

Engg 5001 - Professional Development Creativity and Problem Solving

“... the ability to see relationships
where none appear to exist”

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Creativity in General Context

- **Characteristics**

- Intelligence: ability to learn and the ability to think
- Qualification: formal recognition of successful completion of an education/training program
- Creativity: ability to discern and develop relationships where none appear to exist

- **Comparison and Contrast**

- Most people who create significant things are intelligent
- Many people with the highest level of qualification do not have a single creative idea in their head
- People who are both intelligent and highly creative often achieve only mediocre grades in obtaining qualifications

Psychology of Creativity

- **Personality Traits associated with Creativity**
 - Diligence (sometimes to the point of obsession)
 - Stubbornness (persistent, tenacious, uncompromising)
 - Eccentricity (reclusive, highly sceptical, rebellious)
- **Creativity and the Engineer**
 - Engineering considered to be a creative profession
... but within constraints
 - Analysis and synthesis are part of the creative process
 - High priority on analysis part of engineering processes
... less on synthesis (perhaps needs development)

Models of the Brain

- **Left Hemisphere**

- Communicates using words
(has highly developed verbal abilities)
- logical and systematic
- concerned with matters as they are

- **Right Hemisphere**

- Communicates using images/pictures
(has highly developed spatial abilities)
- intuitive and imaginative
- concerned with emotions and feelings

Intellectual Evolution

- **Organising experience and knowledge**
- **Establishing categories**
- **Recognising patterns**
- **Building on learning and experience**

- **Eureka !**

Blocks to Creativity

- **Mental** (negative attitude)
 - stereotyping or limiting problem unnecessarily
 - believing you are not creative
 - information overload (can't see the forest for the trees)
- **Emotional** (fear of failure)
 - aversion to risk taking
 - judging rather than generating ideas
- **Cultural** (following rules)
 - fear of offending or angering
 - difficulty in communicating your ideas

Blocks and Blockbusters

Blocks	Blockbusters
Mental	Attitude Adjustment
Emotional	Risk taking techniques
Cultural	Rule breaking techniques

Ways through the Blocks

- **Brainstorming** — be open and positive
- **Stimulation** — look at randomly chosen words
- **Futuring** — imagine a solution infeasible today
- **Forced connections** — to trigger options
- **Cross-fertilisation** — get an artist's opinion
- **Rumination** — stop and let things 'percolate'

Brainstorming

- **Group activity of 5-12 people**
- **Facilitator & recorder/scribe**
- **Clearly defined Problem Statement**
- **Relaxed atmosphere**
- **Phase 1 – focus on quantity not quality**
- **Phase 2 – review and refine**
- **Thought Starters and Idea Generators**

Thought Starter – Osborn’s Activity Checklist

- **Adapt**
 - how can this (product, idea, plan) be used as is ?
 - what other uses can it be adapted to ?
- **Modify** – change the material, shape, colour, etc
- **Enlarge** – add new ingredient; make bigger, stronger
- **Reduce** – split up, take something out, make smaller
- **Substitute**
 - who else; what else; where else ?
 - use another ingredient, material or approach
- **Re-arrange**
 - interchange parts, patterns, layouts; transpose cause/effect
 - reverse roles; turn backwards or upside down; sort
- **Combine** – remix parts, ideas; compromise; recategorise

One Minute Idea Generator

- **Go for Quantity**
- **Write down every idea**
- **Play (Lego is sometimes used)**
- **Switch your point of view**
- **What if ?**
 - use idea generating questions
 - use ‘Forced Connectors’
 - use ‘Analogies’

Idea Generating Questions

- **What else can it be used for ?**
- **What could be used instead ?**
- **What if it were larger, heavier ?**
- **What if it were lighter, smaller ?**
- **Can I turn it upside down, inside out ?**

Forced Connections

- **Aim**
 - generate possible new ideas or approaches
- **Process**
 - combine lists of attributes
 - force new connections between them
 - trigger new options

Analogies

- **What does your situation remind you of**
- **Include the word 'like'**
 - Changing a tyre is like changing your shoes
- **Use the analogy to gather bridging ideas**
 - You retie your shoelaces if they feel loose
... can we incorporate a sensor in the car to tell the driver that the tyre is loose

Creativity and Design

The Engineering Design Method

- **Identify the Need and Define the Problem**
- **Assemble Design Team**
- **Identify Constraints and Criteria for Success**
- **Search for Solutions**
- **Feasibility Studies**
- **Preliminary Design**
- **Detailed Design**
- **Construct Solution**
- **Verify and Evaluate**

Creativity and Design

Creative Resolution of Issues

- **Confront**
- **Change the Source**
- **Isolate**
- **Invert**
- **Divide**
- **Use Analogies**
- **Use Product Attributes**

Creative Groups Avoid ...

- **We tried that before**
- **That's a stupid idea**
- **You can't do that**
- **We don't have time**
- **It's impossible**
- **The last thing we need is more ideas**
- **They will think that we are crazy**

Creative Groups Encourage ...

- **What would happen if ?**
- **Let's review all the options**
- **We need more information**
- **On that basis ... I've changed my mind**
- **How could we improve ?**
- **What have we missed ?**
- **Wouldn't it be fun if ?**

Creative People ...

- **The already creative**
- **The sometimes creative**
- **The yet to be creative**

Problem Solving - Lecture Outline

- **Problem Solving Overview**
- **Structure – how do we solve problems ?**
 - Problem Solving “Heuristic”
 - Problem Definition
 - Generating Options (for solutions)
 - Making Decisions
 - Implementing Solutions
 - Evaluation of Results

1. Problem Solving Overview

Types of Engineering Problems

- **Research**
- **Knowledge and Troubleshooting**
- **Mathematics**
- **Resource and Logistics**
- **Social**
- **Design**

Problem Solving

- **a Creative Activity**
 - you all have creativity and you all have knowledge
 - extra natural ability and aptitude is advantageous
- **can be a Learned Skill**
 - from effective problem solver “mentors”
 - many different published “strategies”
 - by discipline, perseverance, time and patience
 - by using “heuristic rules”

(heuristics = study of how discoveries are made; involves “trial and error”, “rules of thumb”, usually not precise mathematical equations)

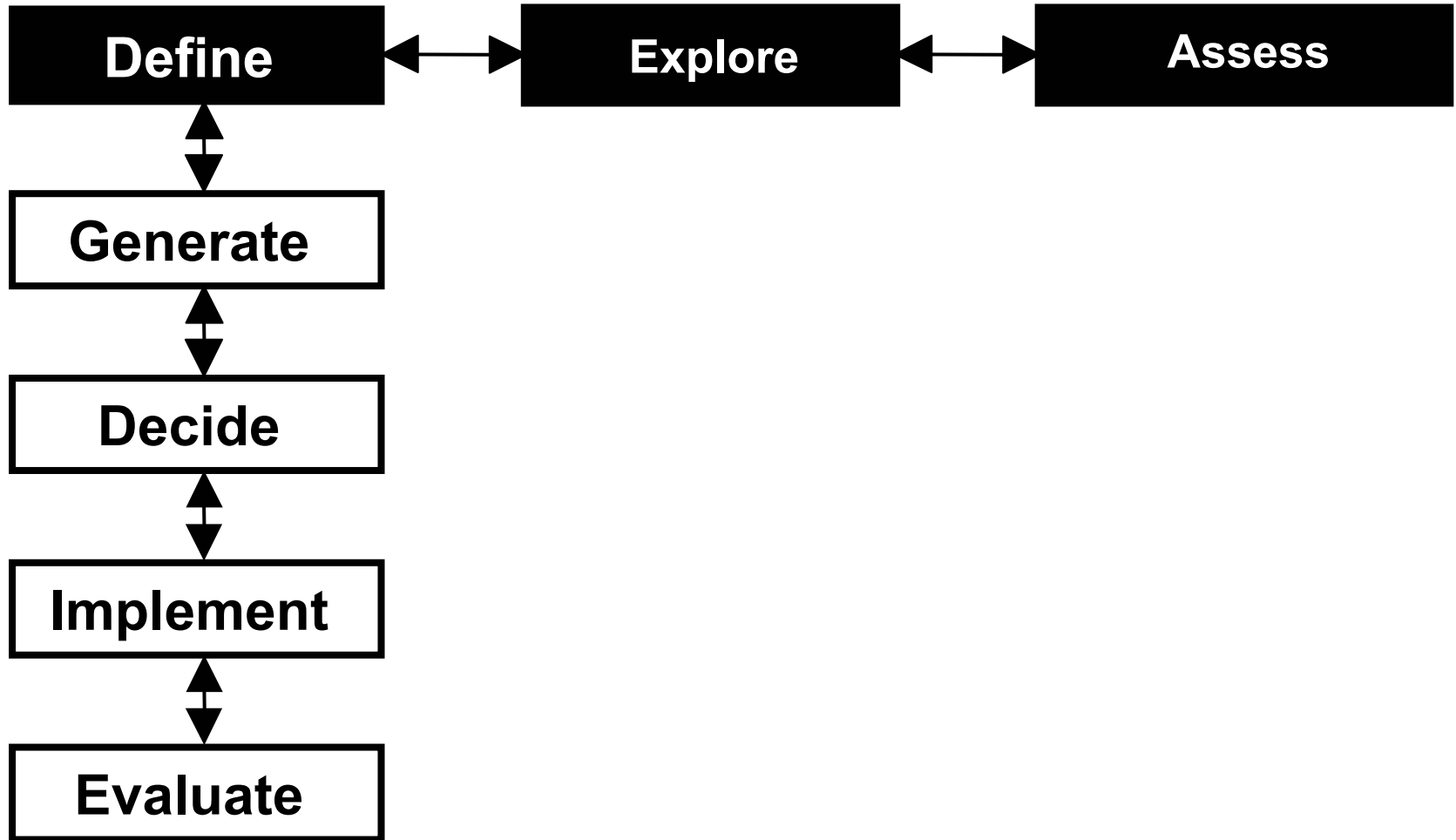
2. How do we Solve Problems

- A **“Heuristic” Technique** is essentially a **“trial and error”** approach
 - a number of options are generated and the best selected by “try-it-and-see” experimentation
 - use of “rules of thumb” is very common
- **Heuristics are generally aids for thinking**
 - not guaranteed to produce good results

Problem Solving Heuristic

- **Define** the problem
- **Generate** options for solution
- **Decide** on the course of action
(evaluate optional solutions)
- **Implement** the chosen solution
- **Evaluate** the result
(re-evaluate if required)

Steps in Problem Solving Heuristic



Defining the **Real** Problem (1)

Explore the Background

- **Research** the subject details
 - read, collect data, think
 - talk with others ... especially experts
- **Investigate** the subject “environment”
 - **Who** defined the problem ?
(is there a vested interest ?)
 - on **What Basis** is the problem defined ?
(is there bias, subjectivity or error ?)
- **Verify** your findings
 - is it **Really** a problem ?

Defining the **Real Problem (2)**

Lateral Assessment

- Does the problem **Change if Restated** in different ways ?
- Is there a **Relationship** between the **Desired Situation** (ie: without the problem) and the **Present Situation** (ie: with the problem) ?
- Can something be done to make it **OK to Do Nothing** ? (ie: not solve problem posed)

Problem Restatement

- Restating problem helps to **inject ideas**
- **Some suggested techniques**
 - vary stress pattern by placing emphasis on different words and phrases
 - choose a term that has an explicit definition and substitute that definition wherever it appears
 - make an opposite statement, change positives to negatives and vice versa
 - change ‘every’ to ‘some’, ‘always’ to ‘sometimes’, ‘sometimes’ to ‘never’ and vice versa
 - replace ‘persuasive words’ such as ‘obviously’ and ‘certainly’ with non-persuasive words like ‘possibly’
 - replace words with equations or pictures, & vice versa

Problem Restatement Example

Toasty O was a well selling cereal when it first came on the market. However, after several months, sales dropped.

Marketing identified that customer dissatisfaction was expressed in terms of a stale taste.

The perceived problem was:

“Cereal is not getting to market fast enough to maintain freshness.”

- *Vary word stress by placing emphasis on different words and phrases.*

Cereal is not getting to market fast enough to maintain freshness.
(Do our other products get there faster ?)

Cereal is not **getting** to market fast enough to maintain freshness.
(Can we make the distance or time shorter ?)

Cereal is not getting to market fast enough to maintain **freshness**.
(How can we keep the cereal fresher for longer ?)

Problem Restatement Example

Toasty O was a well selling cereal when it first came on the market. However, after several months, sales dropped.

Marketing identified that customer dissatisfaction was expressed in terms of a stale taste.

The perceived problem was:

“Cereal is not getting to market fast enough to maintain freshness.”

- *Soften definitives, harden conditionals.*

Cereal **may** not be getting to the market fast enough to **always** maintain freshness.

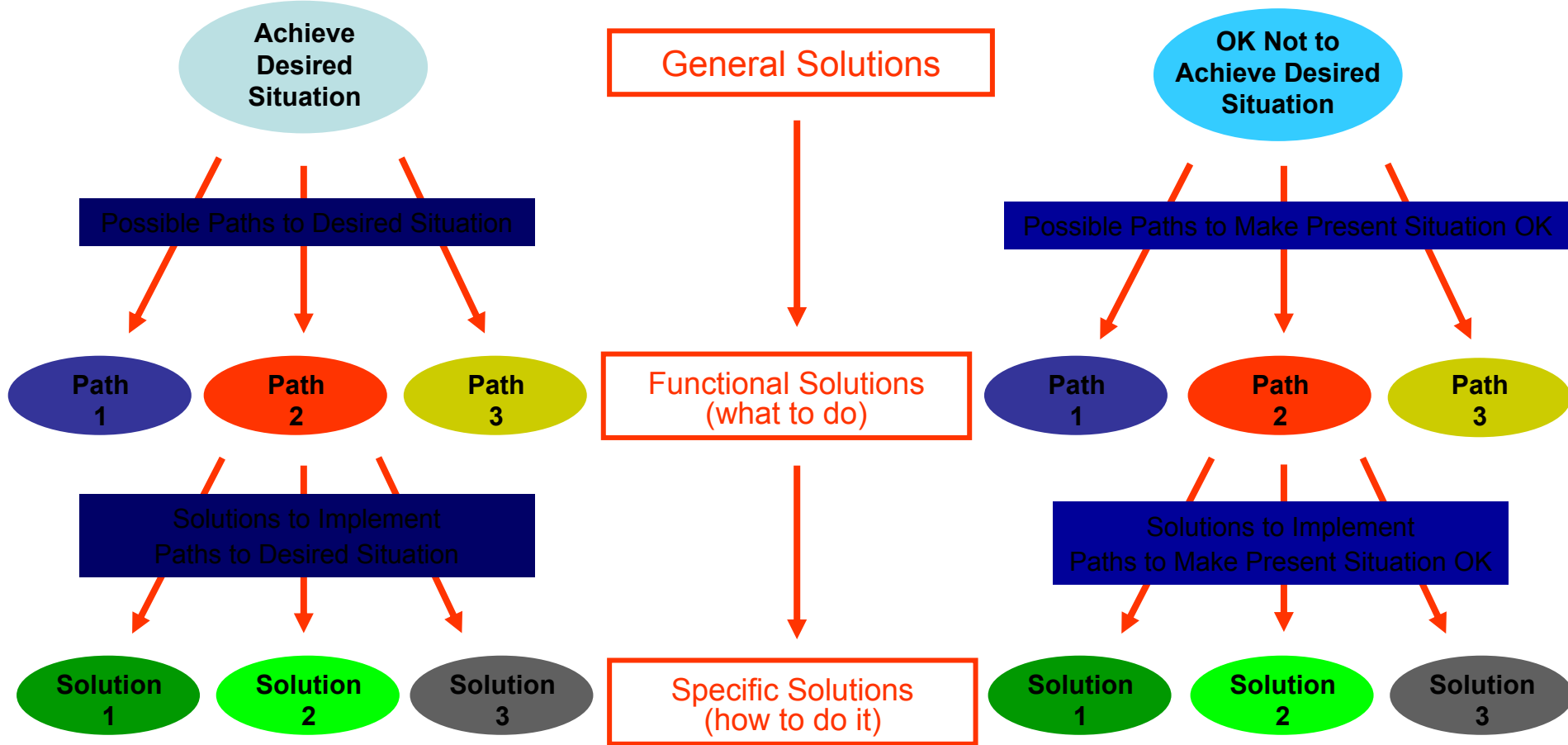
(Why isn't our cereal always fresh ?)

- *Make an opposite statement, change positives to negatives and vice versa*

Get the cereal to the market **so slowly** that it will **never** be fresh.

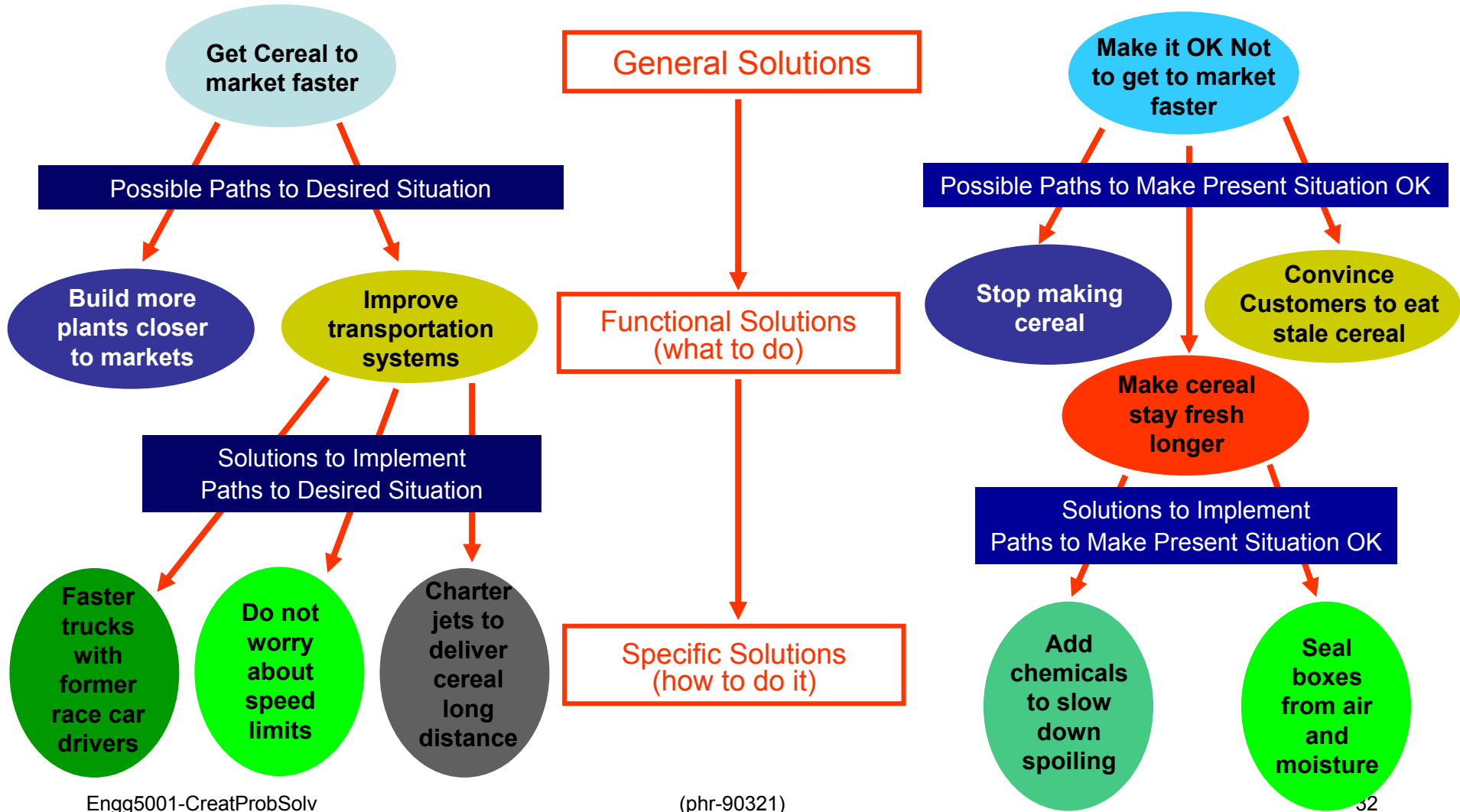
(How long do we have to maintain freshness and what controls it ?)

Duncker Diagram



Duncker Diagram Example

Problem: Cereal is not getting to market fast enough to maintain freshness



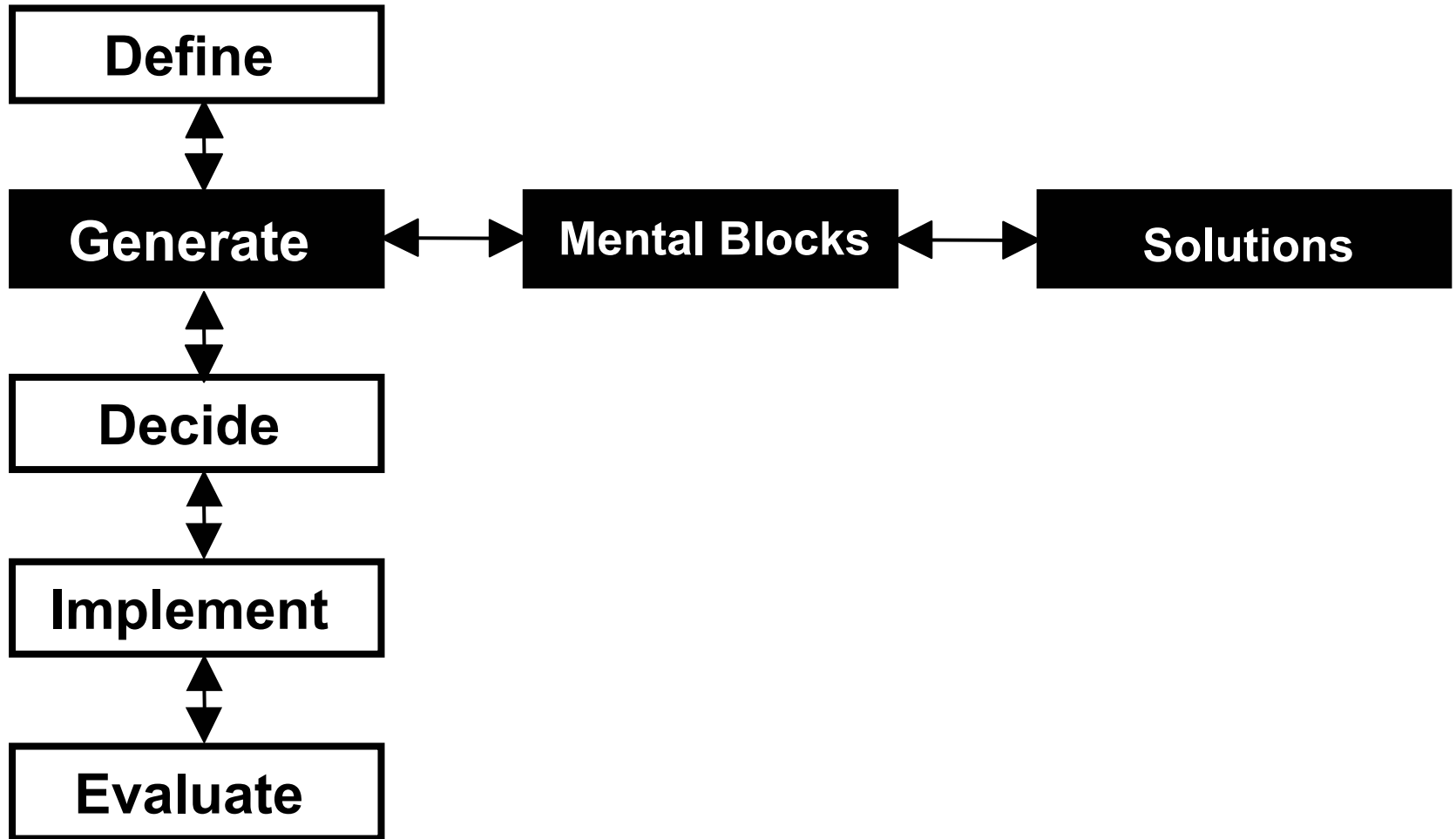
Define - What Next (1)

- **Evaluate New Problem Definition**
 - have **all components** of the problem been identified ?
 - have **all constraints** been identified ?
 - what is **missing from** (or extraneous to) the problem definition ?
 - have we **challenged assumptions** and information given with the original problem definition ?
 - have we distinguished **fact from opinion** ?

Define - What Next (2)

- **Should the Problem be Solved ?**
 - is it **worth** solving ?
 - does a solution **exist already** ?
 - are **resources available** to solve the problem ?
 - is there **enough time** available to solve the problem ?

Steps in Problem Solving Heuristic

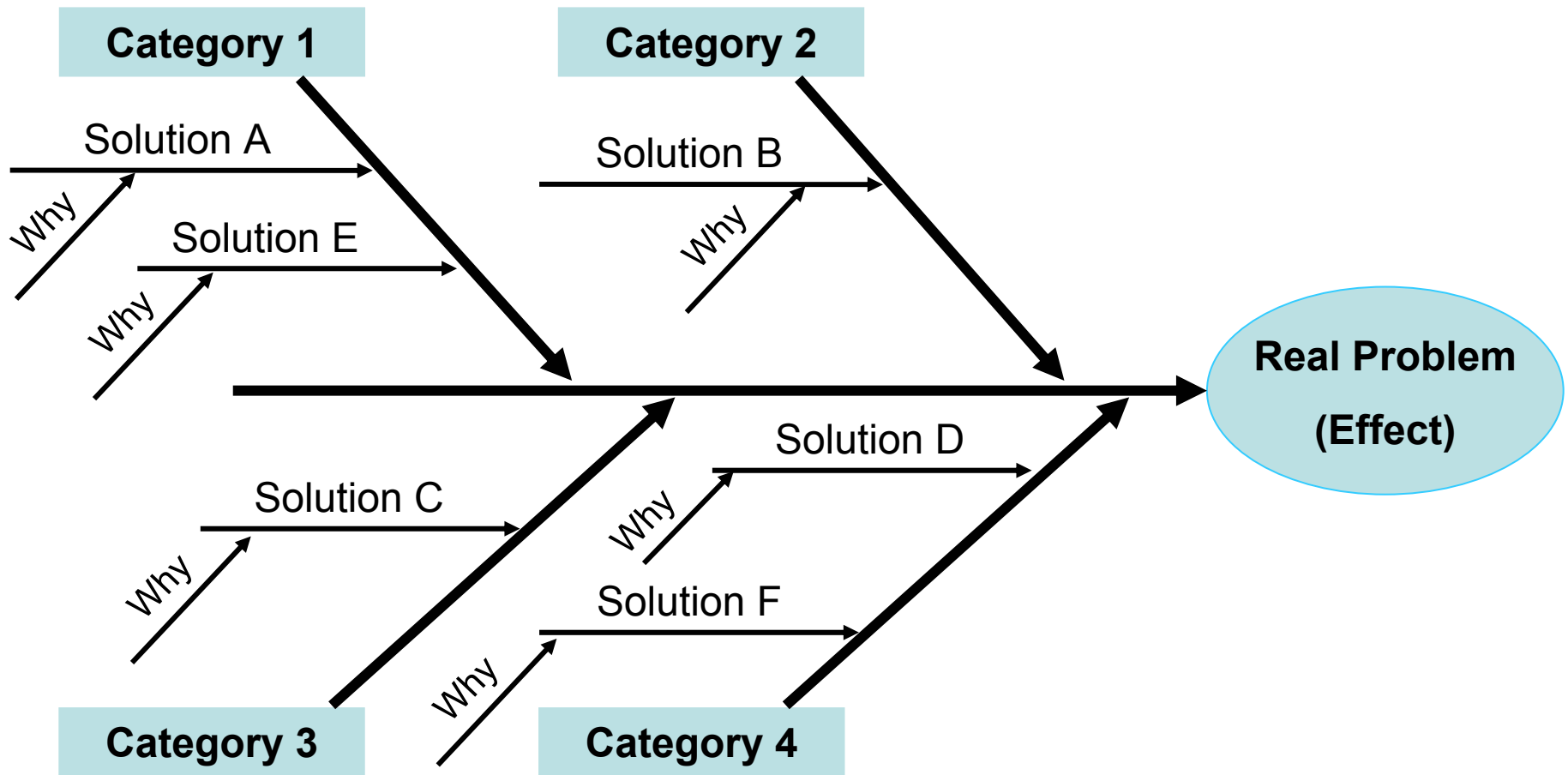


Generate – Several Key Issues

- **Rush to accomplishment / premature closure**
 (“Nothing is more dangerous than an idea, when it is the only one that you have”)
 - does a solution **exist already** ?
 - are enough **resources** available ?
 - is there enough **time** available ?
- **Start Considering Solutions**
 - once you have defined the problem you want to make sure you generate the **best** solution
 - many times **blocks** hinder your progress

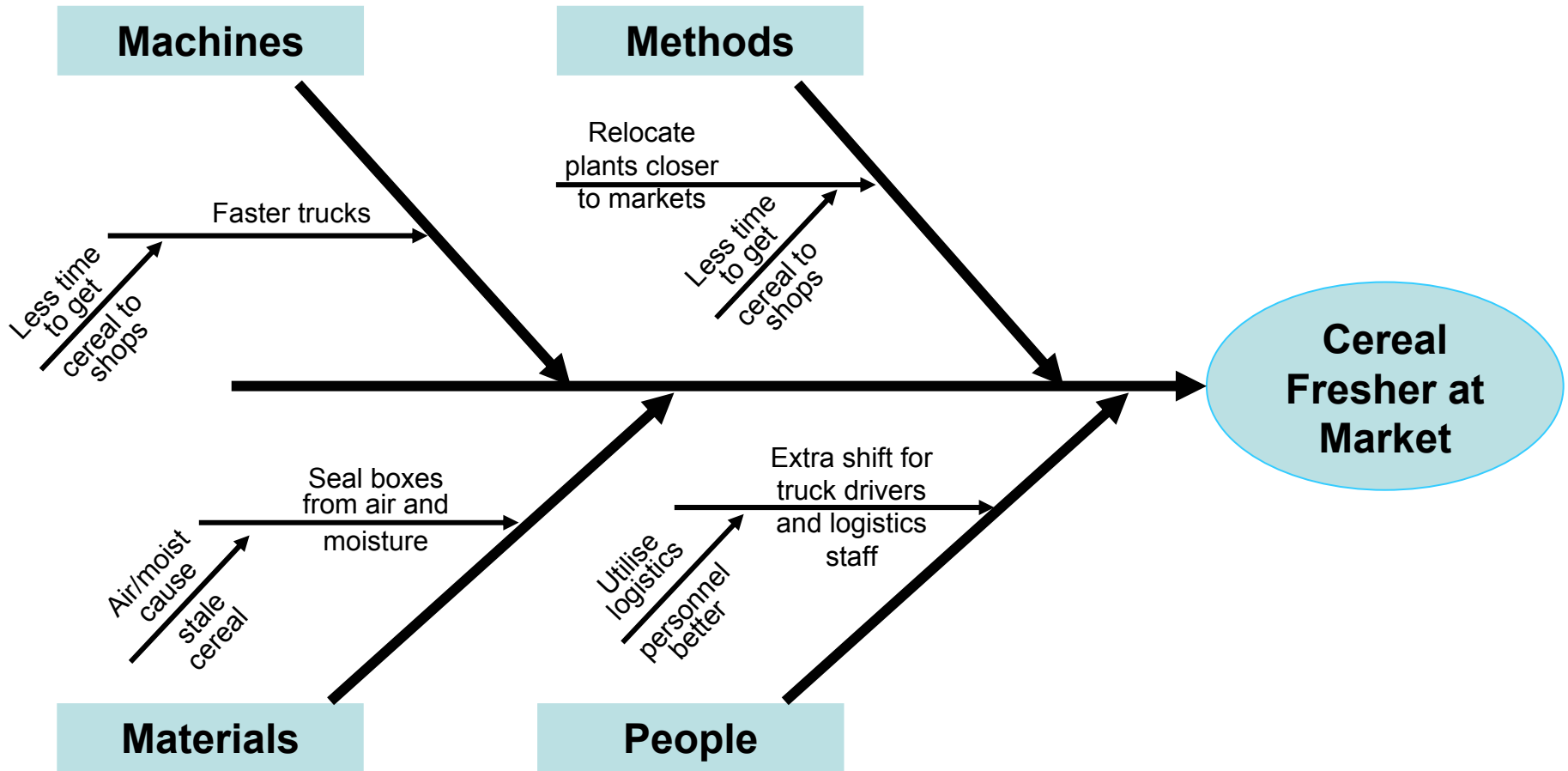
Organising Ideas

Ishikawa's Fishbone Diagram

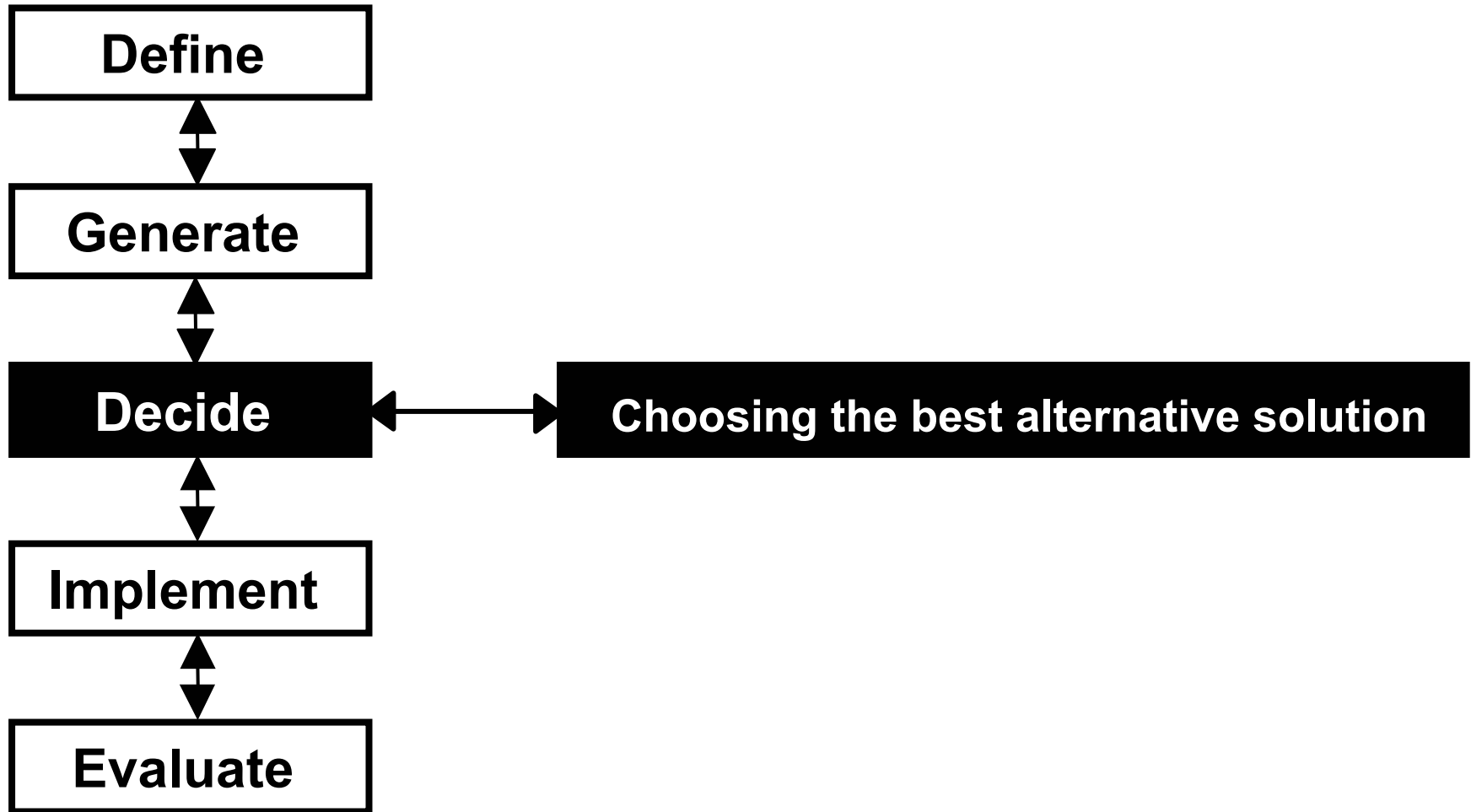


Fishbone Diagram Example

Problem: Cereal is not getting to market fast enough to maintain freshness



Steps in Problem Solving Heuristic



Kepner–Tregoe Method (K–T)

- an **Organisational Approach** to decision making
- **Four steps in overall K-T heuristic:**
 - Situation Analysis: critical aspects first
 - Problem Analysis: what past event may have caused problems ?
 - Decision Analysis: what actions are needed to correct problem ?
 - Potential Problem Analysis: how to prevent further problems ?
- **Primarily for engineering problems in progress**
 - can aid searching for real problem in any design process

K–T Decision Analysis (1)

- **How to choose the **best** solution from a number of “Alternatives”**
 - the Alternatives are the Potential Solutions identified in the Generate step
- **Write a concise **decision statement****
 - collect and analyse information and data
 - talk with people familiar with the problem
 - if possible, view the problem first hand
 - confirm all findings

K–T Decision Analysis (2)

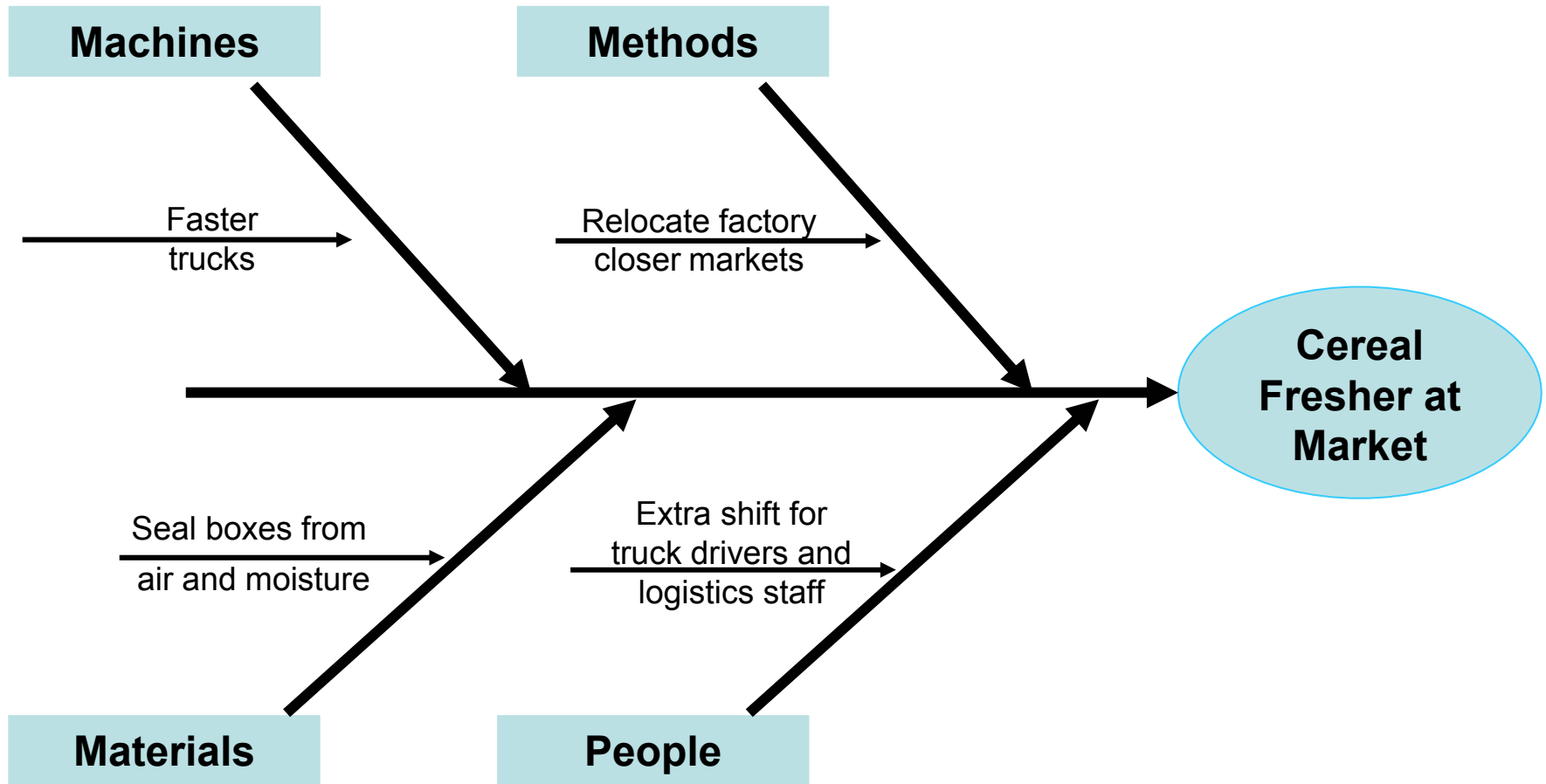
- Specify the **objectives** of the decision
- Divide objectives into **musts** and **wants**
- **Musts** are **mandatory** to a successful solution
 - if a solution satisfies **all** musts then it is a **GO**
 - if it **does not** satisfy **even only just one** of the musts it is a **NO GO**

K–T Decision Analysis (3)

- **Wants are desirable but not mandatory**
 - assign a **Weight (1-10)** to each Want on **how important** it is
 - assign a **Rating (0-10)** to each Alternative Solution as to how well it **satisfies each Want**
 - a **Score** for a particular solution can be determined by **multiplying** its Weight and Rating
- Alternative Solutions are **Ranked** by aggregate (ie: total) level of **Score**

Fishbone Diagram Example

Problem: Cereal is not getting to market fast enough to maintain freshness



K-T Decision Analysis Example

Problem: Cereal is not getting to market fast enough to maintain freshness

Objectives	Alternatives							
	Alternative A	Wgt	Ratg	Mult	Alternative B	Wgt	Ratg	Mult
Cereal Fresher at Market - <u>M</u> ust								
Maintain Competitive on Price in Market - <u>M</u> ust								
Minimal Change to Work Practices - <u>W</u> ant		10				10		
Minimal Change to Ingredients - <u>W</u> ant		6				6		
Minimal law, regulation, or policy effect - <u>W</u> ant		2				2		

K–T Decision Analysis Example (1)

Problem: Cereal is not getting to market fast enough to maintain freshness

	Alternatives							
Objectives	a Faster Trucks	Wgt	Ratg	Mult	b Relocate Factory Closer to Market	Wgt	Ratg	Mult
Cereal Fresher at Market - <u>Must</u>	Yes – GO				Yes – GO			
Maintain Competitive on Price in Market - <u>Must</u>	Yes – GO				No – too expensive to recover costs			
Minimal Change to Work Practices - <u>Want</u>	Probably Minimal Change	10	8	80				
Minimal Change to Ingredients - <u>Want</u>	There will be no change at all	6	10	60				
Minimal law, regulation, or policy effect - <u>Want</u>	Possibly Minimal Effect	2	5	10				
Sum of Multiple = <u>Score</u>				150				0

K–T Decision Analysis Example (2)

Problem: Cereal is not getting to market fast enough to maintain freshness

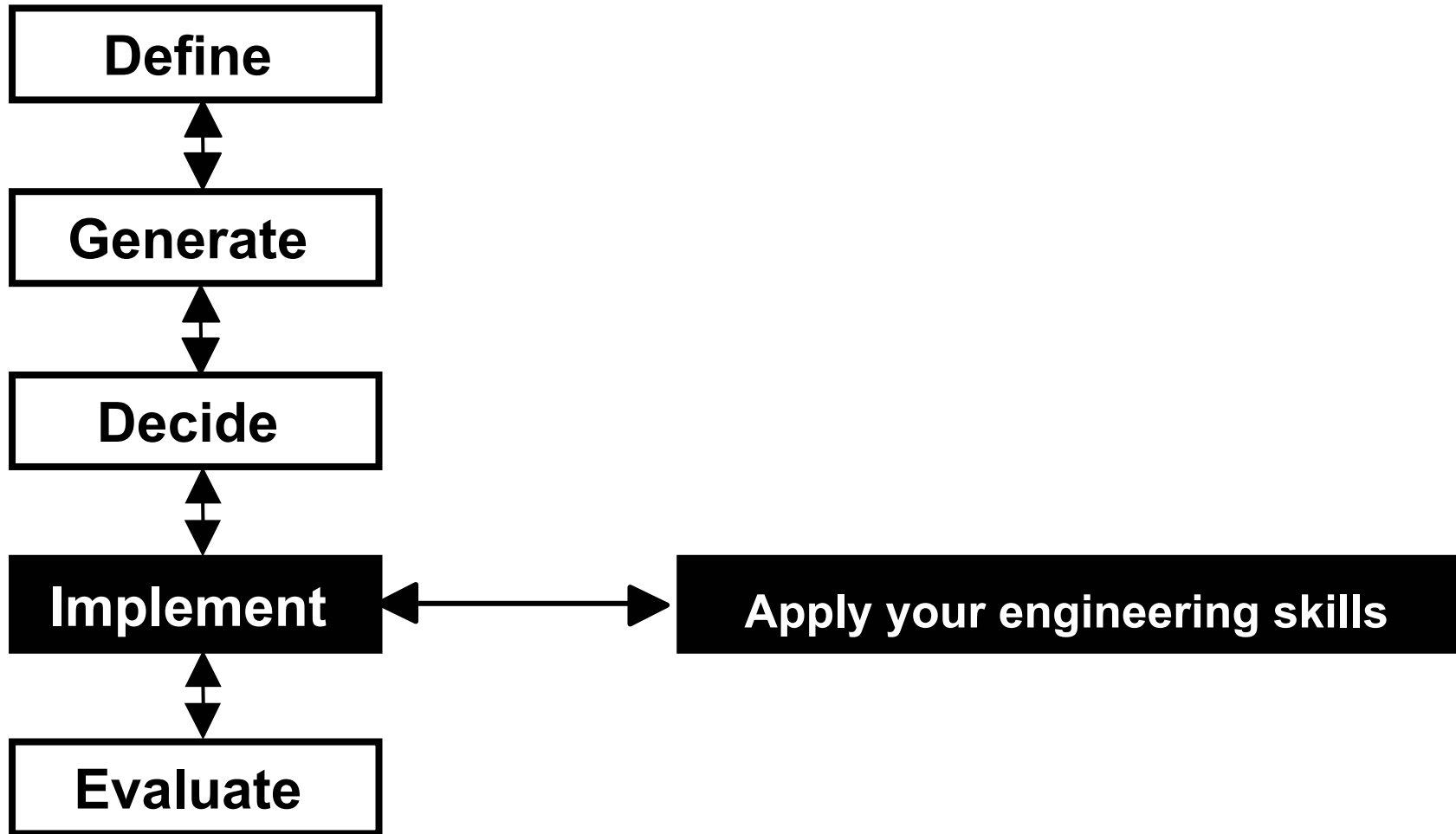
	Alternatives							
Objectives	c Seal Boxes from Air & Moisture	Wgt	Ratg	Mult	d Extra Shift for Logistics Staff	Wgt	Ratg	Mult
Cereal Fresher at Market - <u>Must</u>	Yes – GO				Yes – GO			
Maintain Competitive on Price in Market - <u>Must</u>	Yes – GO				Yes – GO			
Minimal Change to Work Practices - <u>Want</u>	There will be no change at all	10	10	100	Changes will be significant	10	2	20
Minimal Change to Ingredients - <u>Want</u>	There will be no change at all	6	10	60	There will be no change at all	6	10	60
Minimal law, regulation, or policy effect - <u>Want</u>	Probably Minimal Effect	2	8	16	Possibly Minimal Effect	2	5	10
Sum of Multiple = <u>Score</u>				176				90

K–T Decision Analysis Example (3)

Problem: Cereal is not getting to market fast enough to maintain freshness

Rank (by Sum of Multiple)	Alternative	Score
1	c. Seal Boxes from Air & Moisture (provides most benefit)	176
2	a. Faster Trucks	150
3	d. Extra Shift for Logistics Staff	90
4	b. Relocate Factory Closer to Market (does not meet one of the 'Must')	0

Steps in Problem Solving Heuristic



Implementation (1)

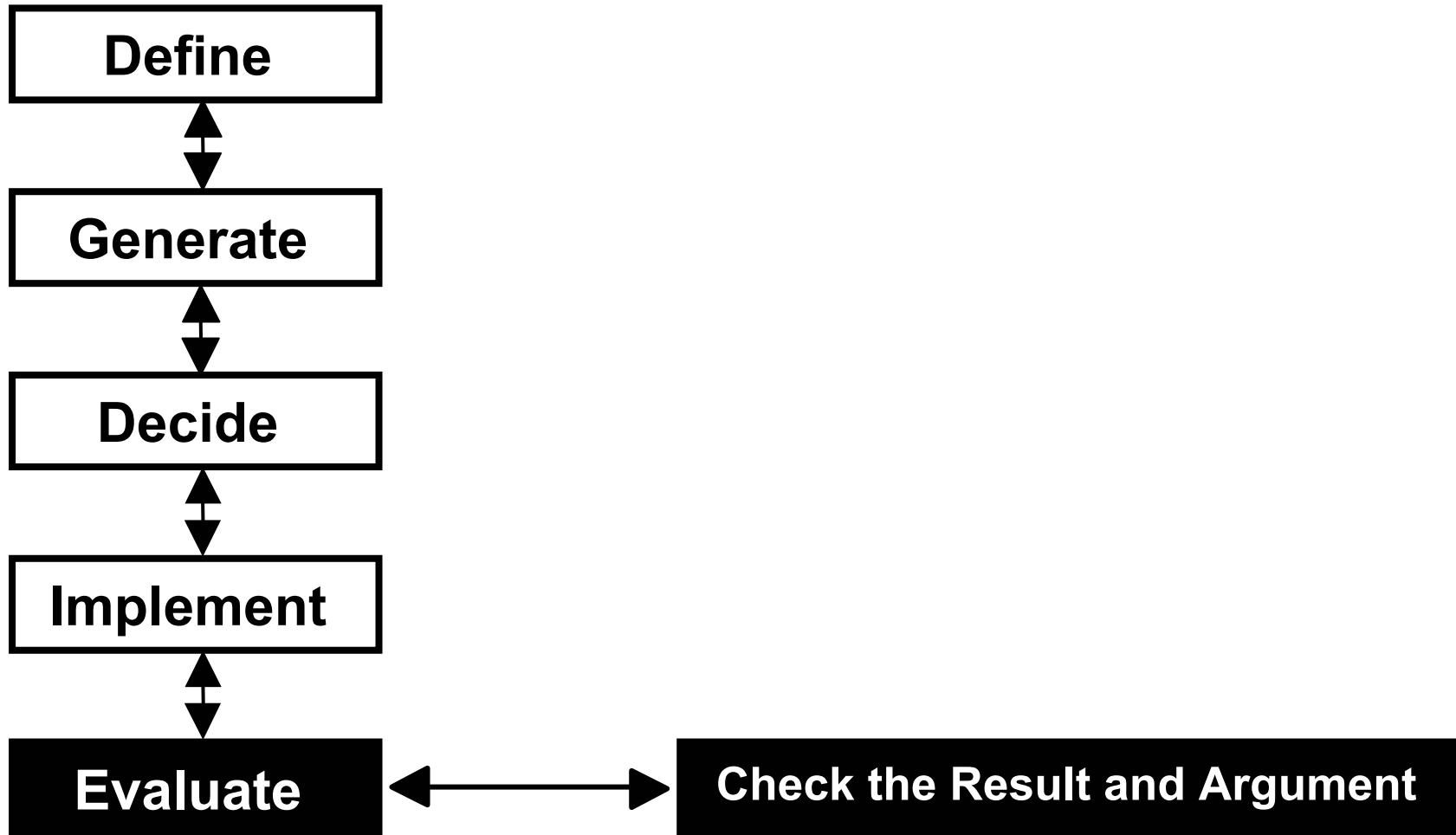
- **Approval**
 - management
 - financial
 - regulatory
- **Planning**
 - schedule (Gantt chart, critical path)
 - coordination and development
 - necessary resources

Implementation (2)

- **Application**

- Evaluation: qualitative/quantitative judgments about how material and methods satisfy problem criteria
- Synthesis: formulation of problem statement and testing procedures from “fuzzy” situations
- Analysis: break the problem into parts, identify missing, redundant and contradictory information
- Organisation: set of activities to be undertaken
- Comprehension: understanding, manipulation and/or extrapolation of information
- Knowledge: remembering previously learned material

Steps in Problem Solving Heuristic



Evaluation Guidelines

- Evaluation should be **ongoing** process
- **Fully** examine solutions **regularly**
 - check that solution is **blunder free**
 - check the **reasonableness** of the results
 - check that **criteria and constraints** are **satisfied**
 - check **procedure and logic** of all **arguments**
 - analyse for **potential problems**
 - confirm **all** findings
- **Have an independent review of the work**

Evaluation Checklist

- Does solution address the **real problem**
- Is it a **permanent** solution or a **patch-up**
- Have **all** consequences been identified
 - economics
 - environmental
 - occupational health and safety
 - social
- Does solution meet all **customer needs**
- Is it an **Ethical** solution

Evaluation - Ethical Considerations

“Solutions are not always black and white with regard to ethics, but multiple shades of grey”

- **Ethics Checklist**

- is the solution to the problem **legal**
- is it **balanced**
- is it **properly documented** and **accounted for**
- would you be **confident and satisfied** to expose it to **public scrutiny**