

Chapter 2:

Learning & Memory



No learning if no memory

Test 1

Please cite as many cities as possible in 30 seconds

Test 2

Please memorize the following
cities list during 1 minute

1. Manchester
2. Brussels
3. Lille
4. Athens
5. Lisbon
6. Amsterdam
7. Lisbon
8. Washington
9. Camberra
10. Tunis
11. Montreal
12. Tokyo
13. Oslo
14. Berlin
15. Bratislava
16. Tashkent
17. Bejing
18. Calcutta
19. Marseille
20. Luzern

A lesson

A lesson

NUUK

What is the capital of Greenland ?

The Lecture Model

Information

Perception



Processing



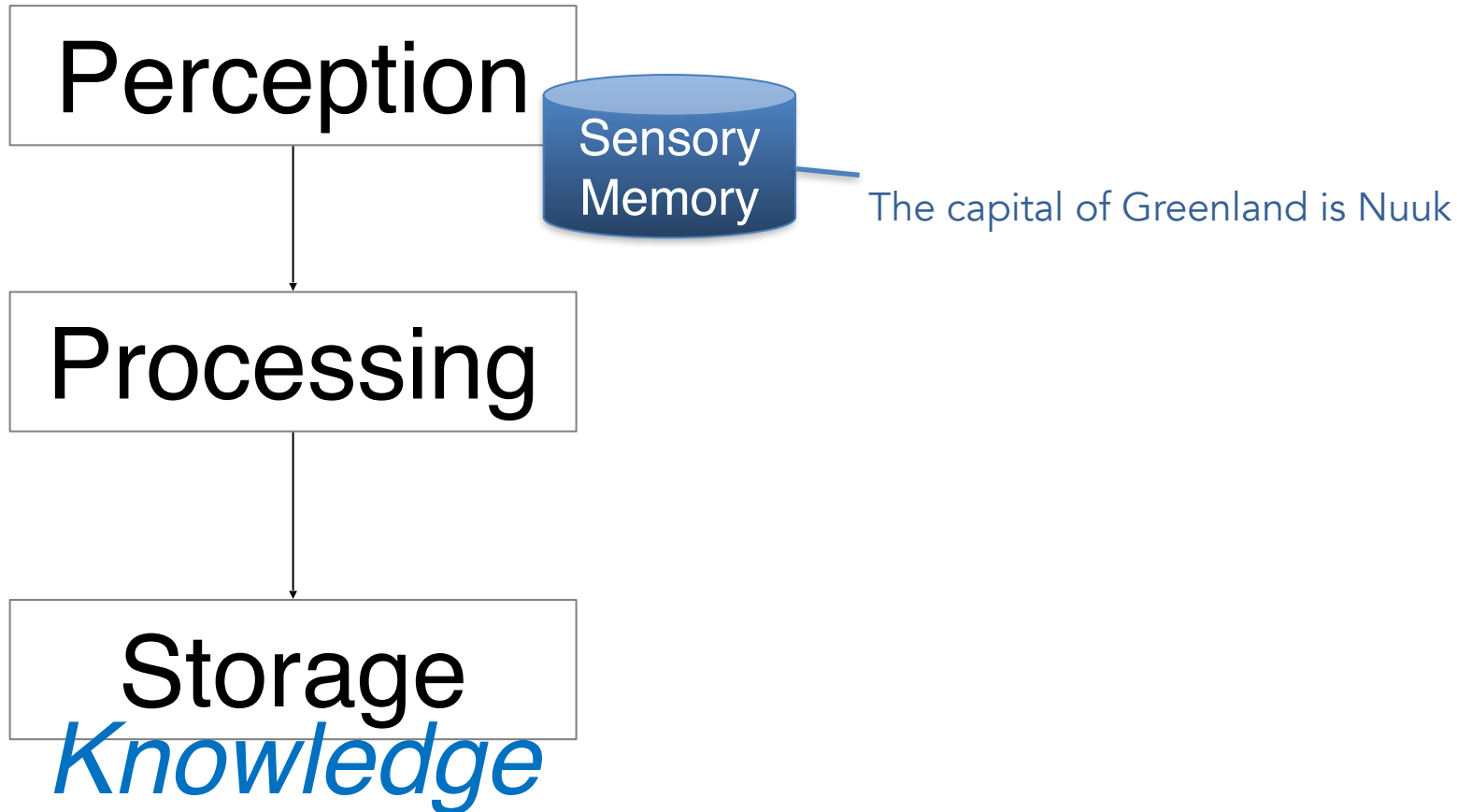
Storage

Knowledge

The capital of Greenland is Nuuk

The Lecture Model

Information



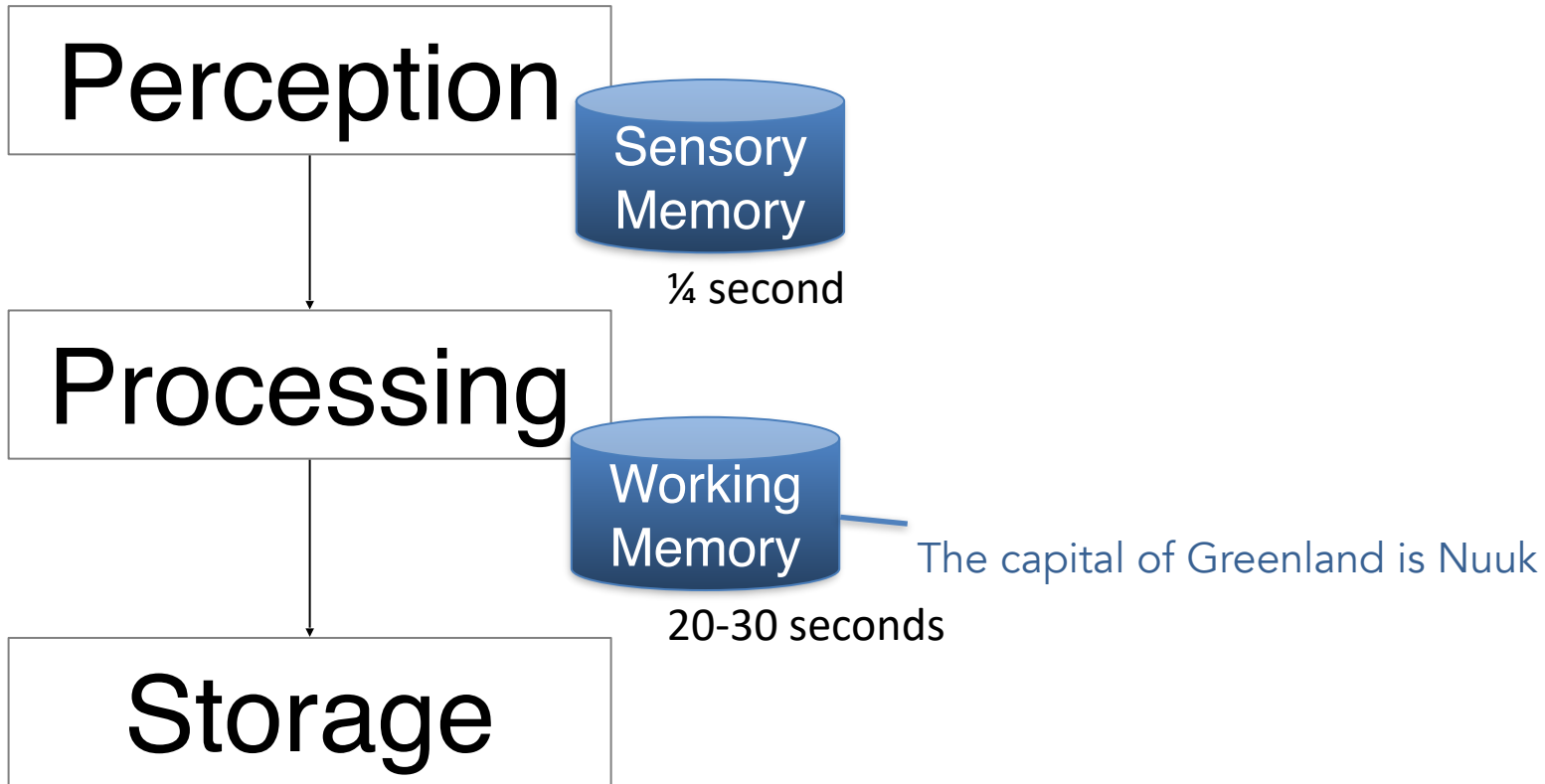


As you can guess, the Danish name of this city is Godthåb

What is the capital of Greenland ?

The Lecture Model

Information



Knowledge

My phone number is 076 825 34 57

My phone number is 076 825 34 57

My phone number is 079 353 11 64

13904

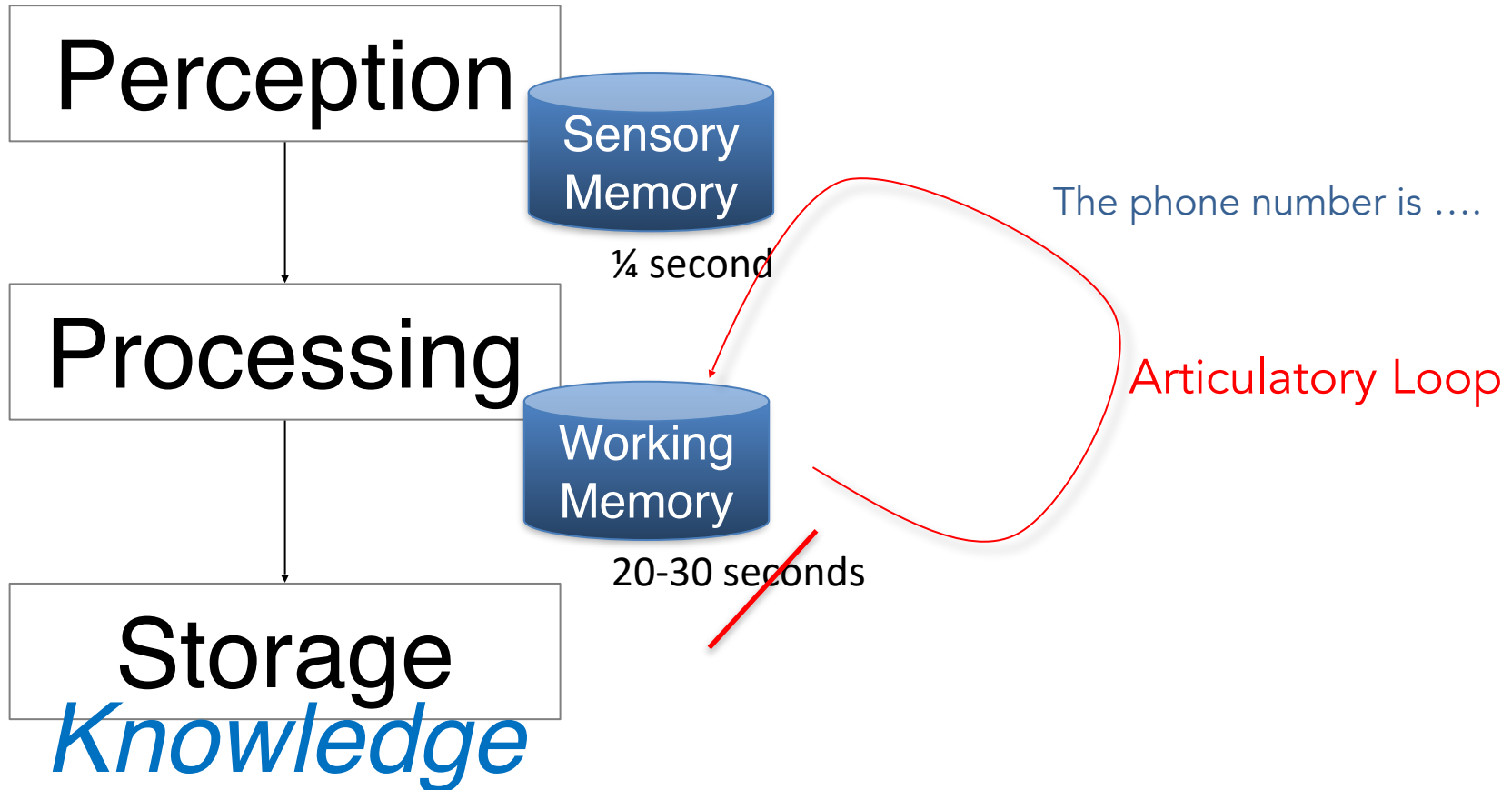
2 JASE333.COM



My phone number is 079 353 11 64

The Lecture Model

Information



My car plates are VD 657 31 07

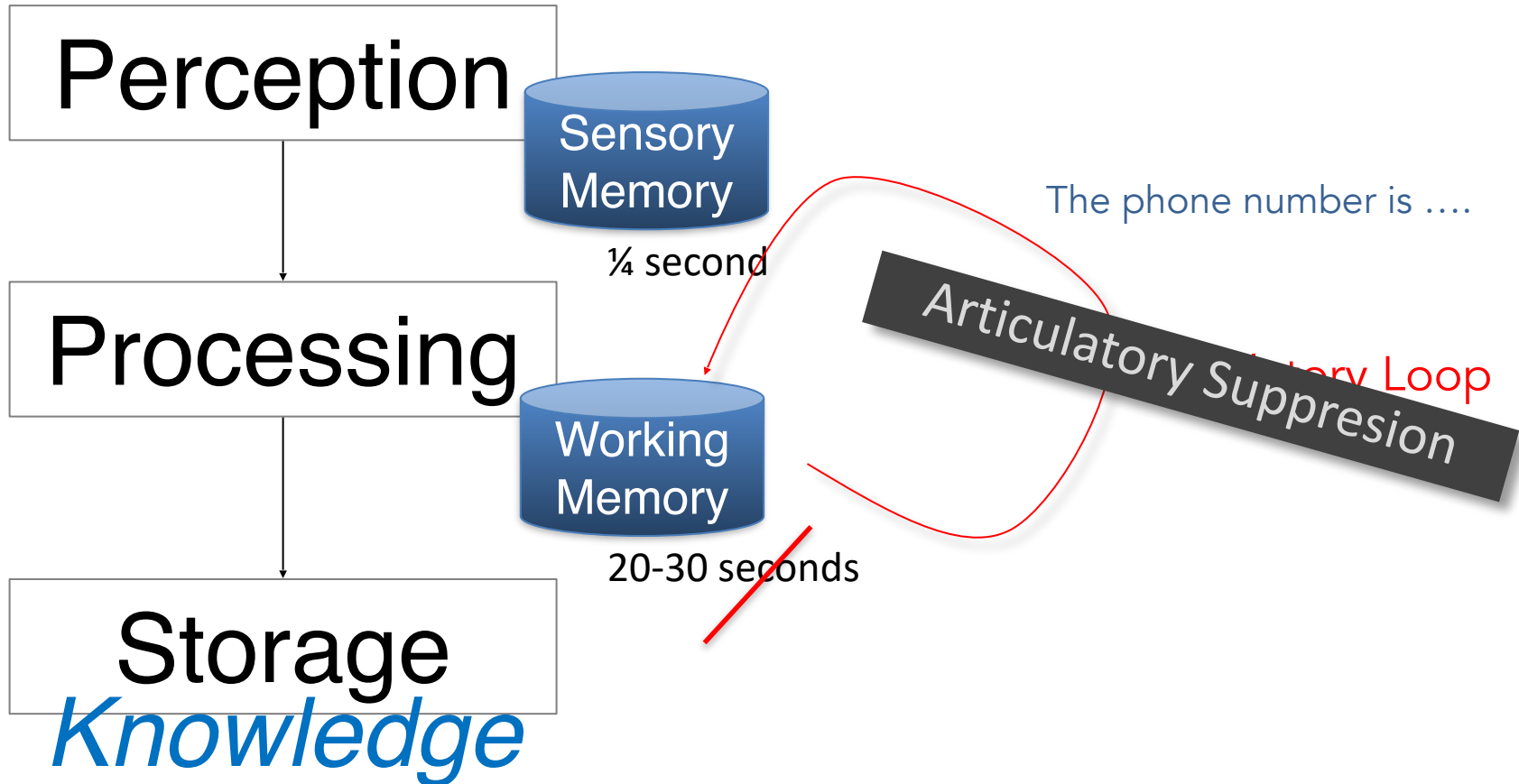
READ ALOUD

Nuuk has a long history of habitation. The area around Nuuk was first occupied by the ancient pre-Inuit, Paleo-Eskimo people of the Saqqaq culture as far back as 2200 BC when they lived in the area around the now abandoned settlement of Qoornoq.

My car plates are VD 657 31 07

The Lecture Model

Information



My password is 123680



READ ALOUD

For a long time, Nuuk was occupied by the Dorset culture around the former settlement of Kangeq but they disappeared from the Nuuk district before AD 1000. The Nuuk area was later inhabited by Viking explorers in the 10th century (Western Settlement), and shortly thereafter by Inuit peoples.

What is my password ?



Information

Perception

Sensory
Memory

Processing

Working
Memory

- Verbal / Phonological Loop
- Visual-Spatial Sketchpad

Storage

Knowledge

What is the capital of Greenland ?

Information

Perception

Sensory
Memory

Processing

Working
Memory

Storage

Long Term
Memory

Knowledge

The capital of Greenland is Nuuk

Information

Perception

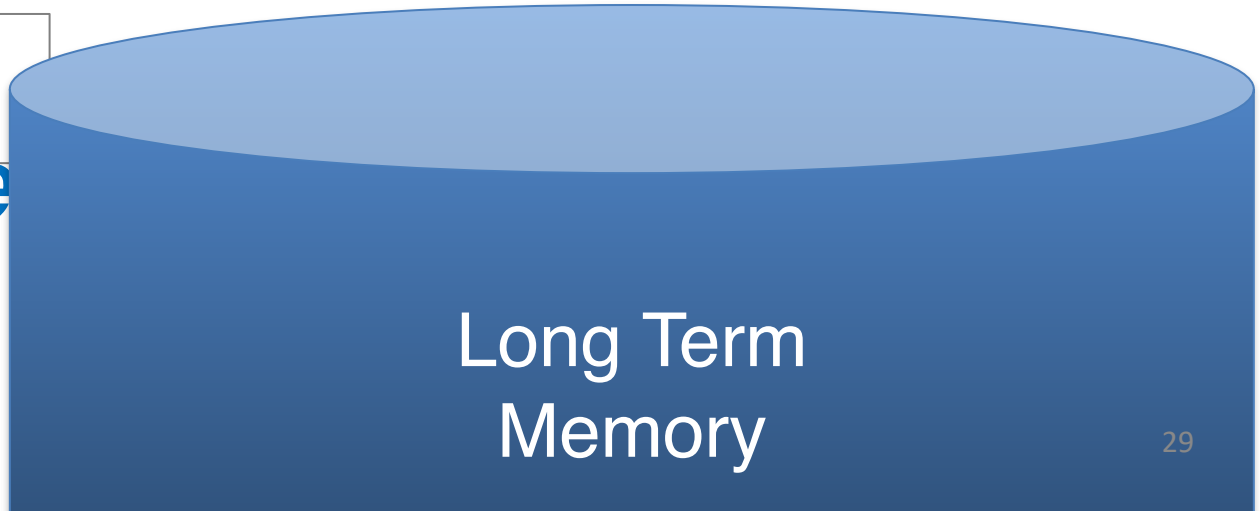


Processing



Storage

Knowledge

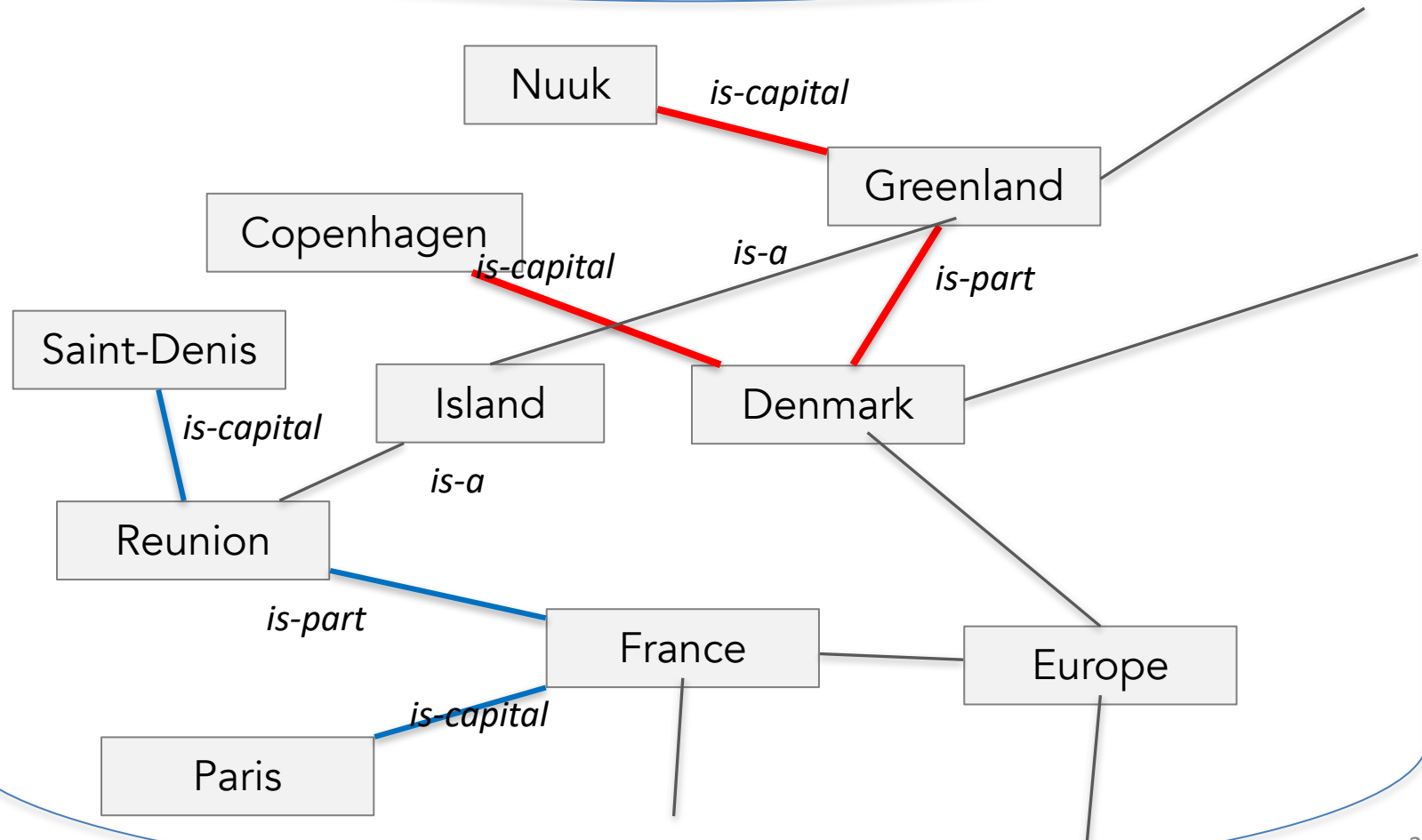


Nuuk is to Copenhagen,

what

Saint-Denis is to ?

Nuuk is to Copenhagen
What Saint-Denis is to



Information

Perception

Processing

Storage
Knowledge

Experience

UNLIMITED, MULTIMODAL

MOSTLY VERBAL
LIMITED in SIZE
LIMITED In TIME (20-30 s)

Working
Memory

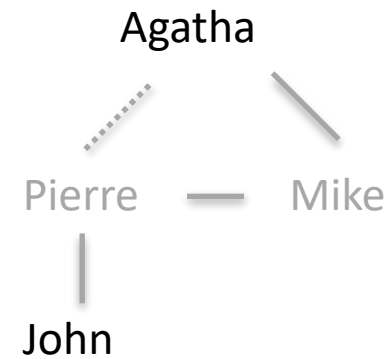
EXTREMELY LARGE, SEMANTIC

Long Term Memory

1. John is the son of Pierre
2. Pierre is the brother of Mike
3. Mike is the son of Agatha

Who is the grand-son of Agatha ?

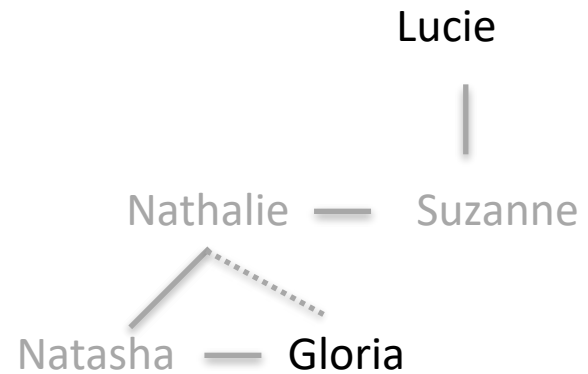
- John
- Pierre
- Mike



1. Nathalie is the sister of Suzanne
2. Suzanne is the daughter of Lucie
3. Natasha is the daughter of Nathalie
4. Gloria is the sister of Natasha

Who is the grand-mother of Gloria?

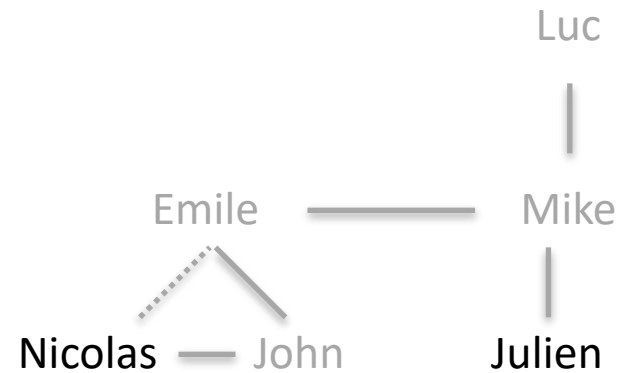
- Nathalie
- Suzanne
- Natasha
- Lucie



1. Luc is the father of Mike
2. Mike is brother of Emile
3. John is the son of Emile
4. Nicolas is the brother of John
5. Julien is the son of Mike

Who is the cousin of Nicolas?

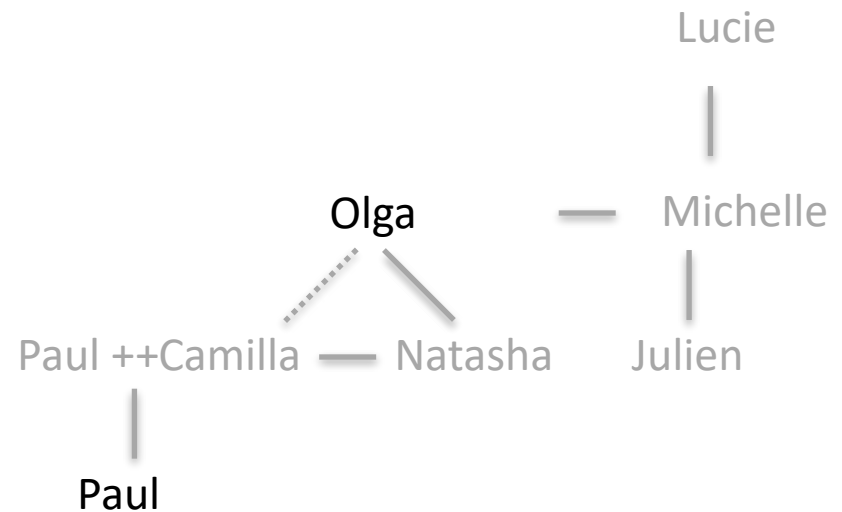
- Luc
- Mike
- John
- Luc
- Nicolas



1. Olga is the sister of Michelle
2. Michelle is the daughter of Lucie
3. Natasha is the daughter of Olga
4. Camilla is the sister of Natasha
5. Paul is the husband of Camilla
6. Donald is the son of Paul

Who is the grand-mother of Donald ?

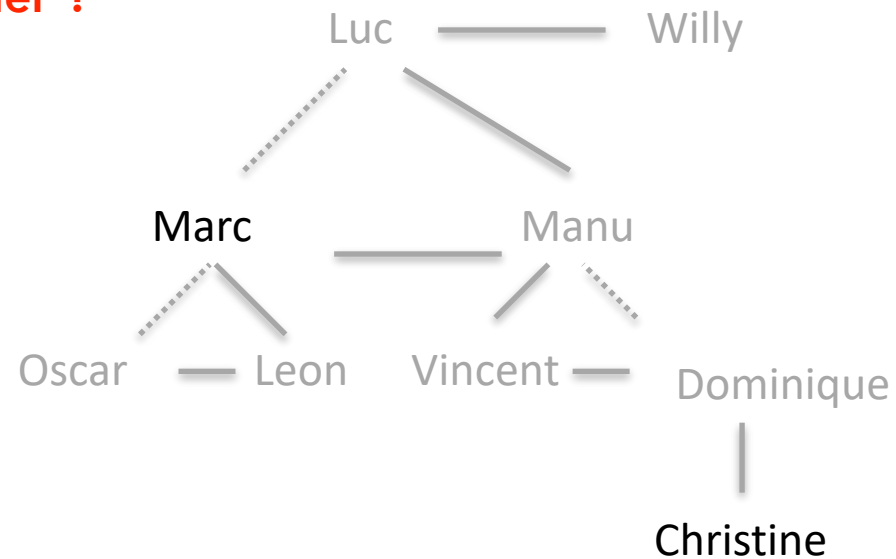
- Michelle
- Olga
- Natasha
- Camilla
- Lucie



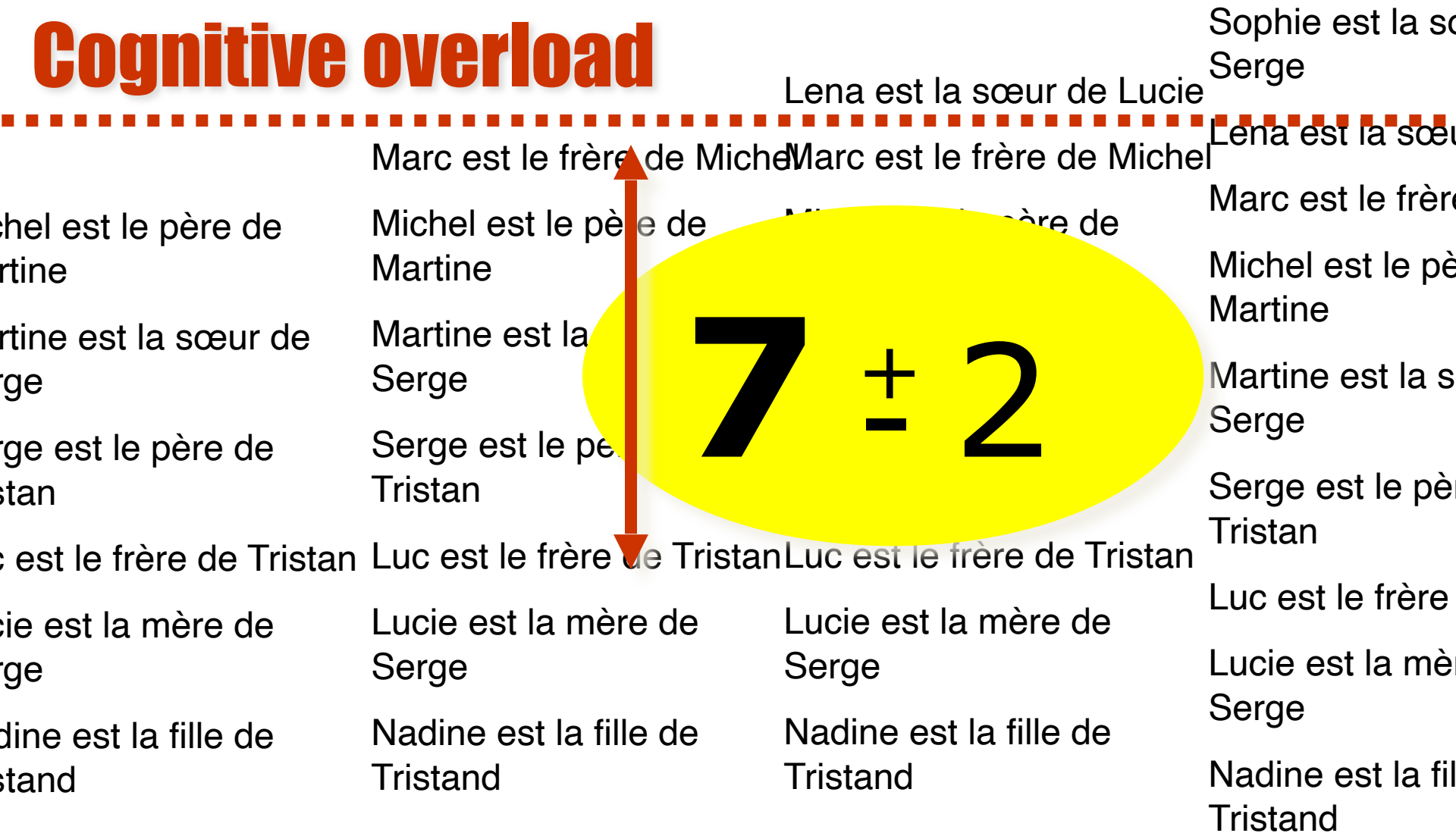
1. Marc and Manu are brothers
2. Leon and Oscar are brothers
3. Leon is the son of Marc
4. Vincent is the son of Manu
5. Willy is the uncle of Marc
6. Dominique is the brother of Vincent
7. Christine is the daughter of Dominique

Who is the brother of Christine's grand-father ?

- Willy
- Dominique
- Marc
- Manu
- Leon
- Oscar
- Vincent



Cognitive overload



Michel is the father of Martine

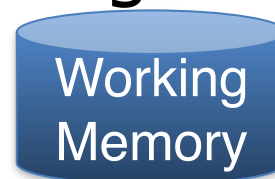
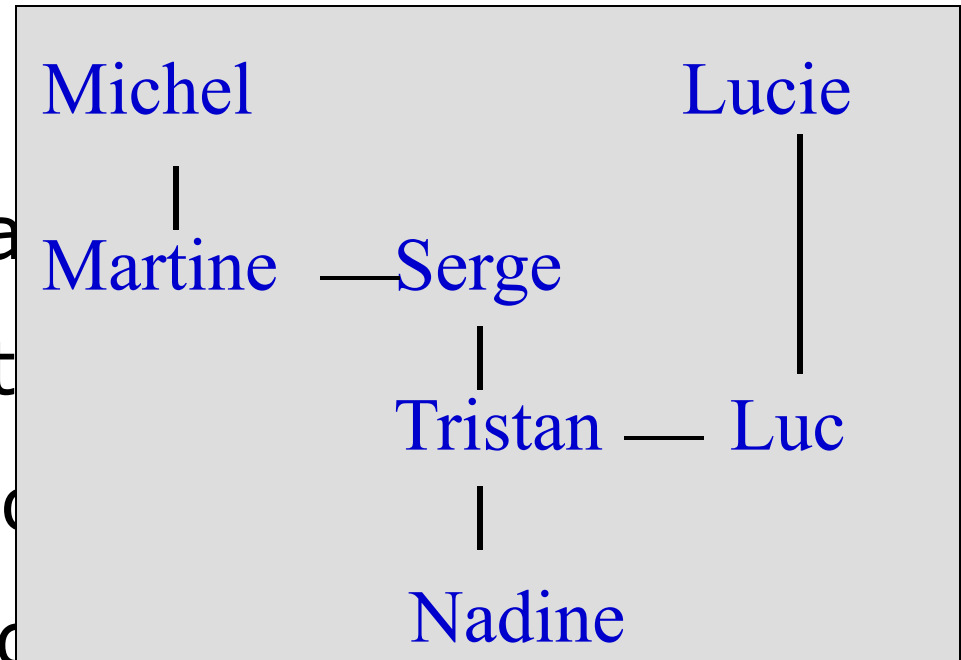
Martine is the

Serge is the fa

Luc is the brot

Lucie is the mo

Nadine is the c

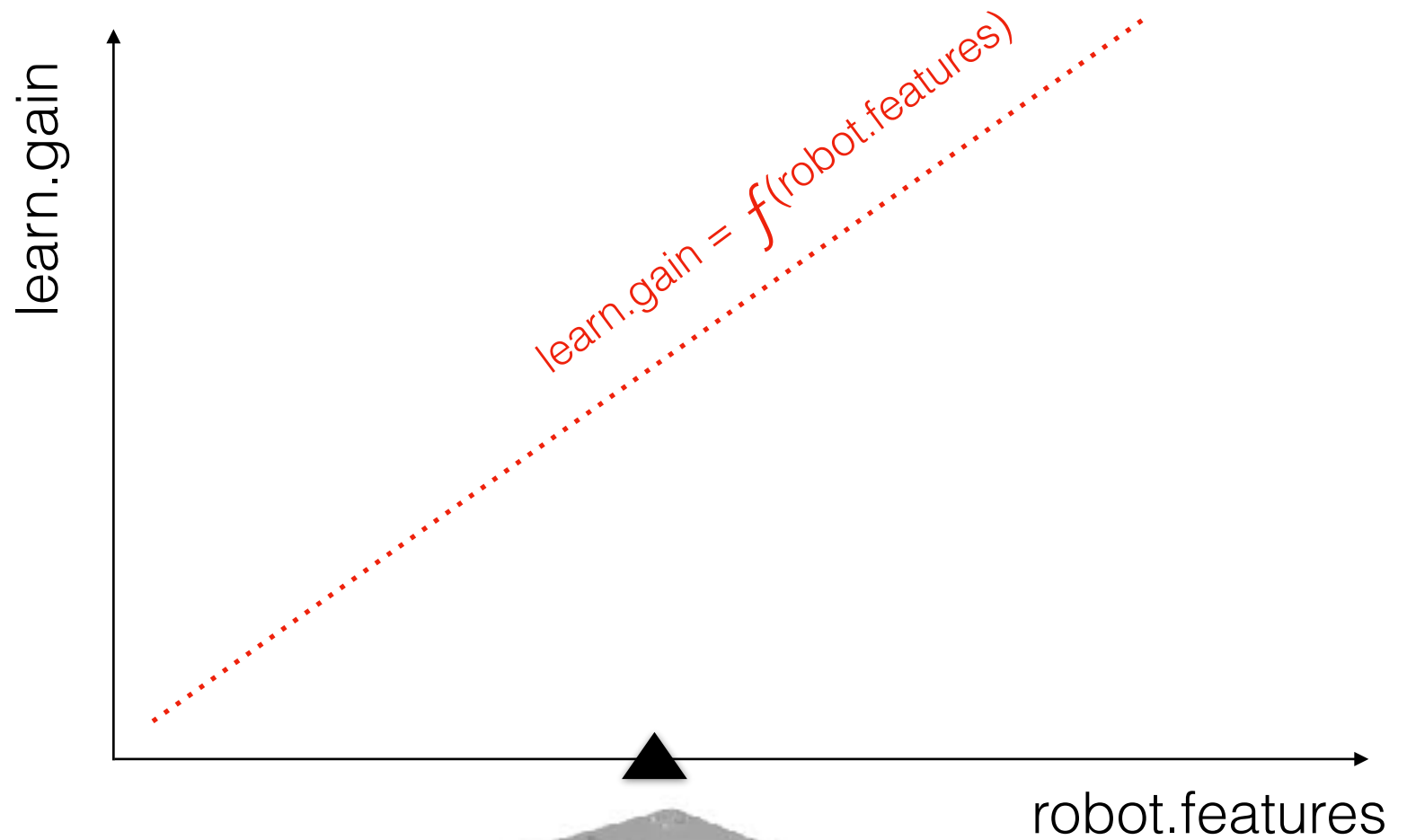


- Verbal / Phonological Loop
- Visual-Spatial Sketchpad

→ Who is the ant of Luc ?

Cognitive Load

No pain, No gain

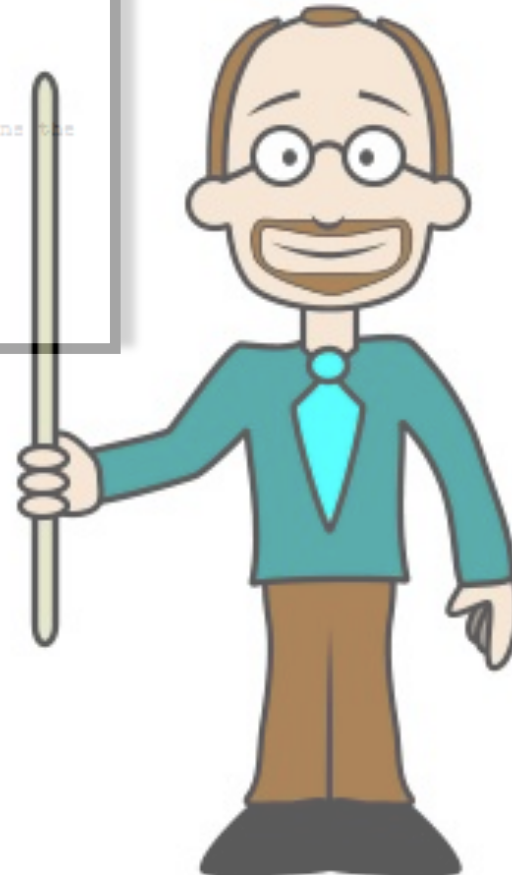


Experience 1



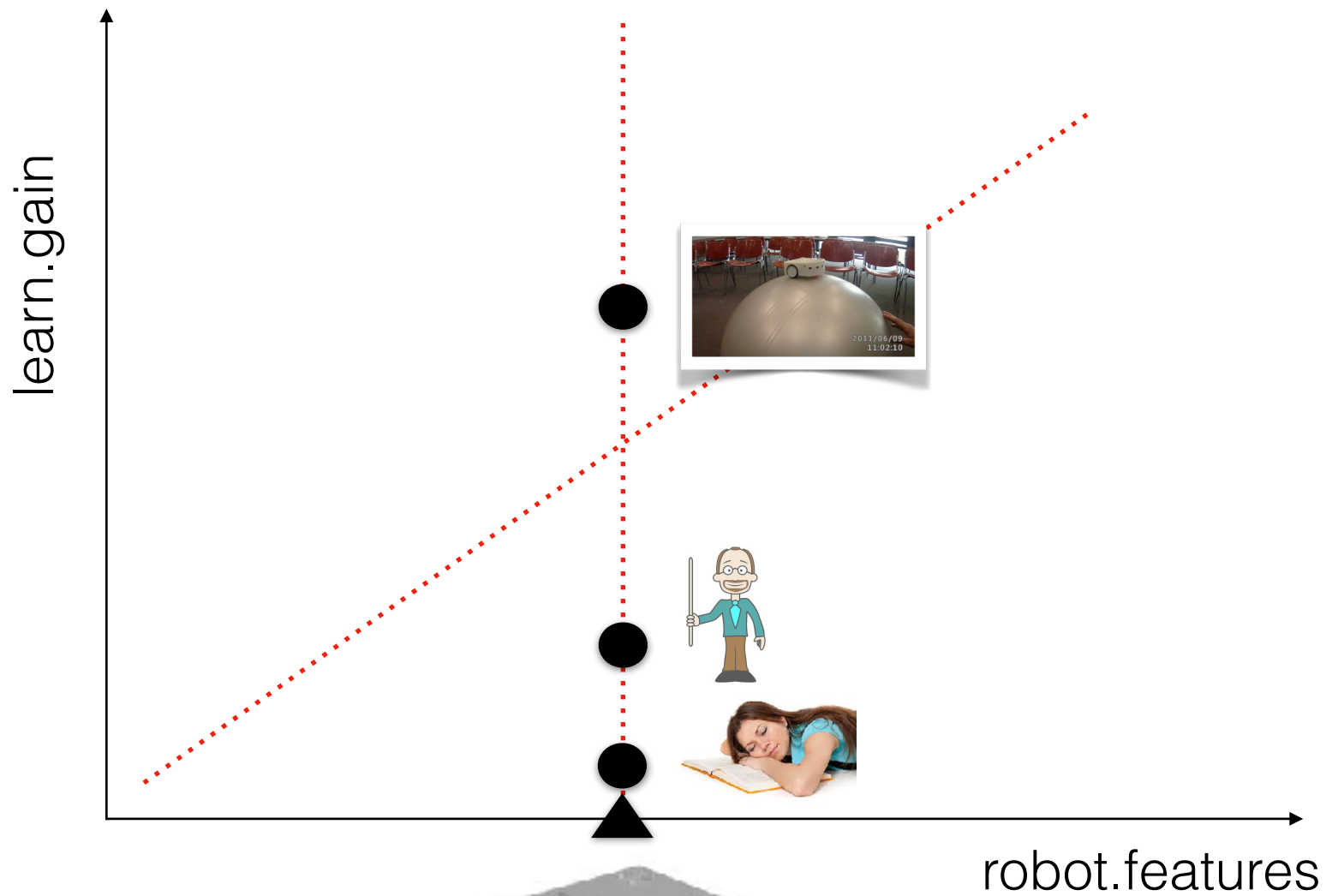
Experience 2

```
26 ### EVENT BUTTON FORWARD ###
27
28 event button.forward
29 # when we press the forward button, it start the line tracking and wait for
   the sync black box
30 if button.forward == 1 then
31     running = 1
32     while 1:
33         X_WAIT_SYNC
34     end
35 ### EVENT BUTTON CENTER ###
36
37 event button.center
38 # when we press the center button, it stops (running + motors), turns the
   lights off and set white to 0
39 if button.center == 1 then
40     running = 0
41     motor.left.target = 0
42     motor.right.target = 0
43     call leds.top(0,0,0)
44     white=0
45 end
```

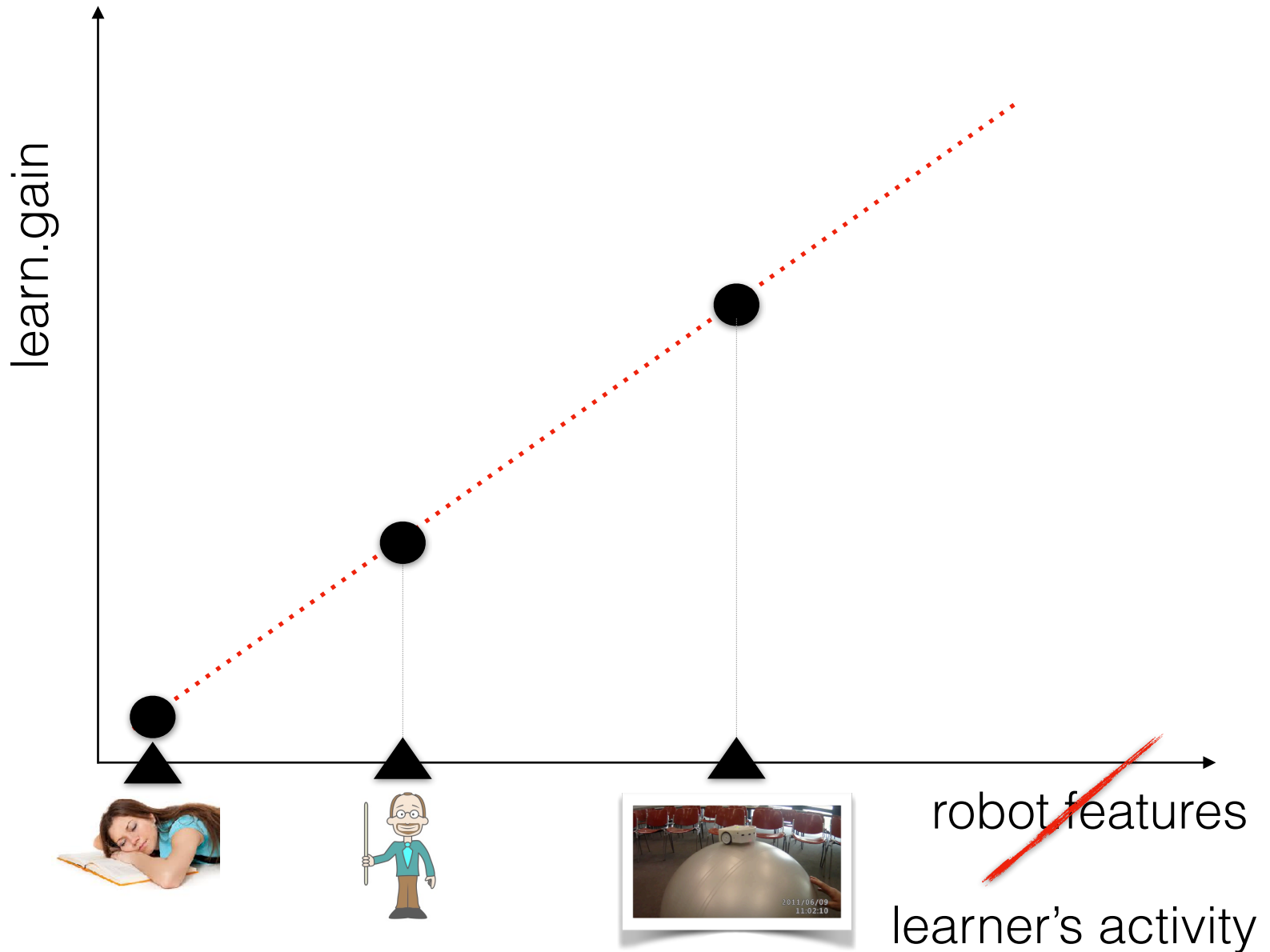




<https://fr.dreamstime.com/photo-stock-le-bel-%C3%A9tudiant-dort-sur-le-livre-image19226880>

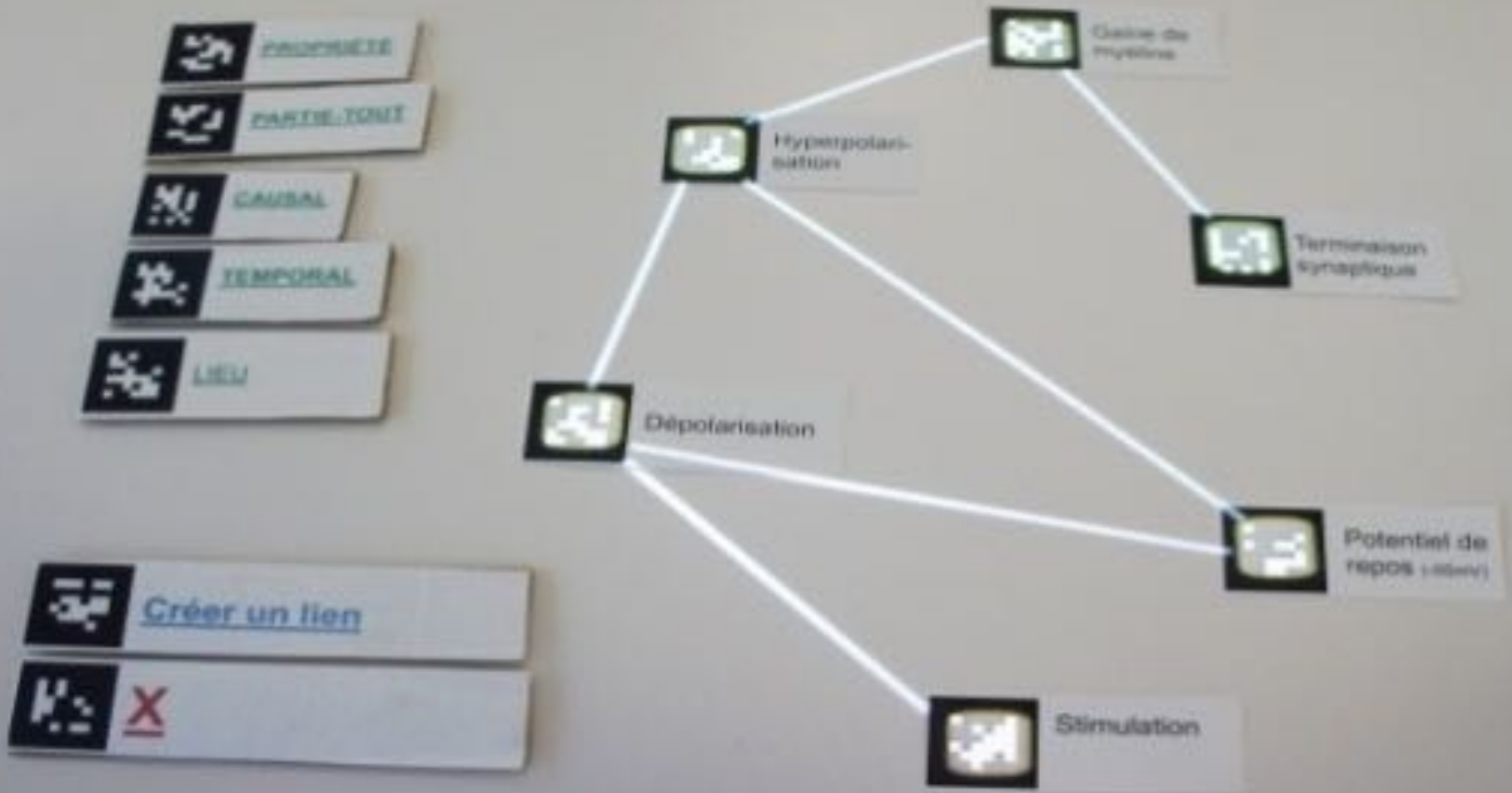


$$\text{learn.gains} = f(\text{learn.activity})$$

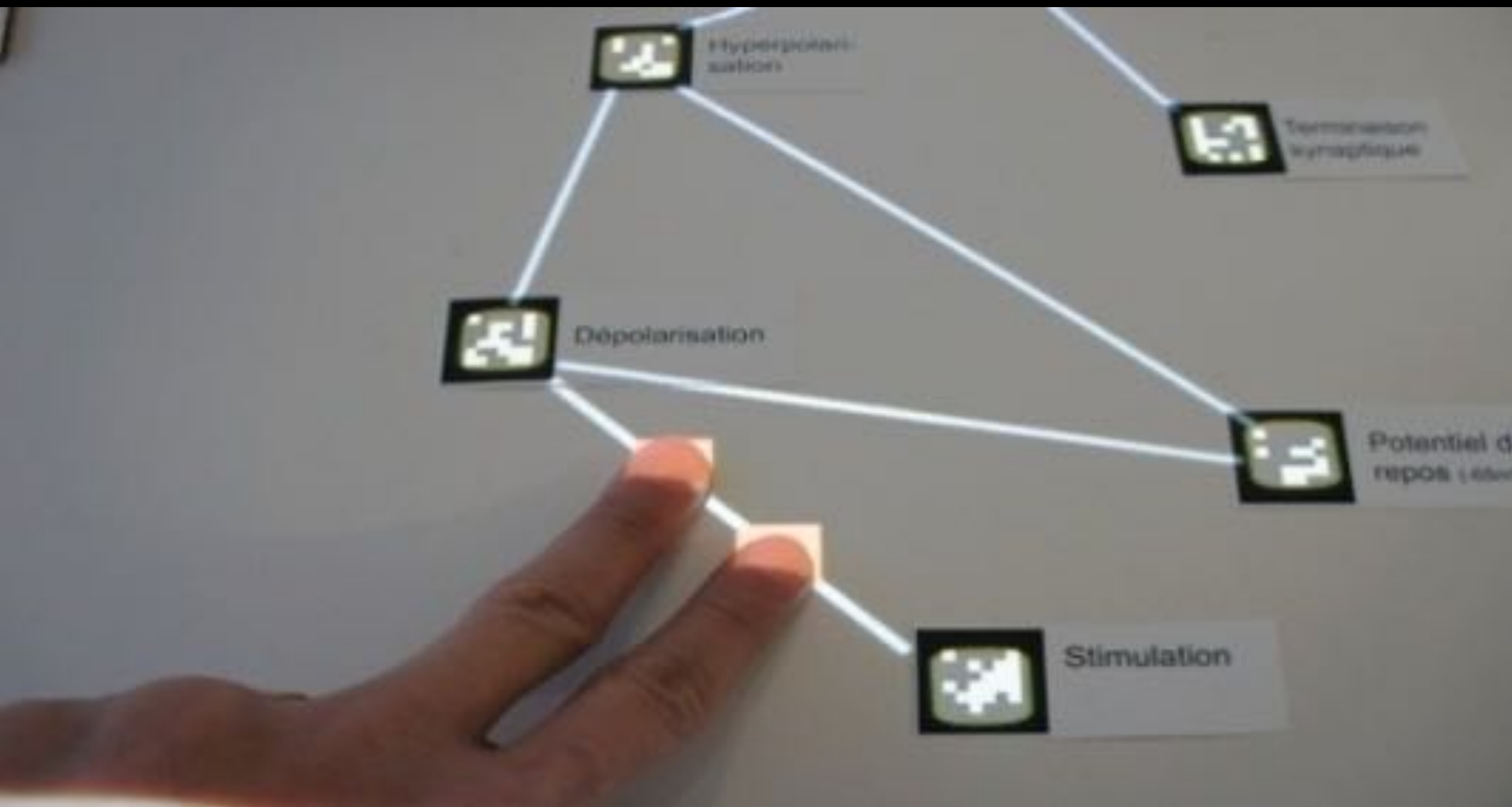




Who will win the next race ?



Concept Map: paper concepts, augmented links



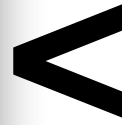
Concept Map: gestures (e.g. cut)



8 teams in the experimental condition



8 teams in the control condition



Information

Perception

Processing

Storage
Knowledge

Experience

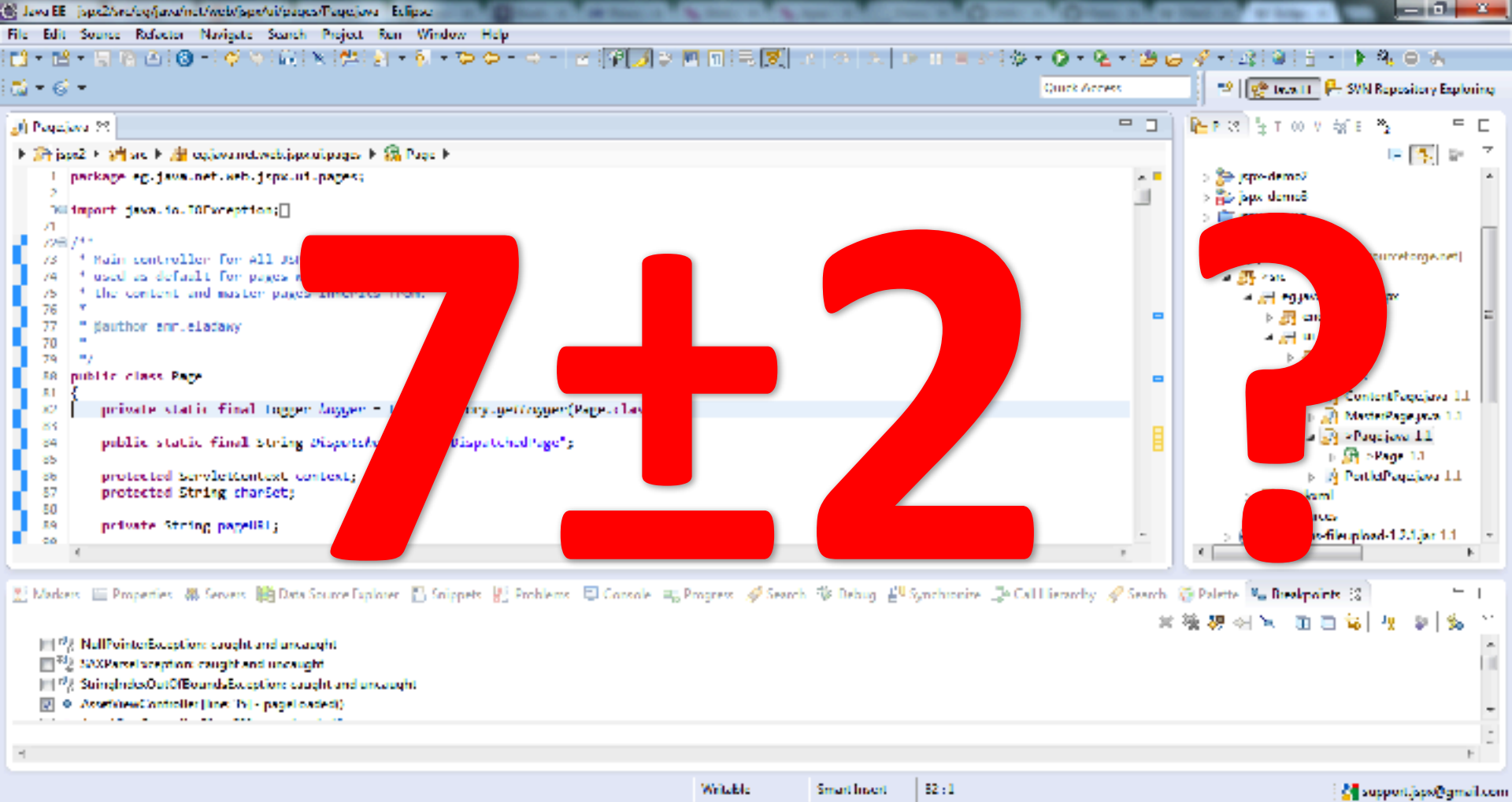
UNLIMITED, MULTIMODAL

MOSTLY VERBAL
LIMITED in SIZE
LIMITED In TIME (20-30 s)

Working
Memory

EXTREMELY LARGE, SEMANTIC

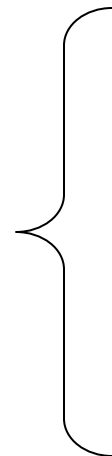
Long Term Memory



Working
Memory

Reducing cognitive load: Compilation

Check the barreer
Tune radio
Speak
Listen
Get your badge
Slow down
Turn



Freiner
Embrayer
Changer
Débrayer
Freiner

The diagram illustrates the flow of information between three memory systems. At the top is a large blue cylinder labeled 'Experience'. At the bottom is another large blue cylinder labeled 'Long Term Memory'. Between them is a smaller blue cylinder labeled 'Working'. Dotted lines connect 'Experience' to 'Working' and 'Working' to 'Long Term Memory'. A solid line also connects 'Experience' directly to 'Long Term Memory'.

Experience

Working

Intrinsic Cognitive Load: some things are harder to learn

Extrinsic Cognitive Load: due to bad design

Germane Cognitive Load : the effort to create schemas

Long Term Memory

Intrinsic Cognitive Load

3 Modular forms

Let $\mathbb{H}$ be the upper half-plane $\{z \in \mathbb{C} \mid \text{Im}(z) > 0\}$. The modular group $\Gamma(1) := \text{PSL}_2(\mathbb{Z})$ acts on $\mathbb{H}$ by linear fractional transformations

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix} z := \frac{az + b}{cz + d}$$

Let N be a positive integer. The level N principal congruence subgroup of $\Gamma(1)$ is

$$\Gamma(N) := \left\{ \begin{pmatrix} a & b \\ c & d \end{pmatrix} \in \Gamma(1) \mid \begin{pmatrix} a & b \\ c & d \end{pmatrix} \equiv \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \pmod{N} \right\}.$$

A subgroup $\Gamma \subset \Gamma(1)$ is called a *congruence subgroup* if $\Gamma(N) \subset \Gamma$ for some $N \in \mathbb{N}$. An important example of a congruence subgroup is

$$\Gamma_0(N) := \left\{ \begin{pmatrix} a & b \\ c & d \end{pmatrix} \in \Gamma(1) \mid c \equiv 0 \pmod{N} \right\}.$$

Let $z \in \mathbb{H}$, $k \in \mathbb{Z}$, and $\begin{pmatrix} a & b \\ c & d \end{pmatrix} \in \text{SL}_2(\mathbb{Z})$. The automorphy factor of weight k is defined as

$$j_k(z, \begin{pmatrix} a & b \\ c & d \end{pmatrix}) := (cz + d)^{-k}.$$

The automorphy factor satisfies the *chain rule*

$$j_k(z, \gamma_1 \gamma_2) = j_k(z, \gamma_2) j_k(\gamma_2 z, \gamma_1).$$

Let F be a function on $\mathbb{H}$ and $\gamma \in \text{PSL}_2(\mathbb{Z})$. Then the *slash operator* acts on F by

$$(F|_k \gamma)(z) := j_k(z, \gamma) F(\gamma z).$$

The chain rule implies

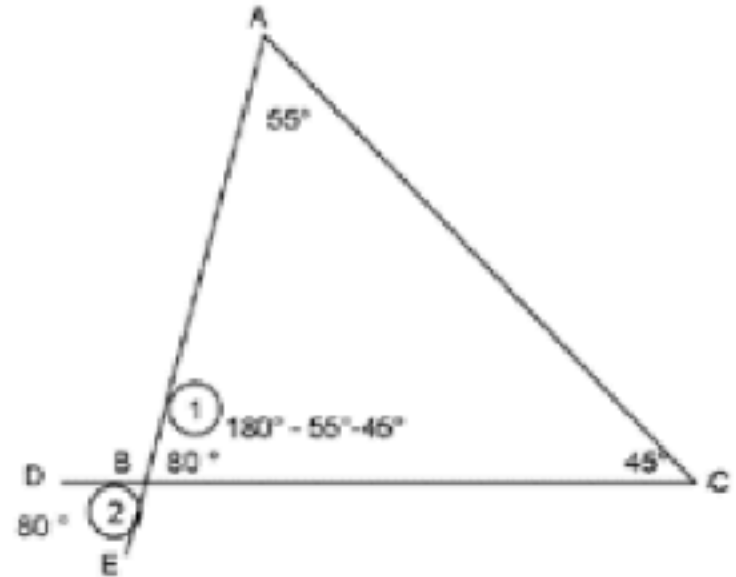
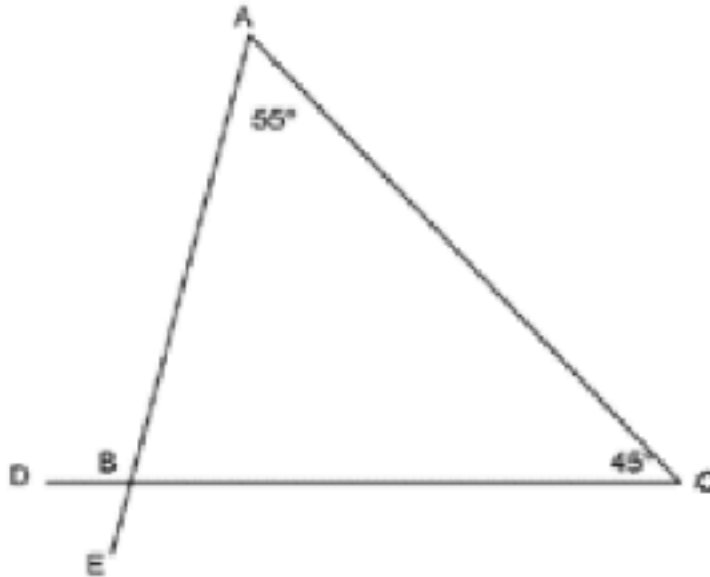
$$F|_k \gamma_1 \gamma_2 = (F|_k \gamma_1)|_k \gamma_2.$$

A (holomorphic) modular form of integer weight k and congruence subgroup Γ is a holomorphic function $f : \mathbb{H} \rightarrow \mathbb{C}$ such that:



Maryna Viazovska

Extrinsic Cognitive Load



In the above figure, find a value for Angle DBE

Solution:

Angle ABC = $180^\circ - \text{Angle BAC} - \text{Angle BCA}$ (Internal angles of a triangle sum to 180°)

$$= 180^\circ - 55^\circ - 45^\circ$$

$$= 80^\circ$$

Angle DBE = Angle ABC (vertically opposite angles are equal)

$$= 80^\circ$$

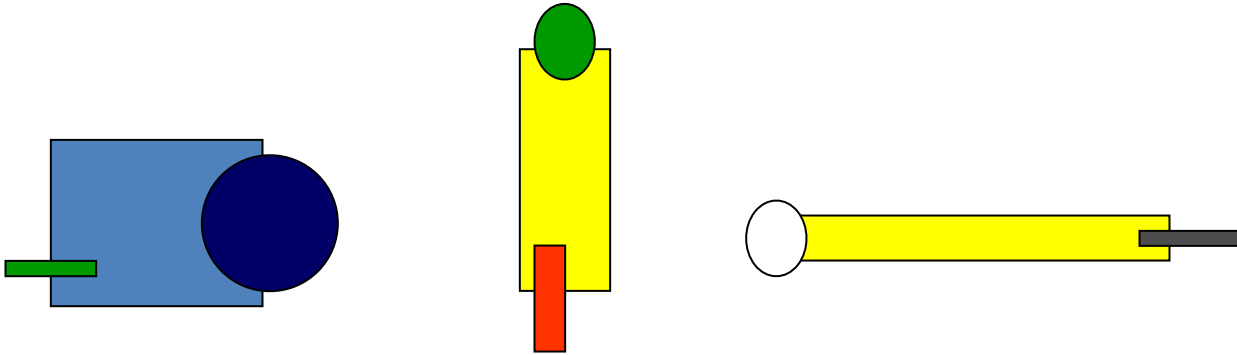
Split Attention Effect

Cognitive load

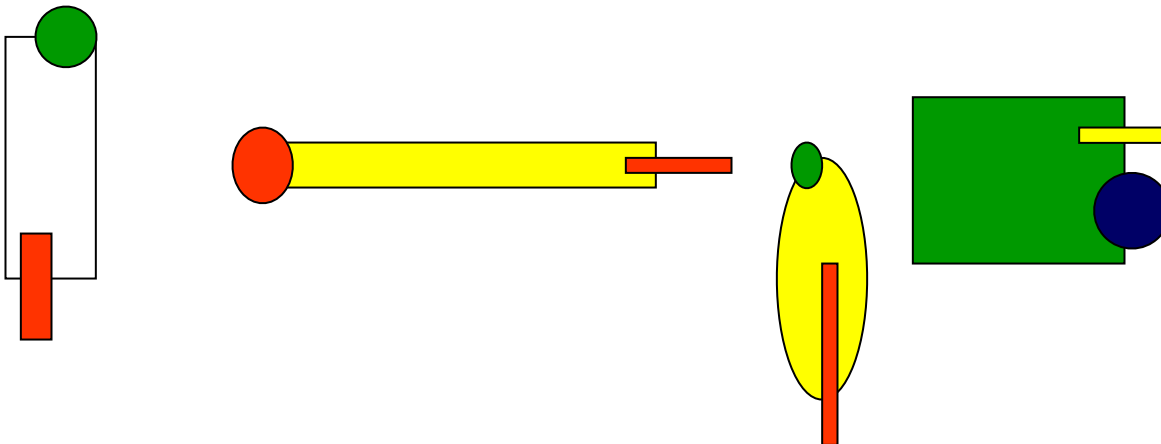
Which statements are correct?

- ① Cognitive load prevents learning
- ② There is no learning without cognitive load
- ③ Cognitive over-load prevents learning
- ④ There is no learning without over-load

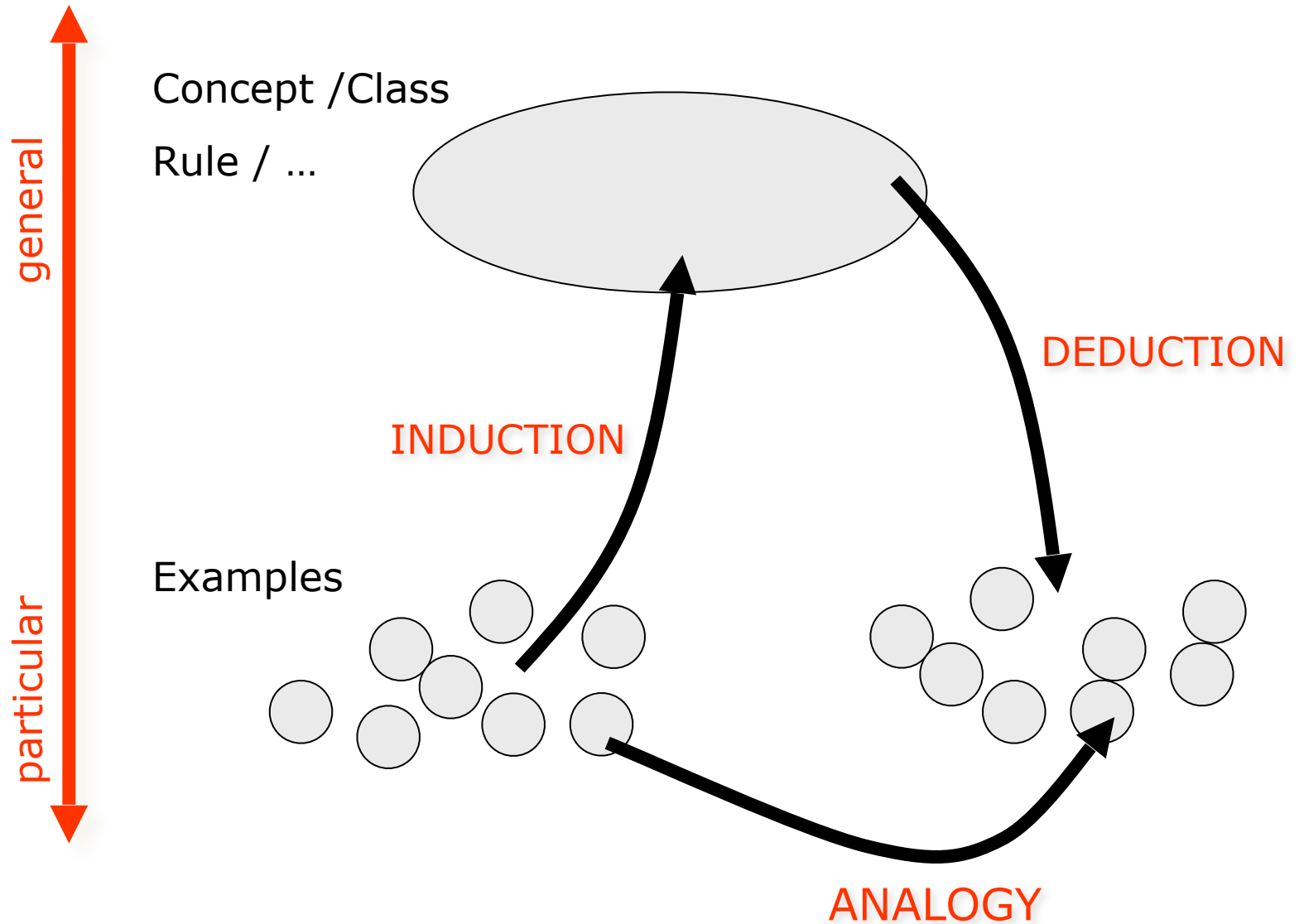
Germane Cognitive Load



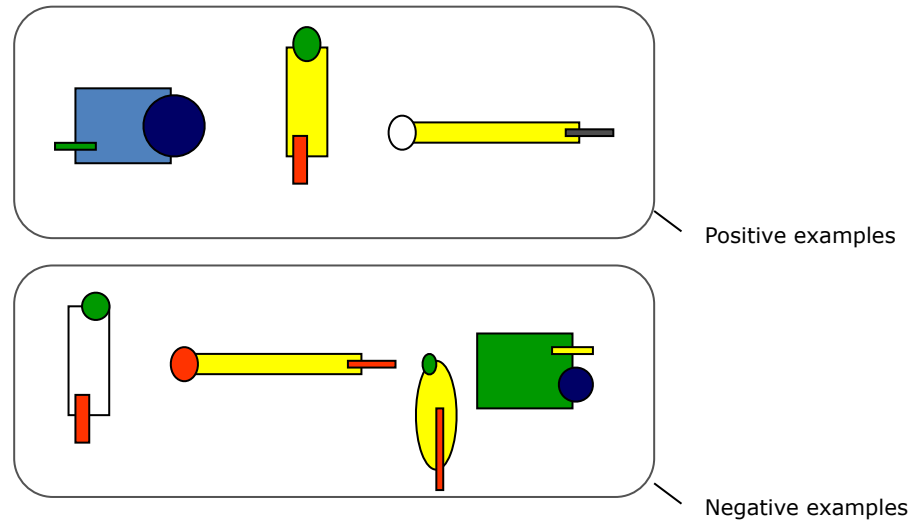
Positive
examples



Negative
examples



Germane Cognitive Load



I-PS

1. A SPUC is... !
2. Is this a SPUC ?

PS-I

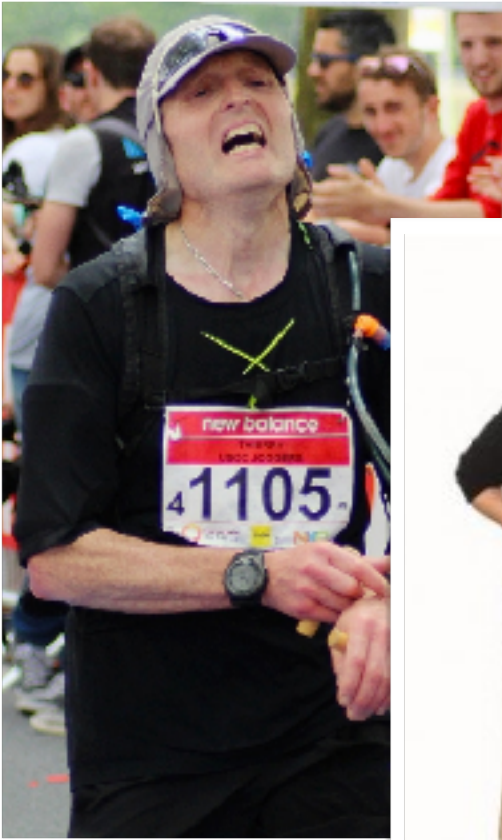
- « *Contrasted cases* »
1. What is a SPUC (induction/discrimination)
 2. A SPUC is... !
 3. Is this a SPUC ?

Intrinsèque

CHARGE COGNITIVE

Extrinsèque

Germane



« If the speed of light is incompressible
then time is elastic »

Is knowledge a copy of information ?

Information

Perception



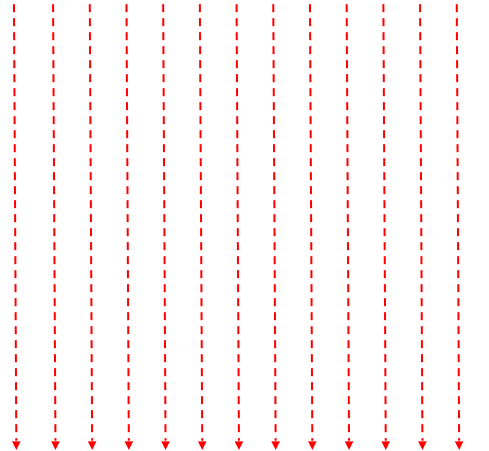
Processing



Storage

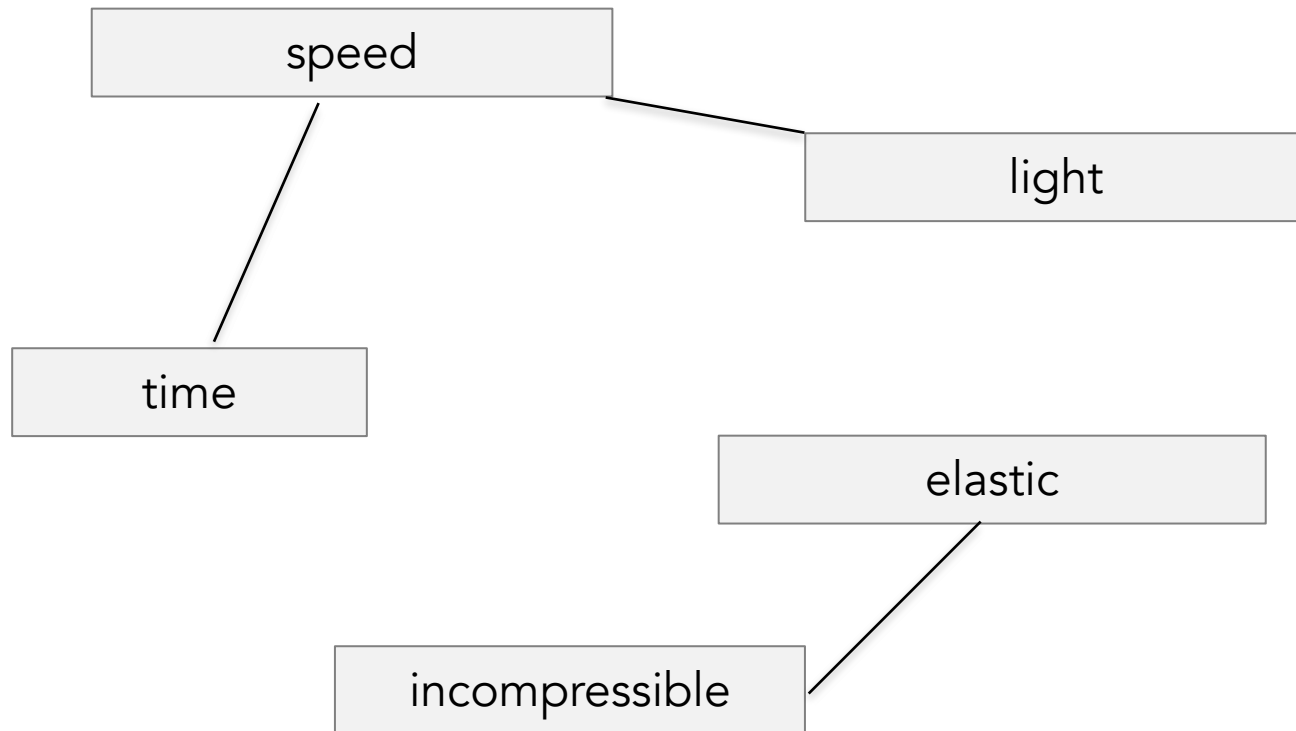
Knowledge

« If the speed of light is incompressible
then time is elastic »

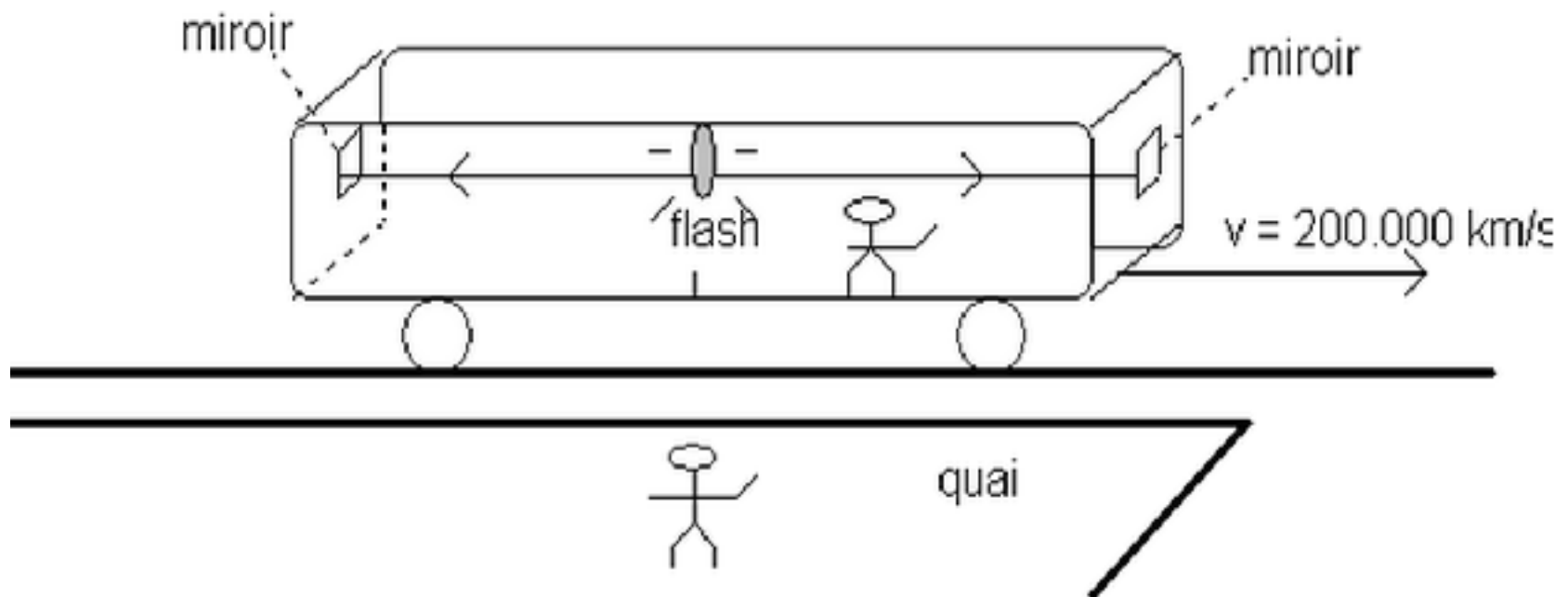


« If the speed of light is incompressible
then time is elastic »

« If the speed of light is incompressible
then time is elastic »



« If the speed of light is incompressible
then time is elastic »



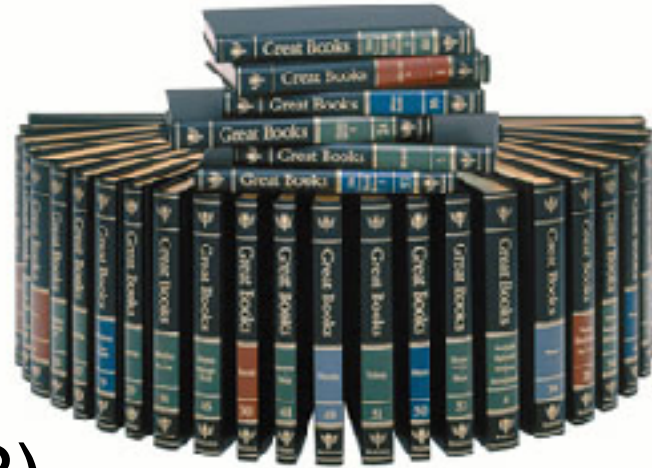
Where is there more knowledge ?

① Encyclopaedia Britannica

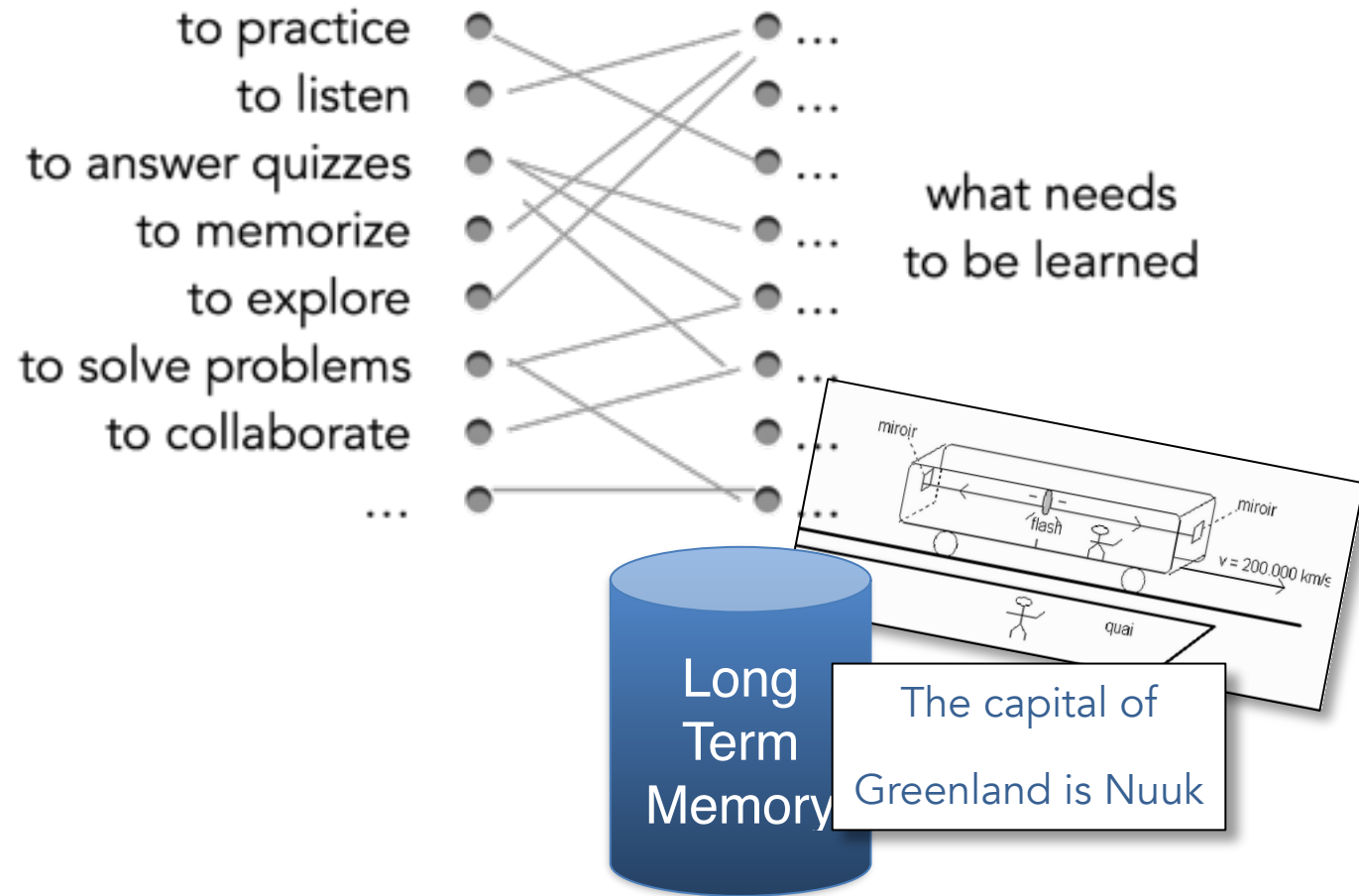
② Wikipedia

③ British Library (112,505,998)

④ The brain of a 4 years old child



<http://blog.trustpilot.com/trusting-information-digital/>



There are different
types of knowledge

Knowledge Taxonomy

If you add some butter when boiling the water, the pasta do not glue to each other

Restricted relativity

The symbol for hydrogen is H

A square is a quadrilateral shape with 4 right angle and 4 isometric sides

The split attention effect refers to the increase of cognitive load due to the distance between a legend and the symbols used in the legend

Evolution (also known as biological, genetic or organic evolution) is the change in the inherited traits of a population of organisms through successive generations.^[1] This change results from interactions between processes which introduce variation into a population, and other processes which remove it. As a

Brussels is the capital of Japan

The length of the hypotenuse is the square root of the sum of the squares of each other side of the triangle.

Knowledge Taxonomy

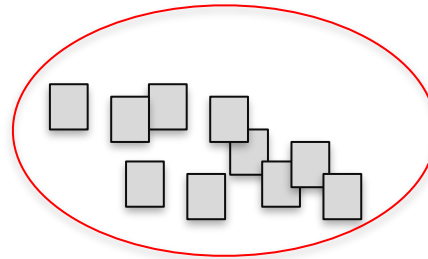
Facts	Brussels is the capital of Belgium
Classes, concepts	A square is a quadrilateral shape with 4 right angle and 4 isometric sides
Rules, principles, algorithms	If you add some butter when boiling the water, the pasta do not glue to each other
Theories, systems	Restricted relativity

Knowledge Taxonomy

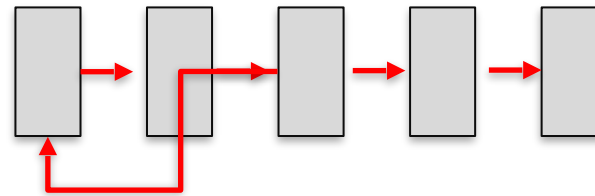
Facts



Classes, concepts



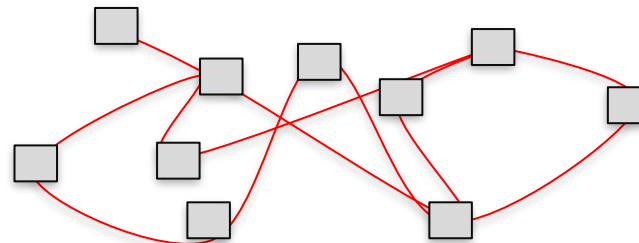
Procedures



Laws



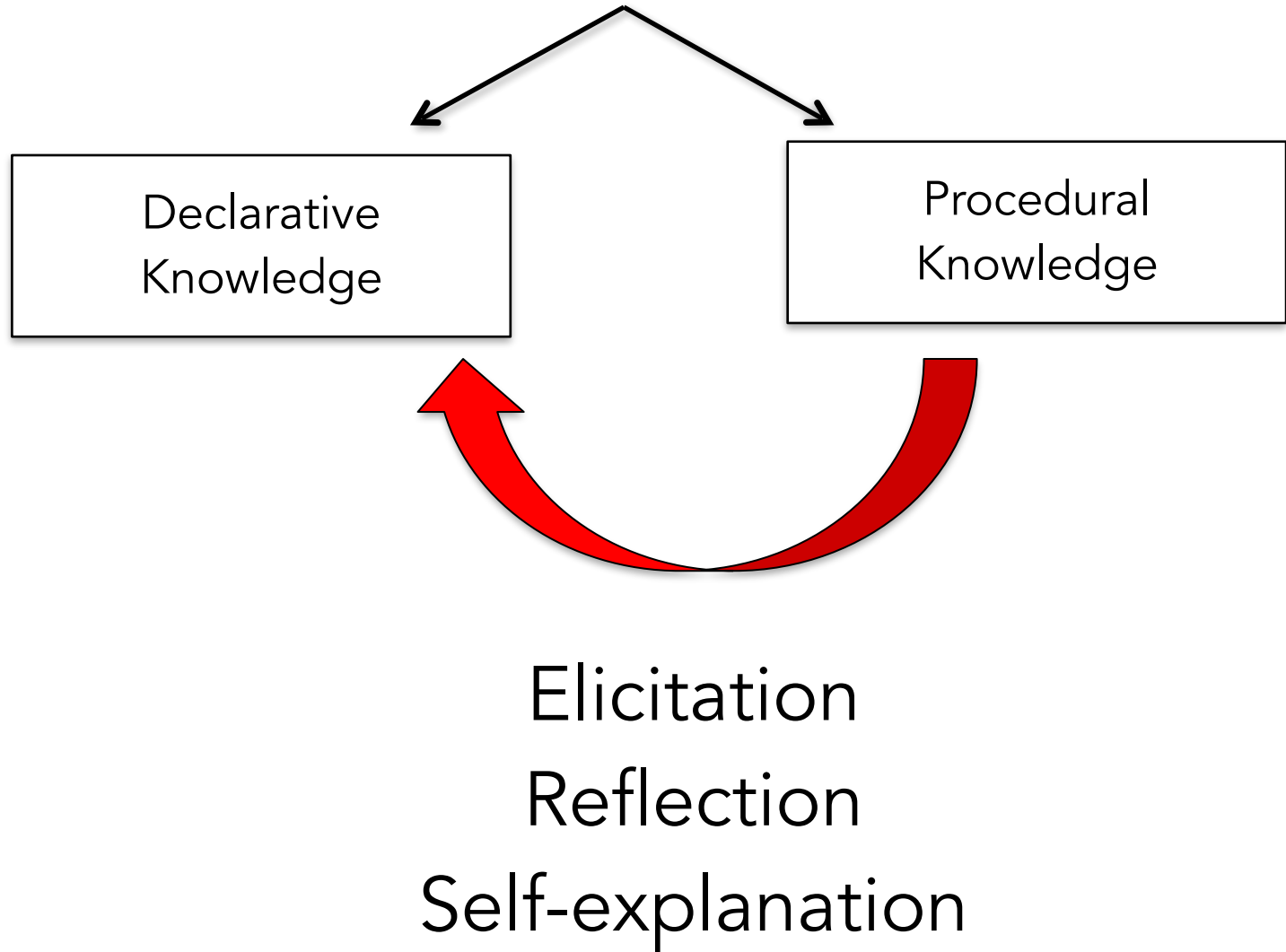
Theories, systems



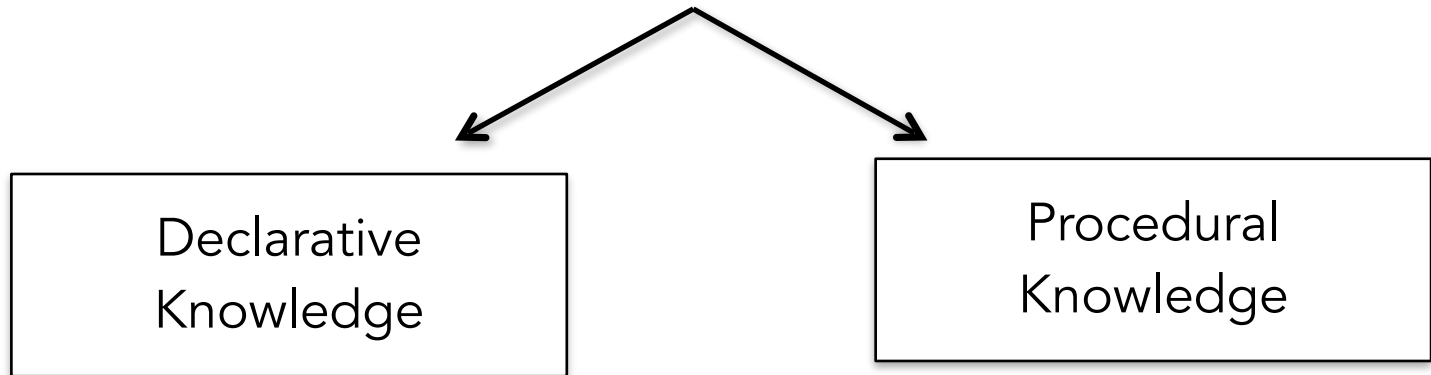
Procédural **versus** Declarative Knowledge

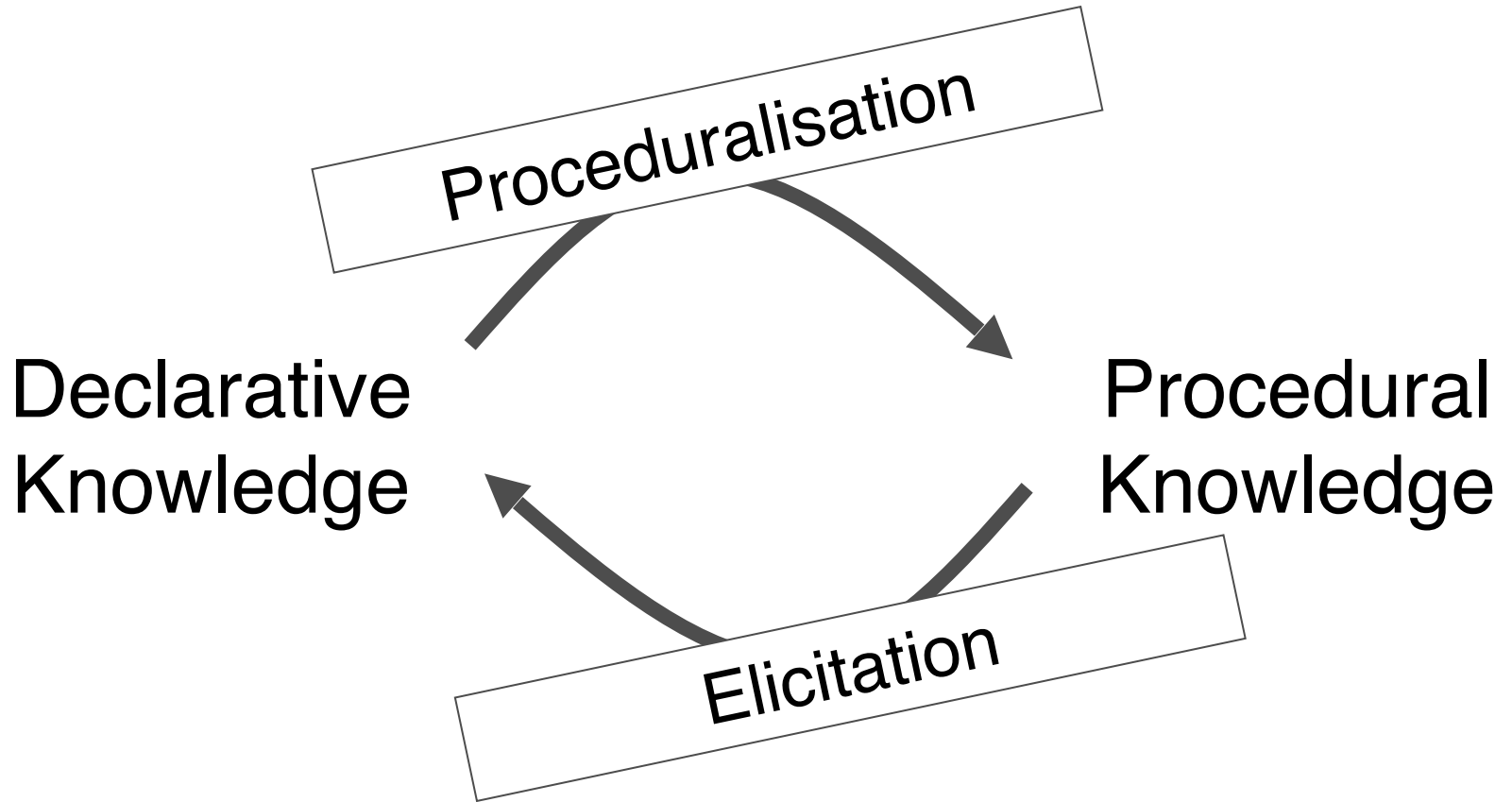


How to be a good manager?



How to be a good manager?

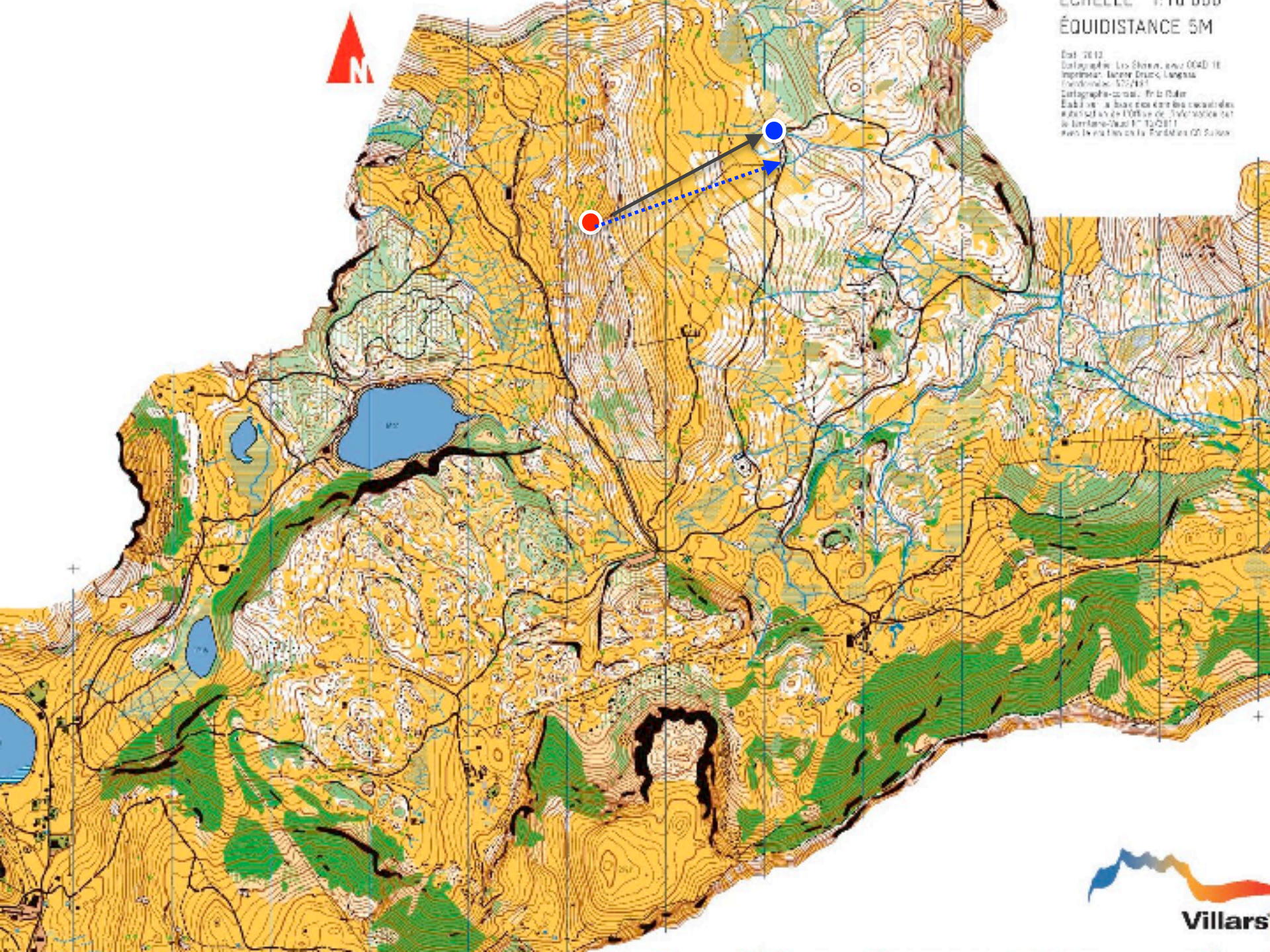




ÉCHELLE 1:10 000

ÉQUIDISTANCE 5M

Dat. 2012
Cartographe: Les Saisons, avec IGN
Imprimeur: Les Saisons, Langha
Coordonnées: 57°45'
Cartographe-conseil: Fr. L. B. L.
Édition: à base des cartes cadastrales
actualisées de 1985 et de 1987, complétées
de données IGN 1987/1988
avec la contribution de la Fondation G. S. L.



Heuristic knowledge

(Problem solving strategies)

- Orienteering: To reach the corner, select a drift-proof azimuth
- To solve a complex problem, decompose it into small simple problems
- Before to write the code of a function, first thing about the data structure
- ...

Metacognition

An army bus holds 36 soldiers. If 1128 soldiers are being bused to their training site, how many buses are needed?

29% 31 remainder 12

18% 31

23% 32

30% did not do the computation correctly

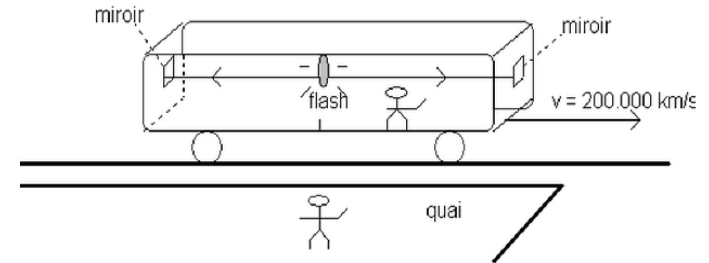
USA National Assessment of Education Progress secondary mathematics exam, 45,000 students nationwide

Schoenfeld, A. H. (1987). What's all the fuss about metacognition? In A. H. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 189-215). Hillsdale, NJ: Lawrence Erlbaum Associates.

Metacognition

- Knowledge about one's **own** knowledge (e.g. "I am not good with numbers", "I don't understand")
- **Regulation** of problem-solving: monitoring one's own plan application (e.g. "If the equation becomes too long, it is not good")

« Si la vitesse de la lumière est incompressible, c'est le temps qui est élastique »

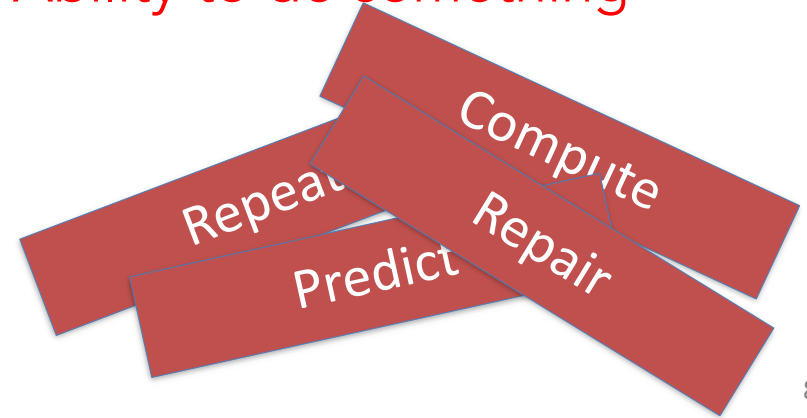


Knowledge

- fact, concept, rule, theory, ...
- declarative, procedural, heuristic
- meta-cognition

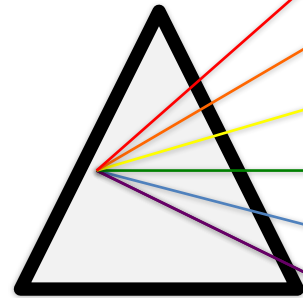
Cognitive Activity

Ability to do something



Knowledge

- fact, concept, rule, theory, ...
- declarative, procedural, heuristic
- meta-cognition



Taxonomy

Cognitive Activity

- Reproduction
- Conceptualisation
- Application
- Exploration
- Mobilisation
- Problem solving

Cognitive Task

Reproduction  The object and the product of the task have been associated before

Conceptualisation

Application

Exploration

Mobilisation

Problem solving

Types of reproduction tasks

Free recall:

What is the capital of Greenland ?

.....

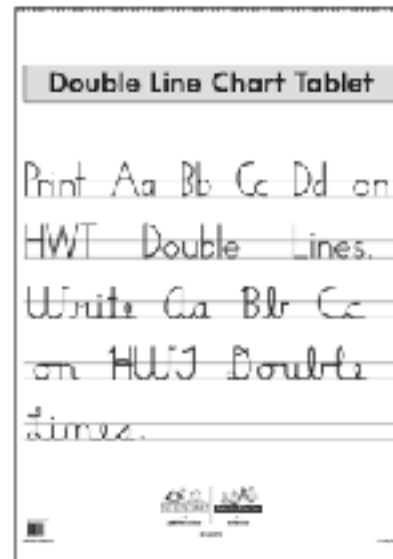
Recognition:

Which is the capital of Greenland ?

- *Tokyo*
- *Lausanne*
- *Nuuk*

Imitation:

Copy « lines »



Cognitive Task

Reproduction

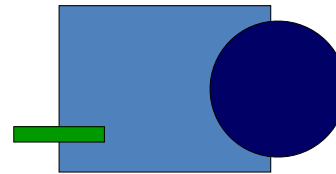
Conceptualisation  Does an object belong to a class ?

Application

Exploration

Mobilisation

Problem solving



SPUCs

Conceptualisation

<https://www.mnn.com/earth-matters/climate-weather/quiz/can-you-name-these-clouds>



Photo: Wikimedia Commons



What kind of clouds are shown here?

Nimbostratus

Noir clouds

Stratocumulus

Shelf clouds

Cognitive Task

Reproduction

Conceptualisation

Application

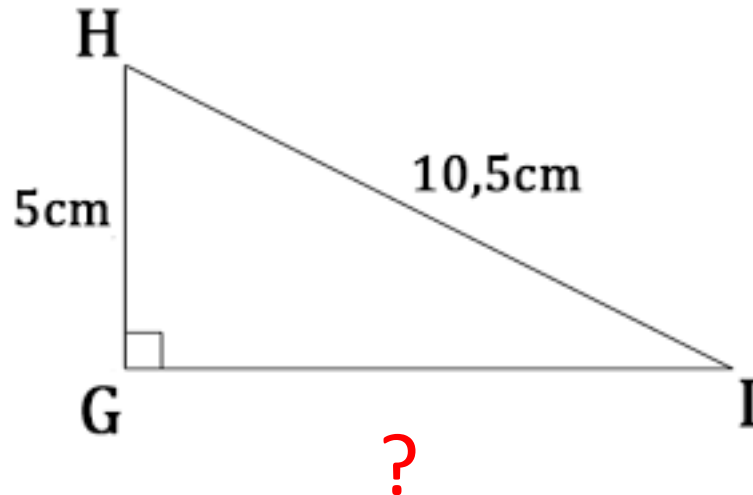


Apply an algorithm to the object
produces the product

Exploration

Mobilisation

Problem solving



Cognitive Task

Reproduction

Conceptualisation

Application

Exploration



Identify a product in some material that matches criteria (object)

Mobilisation

Problem solving

- *Find 2 metaphors in this text*
- *Find 2 prime number above 19*
- *Find a tumor on this image*

Cognitive Task

Reproduction

Conceptualisation

Application

Exploration

Mobilisation



Invent a product that matches
criteria (object)

Problem solving

- *Find 2 metaphors*
- *Find 3 different ways to solve this exercise*

Cognitive Task

Reproduction

Conceptualisation

Application

Exploration

Mobilisation

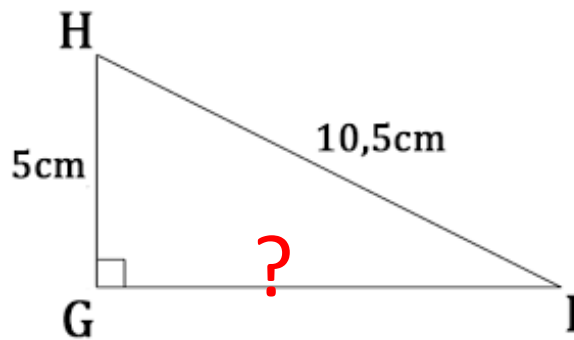
Problem solving



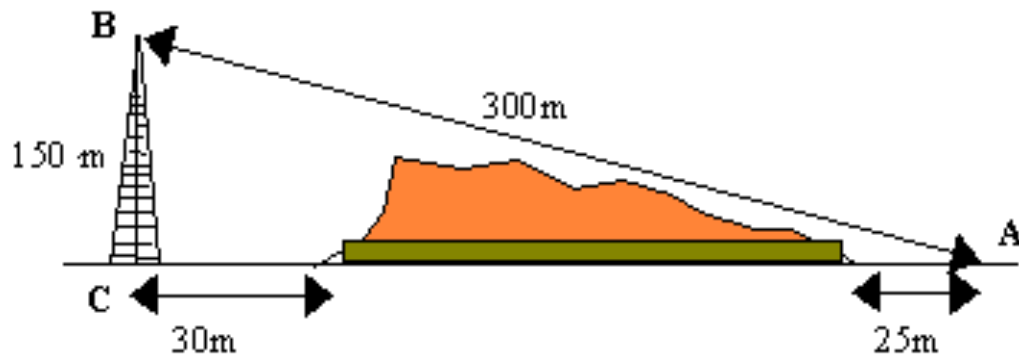
The learner has not the algorithm to compute the solution; this is a **novel** situation

The learner may combine segments of algorithm in a novel way

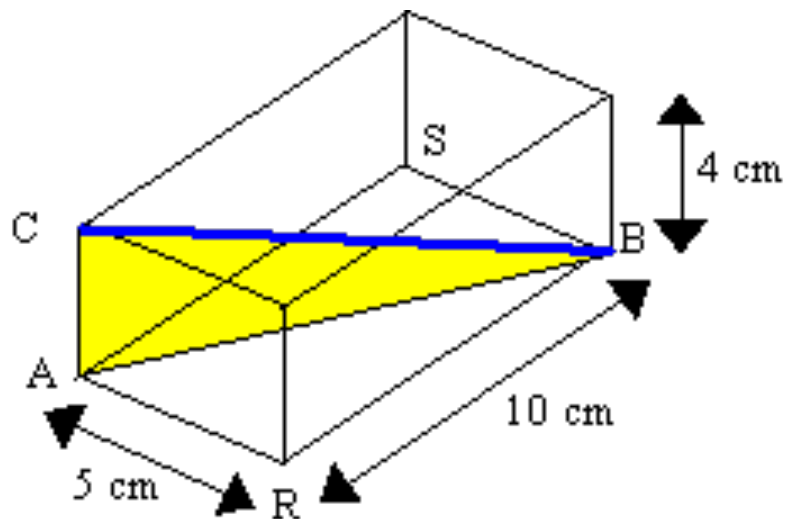
Application



Extrapolation



Problem



Bloom's Taxonomy

West Greene Elementary 2011

Bloom's

Taxonomy

Creating:

Can the student
create new product or
point of view?
Assemble, Construct,
Create, Design, Develop,
Formulate, Write

Evaluating: Can the student justify a
stand or decision?

Appraise, Argue, Defend, Judge, Select,
Support, Value, Evaluate

Analyzing: Can the student distinguish between the different
parts?

Appraise, Compare, Contrast, Criticize, Differentiate, Discriminate,
Distinguish, Examine, Experiment, Question, Test.

Applying: Can the student use the information in a new way?

Choose, Demonstrate, Dramatize, Employ, Illustrate, Interpret, Operate, Schedule, Sketch,
Solve, Use, Write

Understanding: Can the student explain ideas or concepts?

Classify, Describe, Discuss, Explain, Identify, Locate, Recognize, Report, Select, Translate,

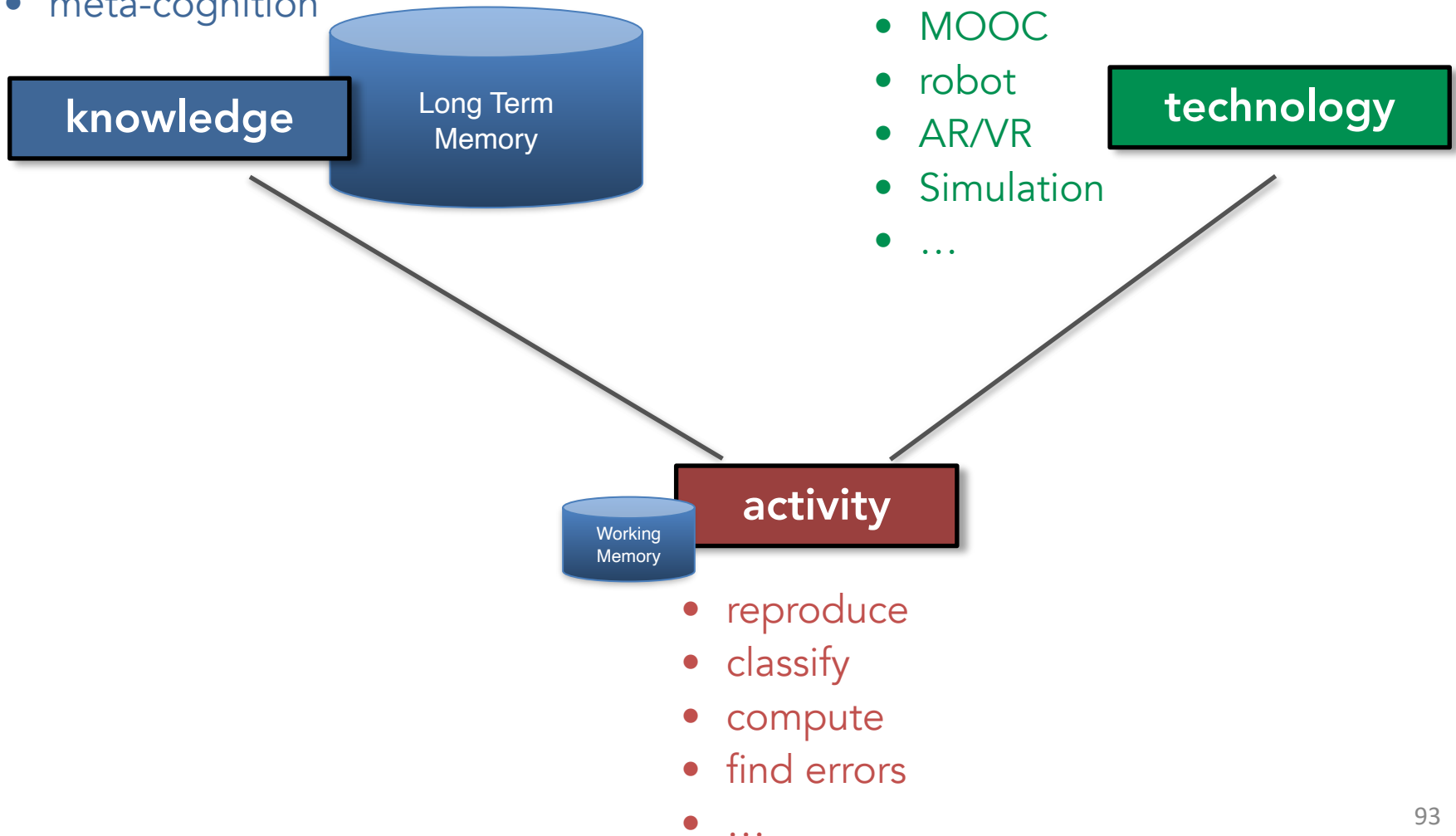
Remembering: Can the student recall or remember the information?

Define, Duplicate, List, Memorize, recall, Repeat, Reproduce, State

Over-represented in exams

Summary

- fact, concept, rule, theory, ...
- declarative, procedural, heuristic
- meta-cognition



For your project

- PS-I = there is a time for telling
- Minimize extrinsic cognitive load
- PS trigger germane cognitive load (but avoid overload)
- Set goals in the upper part of Bloom's taxonomy

Figure 1 Common ways of overwhelming and supporting intrinsic and extraneous load

Type of Cognitive Load	Ways Load Can Be Overwhelmed
Intrinsic Load	• Presenting concepts that are too complex (i.e., concepts that are outside students' instructional level) • Using technical and other unknown language • Presenting too many concepts at once • Presenting interesting but unessential information • Assuming students have memorized formulas, facts, or other needed background knowledge needed to complete a novel task
Extraneous Load	• Presenting a large amount of text on a screen while providing oral instruction (e.g., splitting attention between two competing sources of input) • Presenting large amounts of information in one burst • Presenting abstract information without illustrative images • Presenting processes and strategies without demonstrations • Stimuli from the environment (e.g., noise from other groups or classrooms, uncomfortable temperature, activity outside windows, etc.)

Type of Cognitive Load	Ways Germane Load Resources Can Be Conserved
Intrinsic Load	• Repeat key information • Use rich images to illustrate content • Chunk information into meaningful segments • Provide worked examples • Filter out interesting but unnecessary details • Make connections between content and real-world scenarios • Monitor oral instruction for jargon or other potentially unknown words
Extraneous Load	• Use slides or other instruction with clear images and limited text • Limit distractions not related to lesson • Break instruction into chunks of content and amount of time • Provide frequent breaks and comprehension checks • Use principles of explicit instruction to design and deliver instruction (Archer & Hughes, 2011).