SCIENCE

Thinking and problem solving

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Textbook definitions

Cognition = Thinking

"Rationality means considering relevant data for making a judgement and then consciously manipulating this information to come to the most reasonable conclusion"

Q?

Views evolved over three eras

*Can you identify these eras?

Hint: think togas, grave-robbers, couches

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COGNITION

Classical model of rationality
(developed over last millennia)

- philosophical speculation
  - free will v. determinism
  - mind v. body
  - nature v. nurture
  - rationalism v. empiricism (experience v. logic)
  - reason v. emotion
  - etc .

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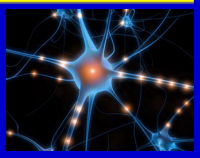
COGNITION

First cognitive revolution
(developed over last century)



- guided by scientific investigation (biology/neurology plus technology/data processors)

⇒ recognition of explicit cognition

conscious step-by-step processing (cf. computer)

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COGNITION

Second cognitive revolution
(developed over last decades)

- guided by psychology (developmental/behavioural/..)

⇒ recognition of implicit cognition

outside awareness, emotions, connectivism (networks, parallel distributed processing)

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COGNITION

⇒ manipulating mental representations for a purpose

- words (language*)
- mental images (visualization)
- mental models (representations)
- concepts (categorization)

*system of sounds/symbols to communicate thought

crucial to reasoning, decision making, problem solving

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Reasoning

Generation and evaluation of arguments and beliefs

- inductive
  (extrapolation of specific to general)
- deductive
  (inference of specific from general)
- analogic
  (understand novelty in terms of familiar)

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Decision-making

Weigh pros and cons of alternatives to make a choice

consider:

- utility
  (value: weighted/expected)
- probability
  (estimated likelihood)

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Problem-solving

Transforming from initial unclear state to more satisfying goal state using operators

problem → solution

operators
(= mental/behavioural processes)

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Problems

Types:

- well-defined problems, often with single solution
  (states/operators easily defined) (absolute)
  (e.g. maths problems, factual questions)
  [grounded in psychometric intelligence]
- ill-defined problems, with multiple answers
  (states/operators vague) (variable)
  (e.g. what is your favourite colour?)
  [socio-emotional in nature]

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Problem-solving strategies

- algorithms (systematic procedures)
  e.g. spell-check, shopping lists, maths
- mental simulation (imagining steps)
  e.g. route selection, open-ended questions

in literate societies, solve many problems with numbers
e.g. recipes, tax guides, shopping, timetables, ..
involves: - memory (working and long-term)
- knowledge (declarative and procedural)

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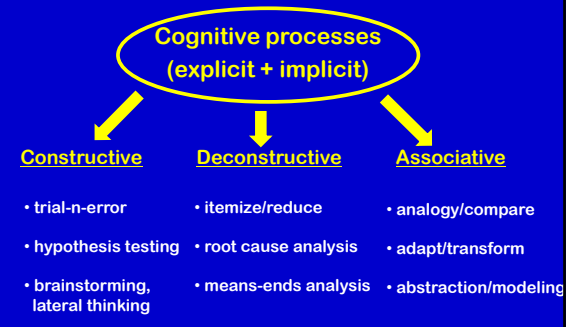
Problem-solving strategies



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Theft!

Three businessmen finish lunch.
The waiter brings the bill for $30.
They each pay $10.
The cashier notes a mistake - the bill only totalled $25.
The cashier gives the waiter $5 in change to return to the men.
The waiter is not good at maths so he gives each businessmen $1 in change and pockets the remaining $2.

This means each businessman paid $9 (originally $10 but received $1 change). Now $9 times 3 equals $27. Add to this the $2 the waiter kept gives $29. What happened to the other $1?

If you follow the money, you see that nothing goes missing ($25 in cash register, $3 with customers, $2 with waiter).
It all depends on your perspective!

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Fishy numbers

Fish and chips cost $8
Fish cost $6 more than chips
How much do chips cost?

Superficial response: $2 ($8 - $6)

Considered response: $1

F + C = 8; but F = C + 6; substituting F gives C + 6 + C = 8; so C = 1

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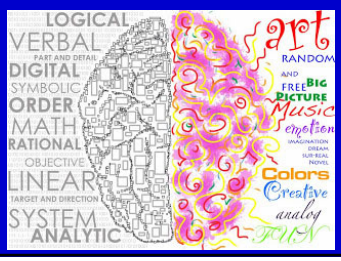
Problem-solving

Involves thought processes
which like other skills
can be improved by practice



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Problem-solving (Wikipedia)

- **Research**: employ existing ideas or adapt existing solutions to similar problems
- **Trial-and-error**: test possible solutions until the right one is found
- **Divide and conquer**: break down large, complex problem into smaller, solvable parts
- **Abstraction**: solve problem in model before applying to real system
- **Reduction**: transform problem into another problem for which solutions exist
- **Analogy**: use a solution that solves an analogous problem
- **Lateral thinking**: approach solutions indirectly and creatively
- **Brainstorming**: suggest large number of solutions or ideas, and combine and develop them until an optimum solution is found
- **Hypothesis testing**: assume a possible explanation and trying to prove/disprove
- **Proof**: try to prove that the problem cannot be solved (the point where the proof fails will be the starting point for solving it)
- **Means-ends analysis**: choose an action at each step to move closer to the goal
- **Method of focal objects**: synthesize seemingly non-matching characteristics of different objects into something new
- **Morphological analysis**: assess output and interactions of entire system
- **Root cause analysis**: identify cause of problem

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Problem-solving process

Four-step linear process:

1. compare initial and goal states (identify differences)
2. identify possible operators (select most likely)
3. apply operators and refine (sub-goal milestones)
4. continue to goal state (evaluate)

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Problem-solving strategies

Systematic approach to biological problems involving numeric/algebraic/statistical procedures

• write down dependent variable (y) (what is required?)	V
• write down independent variables (information given) (this often helps identify process required)	P,n,R,T (Ideal GL)
• check units (convert to SI as required)	(mL)
• write down steps/relationships/equations to use (develop a diagram/flowchart if required)	PV = nRT
• perform calculations	V = 2.33 L
• check answer for sense/sensibility	too small
• conduct dimensional analysis (do units resolve?)	x 1,000 mL

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Problem-solving strategies

M-V-S-A model (popular in enabling sciences)

MODEL make simplifying assumptions, list variables, identify ISO (input-system-output), interactions

VISUALIZE make representation (translate words into symbols)
- verbal (terminology, definitions, analogies)
- pictorial (coordinate system, sketch, symbols)
- graphical (axes, labels, units, plots)
- mathematical (variables, equations, constants)

SOLVE develop answer (identify steps, inter-conversions, transformations, perform calculations)

ASSESS check answer for relevance, logic, sense, perspective, proportion, accuracy, precision

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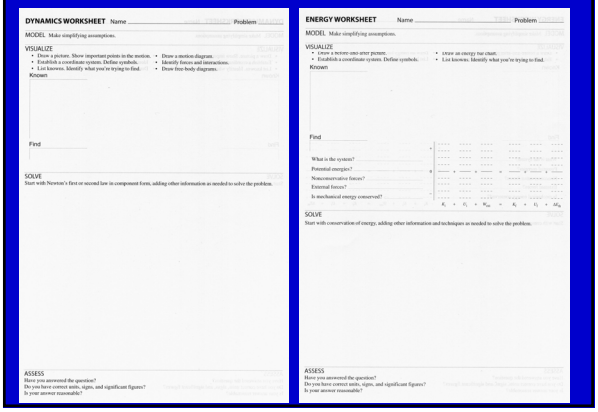
M-V-S-A worksheets



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Problem-solving strategies

ROLE-playing (popular with business Mx)

- Devil's advocate
  (managed conflict)
- de Bono's six hats
  (promote different perspectives)
  (white = neutral; red = emotive; green = creative; black = negative; yellow = positive; blue = chair)

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Key to problem-solving

PRACTICE!

Perform multiple mixed exercises:
- Qualitative
  (draw picture, interpret graph, use ratios, write short explanations…)
- Quantitative
  (perform calculations)
- Do them physically (with motor output), not just temporally (cognitively)
- Learn from mistakes, repetition

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Problem-solving

Many applications within education

Learning by doing!!!

- discovery learning
- problem-based learning
- active learning
- vocational learning
- etc……

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Dangerous DHMO!

Dihydrogen monoxide (DHMO) also known as Hydric acid, Hydronium Hydroxide
- colourless and odourless chemical compound
- highly reactive hydroxyl radical, a species shown to mutate DNA, denature proteins, disrupt membranes, and alter neurotransmitters
- atomic components found in number of caustic, explosive and poisonous compounds such as sulphuric acid, nitroglycerine, ethyl alcohol

Several municipalities in America began enquiries into how to ban this dangerous substance in their locality,

until someone pointed out that it was a web-prank and that DHMO was actually water!

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Marching ants

Imagine 100 ants placed randomly on a 1m straight rod.
The rod is only wide enough for the ants to move in a single file.
The ants are all moving at 1 m per minute.
Each ant will keep moving forward unless it bumps into another ant whereupon they both instantly reverse direction.
When the ants reach the ends of the rod, they fall off.
What is the longest time taken for all ants to fall off?

Because both ants bumping into each other instantly reverse direction, it is as though they walked over each other.
The longest time an ant can spend on the rod is therefore 1minute

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Magical mathematics

Pick a number (of any size)
Double it
Add five
Multiply by 50
Add 1764
Subtract your year of birth

Magic: last two numerals = your age
remaining numerals = your original number

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Magical mathematics

Unmask the magic using simple algebra.
Let the original number be A.
The calculation then becomes
(2A+5)50 + 1764 – year of birth
which simplifies to
100A + (2014 – year of birth)

All you are doing is asking the person to multiply their number by 100 (so it will appear in the final answer), and subtract their year of birth from the current year (thereby giving their current age). No magic!

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PBL
Problem-Based Learning

as per Graduate Medical School, UQ

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Problem-Based Learning (PBL)

PBL embedded in many vocational Schools:

- Medicine
- Dentistry
- Veterinary Science
- Engineering
- etc.....

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Problem-Based Learning

- develop students thinking/reasoning
  (critical thinking, clinical reasoning, DDx, Mx)
- facilitate independent learning
  (learning management, self-directed)

⇒ model professional life
- better communicators
- modern consumers
- critical thinkers
- life-long learners

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Problem-Based Learning

begin with hypothetico-deductive logic
(the 'scientific method')

as prelude to clinical reasoning
and evidence-based medicine

I liken process to doing PhD

P = problem (analysis)
H = hypothesis (deduction)
D = data/evidence (inquiry)

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SCOPE, SEQUENCE

problem released through series of triggers

- trigger 1 presentation
- trigger 2 history
- trigger 3 physical examination
- trigger 4 laboratory tests
- trigger 5 management
- trigger 6 response
- trigger 7 outcome

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SCHEDULE

PBL 5 hours/week

Monday	Thursday	Monday
2 hours	2 hours	1 hour
PBL-1	PBL-2	PBL-3
introduction	progression	closure
4 triggers	2 triggers	1 trigger

at other times:
- fixed resources (lectures/tutes/practicals)
- free resources (CAL/WWW/readings)

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BLOOD ON THE ROAD

Trigger 1: It is 10.30pm on Friday night, when the car ahead of you runs off the road and crashes into a tree. You see a young male struggle out of the wrecked car with blood spurting from a wound in his left thigh.

duty of care
first aid
precautions

Trigger 2: You move the driver, Mark, away from the wrecked car and manage to control the bleeding by pressing on the open wound. Mark is conscious and complains of feeling thirsty and cold. He is pale and has a rapid pulse (130/min) and respiratory rate (30/min).

haemorrhage
hypovolaemia
homeostasis
- vascular
- respiratory

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OUT, OUT, DAMN'D SPOT

Trigger 1: You are a GP working in Brisbane. Your next patient is Danny who has a large abscess on his left cheek. There is moderately severe acne over the rest of his face.

skin
infection
inflammation

Trigger 2: Danny is an 18 yr old uni student. He lives at home with his parents and 2 older brothers. He works part-time as a kitchen-hand at a fast-food outlet. He started getting pimples at the age of 14, usually on his face but at times across his shoulders. The abscess developed suddenly and he cannot recall squeezing a pimple at that site.

microbiology
- abscess
- acne

predisposition

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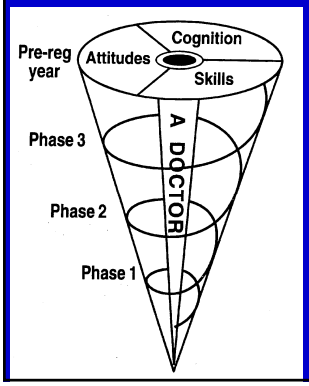
TRUST THE CURRICULUM



- not *ad hoc*
- highly orchestrated
- revisit content (spiral cf. platform)
- consolidate process

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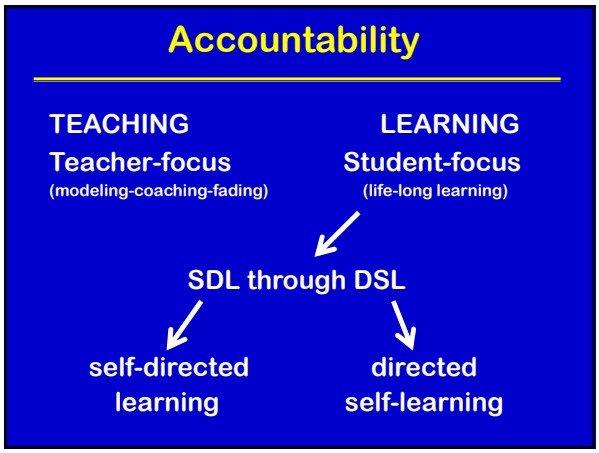
Accountability
TEACHING
Teacher-focus
(modeling-coaching-fading)
LEARNING
Student-focus
(life-long learning)
SDL through DSL
self-directed
learning
directed
self-learning

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