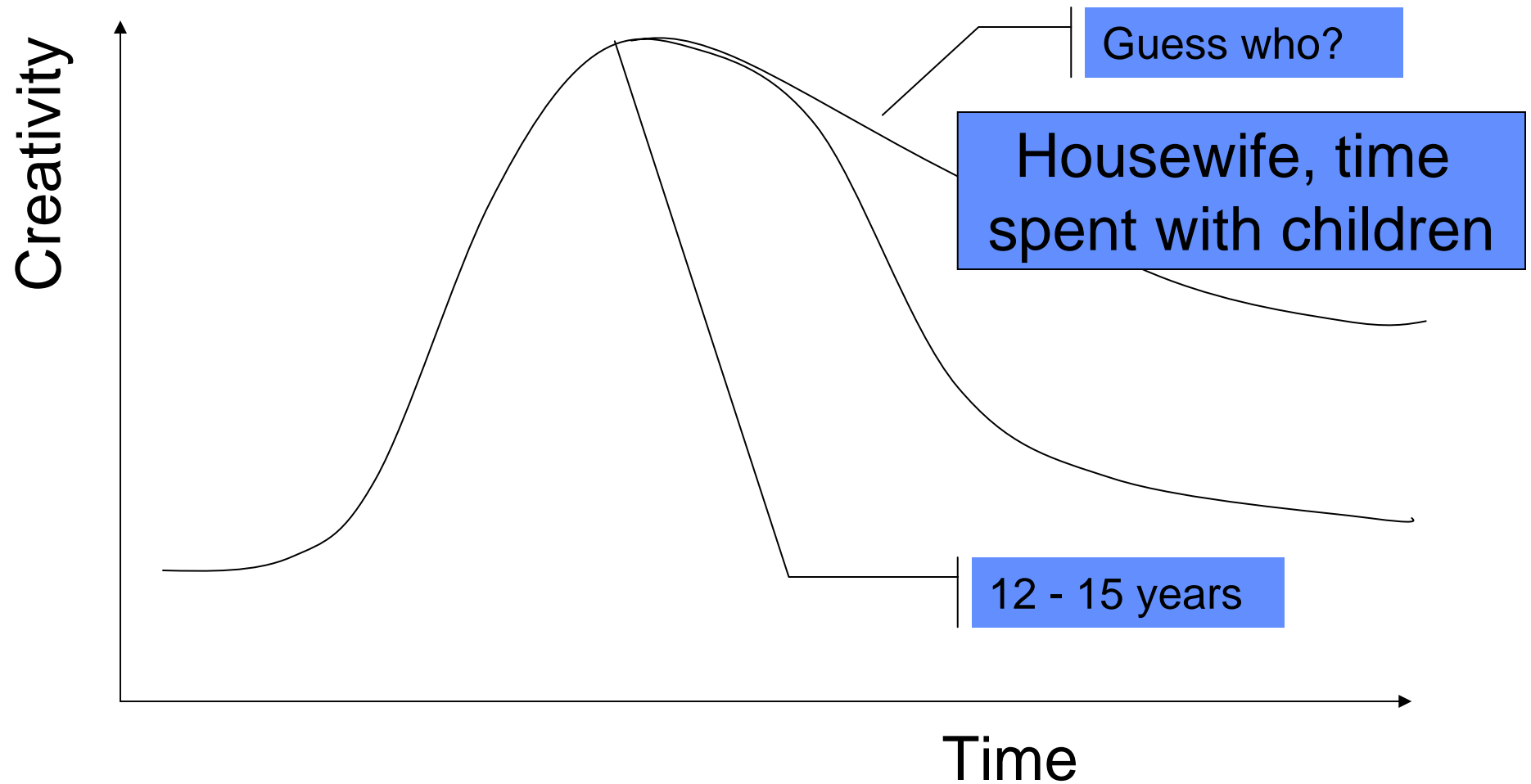
S-CURVE - PRODUCT LIFE CYCLE



- **A new association of two or more things/ideas. E.g. Tape and Paper (3M post it notes)**
- **To create new “Paradigm”, “Rules and Regulations”, “way of doing things”, “Patterns of behavior that establish boundaries.**
- **To create a better and new method to perform a function, e.g. laser printing instead of dot matrix printing, staple instead of paper clip, velcro instead of snaps or shoe laces...**

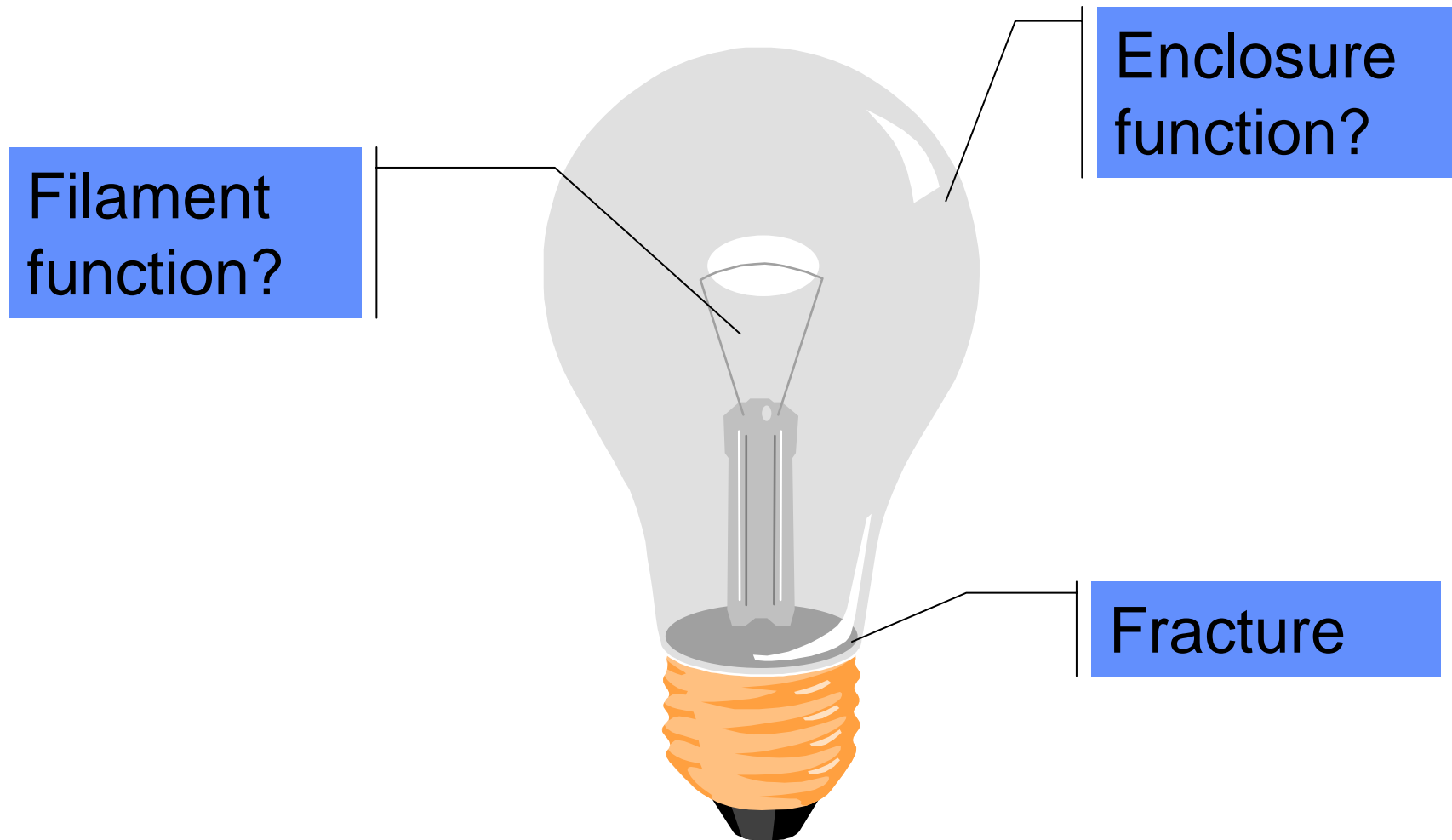
- Project constraints -- resources, budget, time..
- Limits of our own breadth of technical knowledge, Mechanical, chemistry, electronics,...
- Psychological Inertia
 - Results of life experiences/cultural background
 - Staying within ones discipline/ Difficulty thinking outside your specialty/ Looking for solutions where we are comfortable.
 - This is the way we always did it syndrome
 - Gets worse as we get older (Age graph)

AGE GRAPH



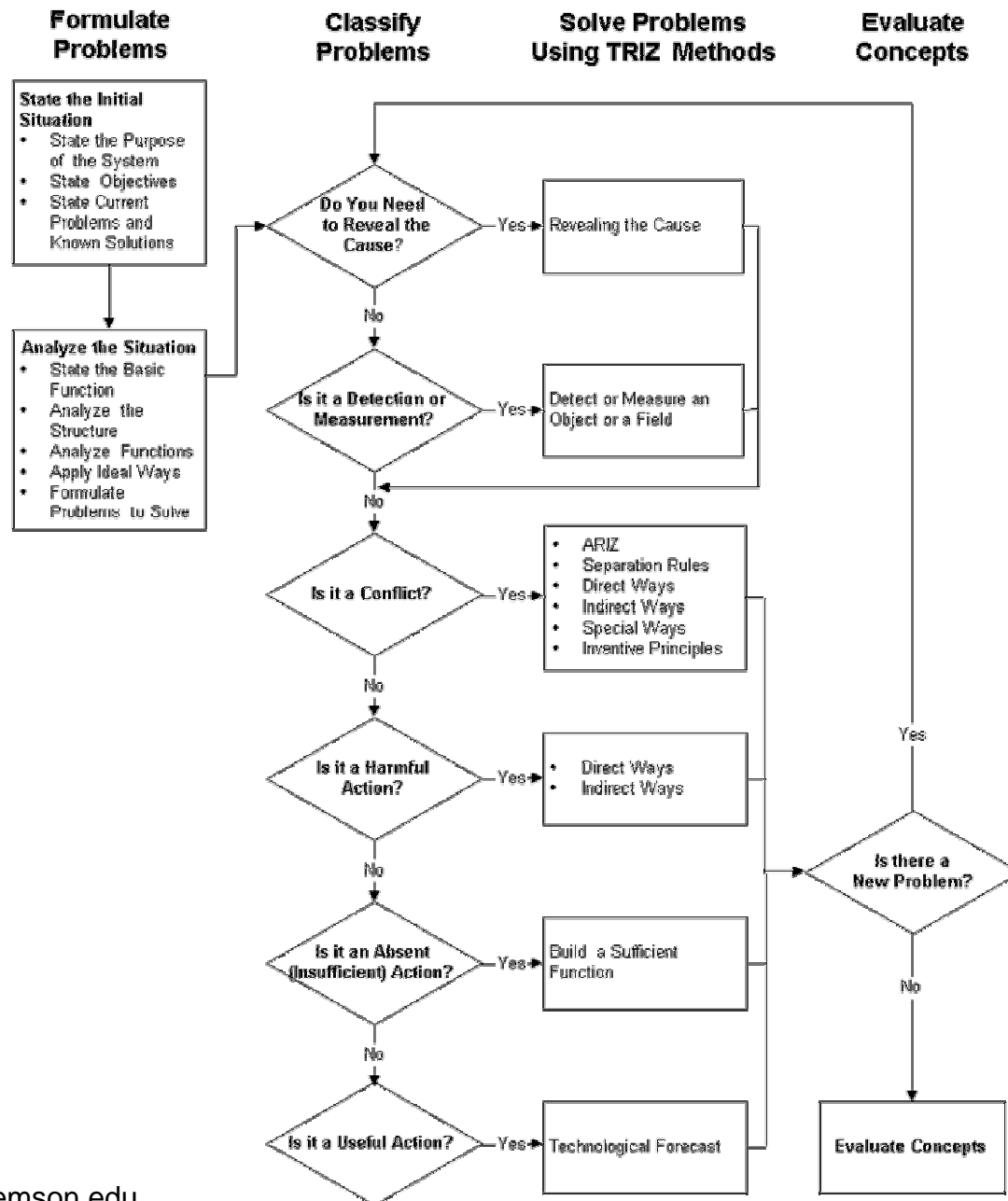
- We give up and compromise too easily
- We don't deal well with conflict
- When kids can't solve a problem, they cry; when adults can't solve a problem, they compromise

SOLVING THE WRONG PROBLEM



- **Reveal cause of failure**
- **Detect or Measure an object or its field**
- **Build substance-field models of the simplest sufficient systems**
- **Solve conflicts**
 - **Physical contradiction separation**
 - **Direct elimination of a harmful or unwanted action**
 - **Indirect elimination of a harmful or unwanted action**
 - **Introduction of a substance or a field**

Triz Flowchart



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- Many Idea Generation techniques exist
- Try different ones to identify the one(s) that work best for you.
- Consider the problem, some idea generation methods work better for certain problems than others (using pictorial representations versus textual representations)
- Check into Triz, interesting methodology to support decision making. Look at the several sites on the web. www.triz.org. or www.trizconsulting.com or others.