

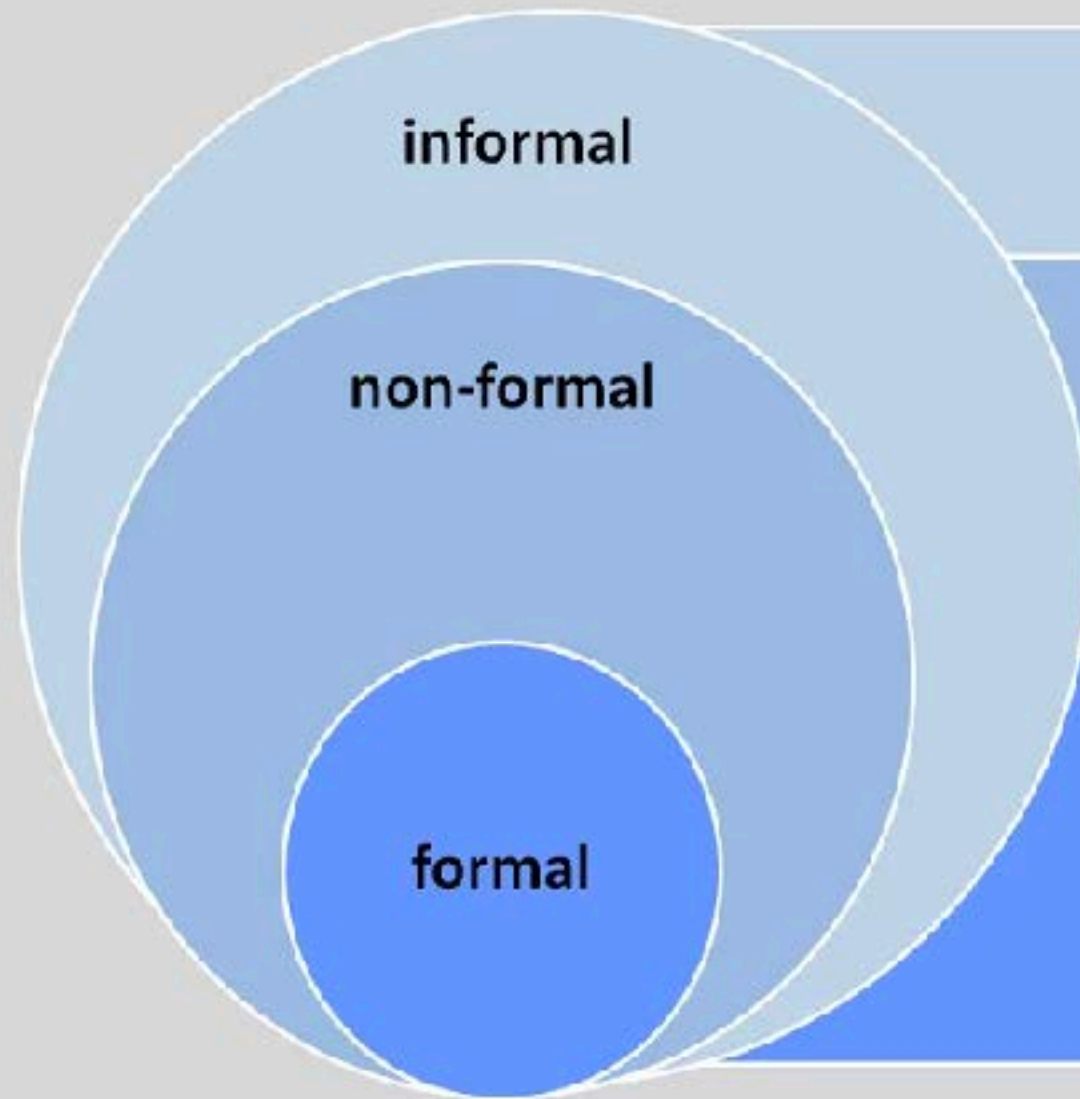
CS411 - P. Dillenbourg

Chapter 2:

Basic Concepts in Learning Sciences

What did you learn ?

- To solve equations
- To compute a standard deviation
- To play soccer
- To appreciate Giacometti
- To ride a bike
- To wake up early
- To accept that people have different opinions
- To be happy despite problems
-

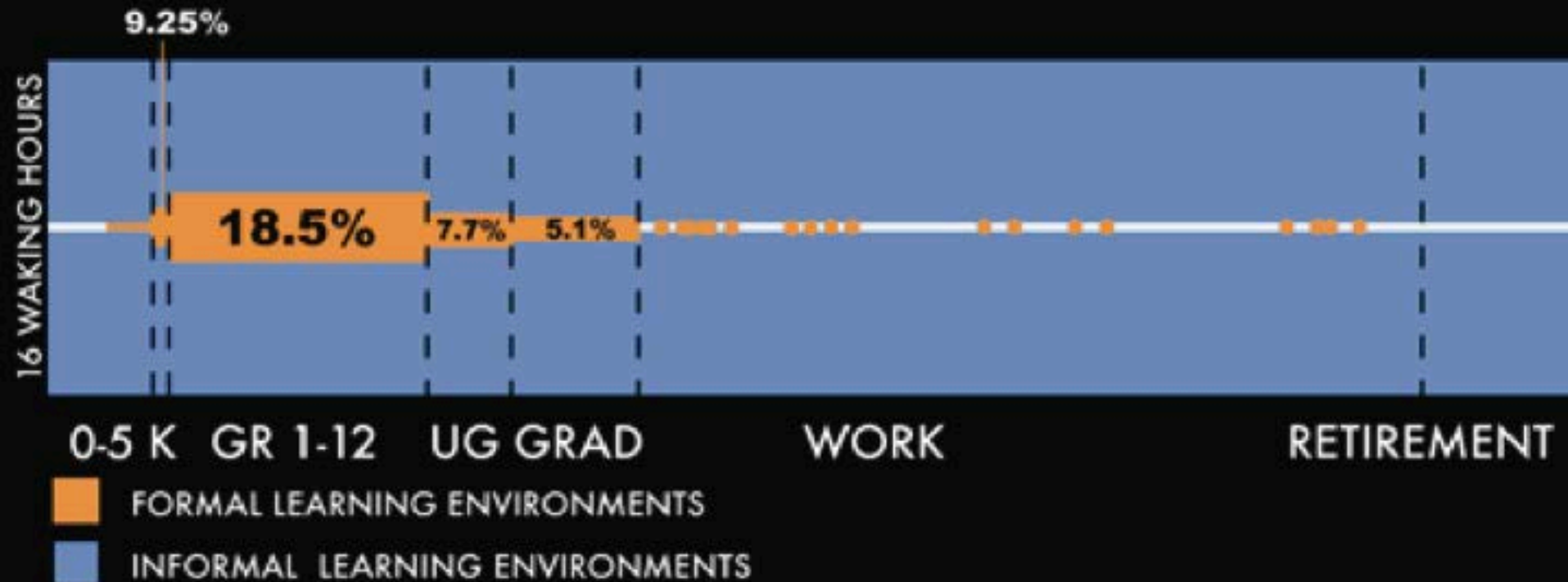


“Informal learning is learning that occurs in daily life, in the family, in the workplace, in communities and through interests and activities of individuals.”

“Non-formal learning is learning that has been acquired in addition or alternatively to formal learning. In some cases, it is also structured according to educational and training arrangements, but more flexible. It usually takes place in community-based settings, the workplace and through the activities of civil society organisations.”

“Formal learning takes place in education and training institutions, is recognised by relevant national authorities and leads to diplomas and qualifications. Formal learning is structured according to educational arrangements such as curricula, qualifications and teaching learning requirements.”

LIFELONG AND LIFEWIDE LEARNING



Digital technologies blur the lines between formal and informal education

	Formal	Informal
E-learning		
Simulations		
MOOCs		
Museum guide		
YouTube		
Facebook		

Examples of **exam** questions

- ① In the following learning environment, would the learner rather encounter problems due to **cognitive load** or to **metacognition** ?
- ② What should you change in this learning environment to engage the learner into **inductive** reasoning ?

N **U** **U** **K**

What is the capital of Greenland ?

The Lecture Model

Information

Perception



Processing



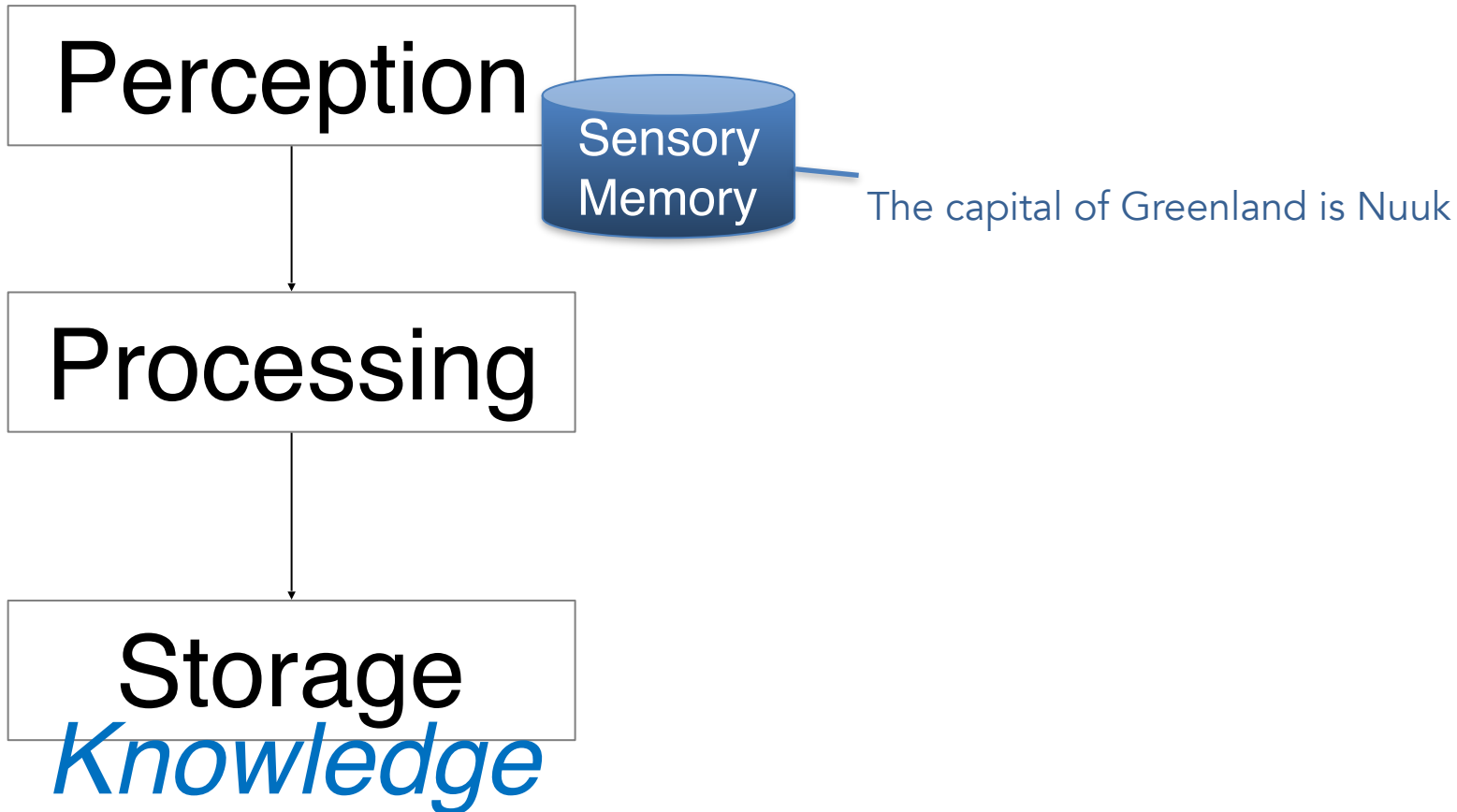
Storage

Knowledge

The capital of Greenland is Nuuk

The Lecture Model

Information



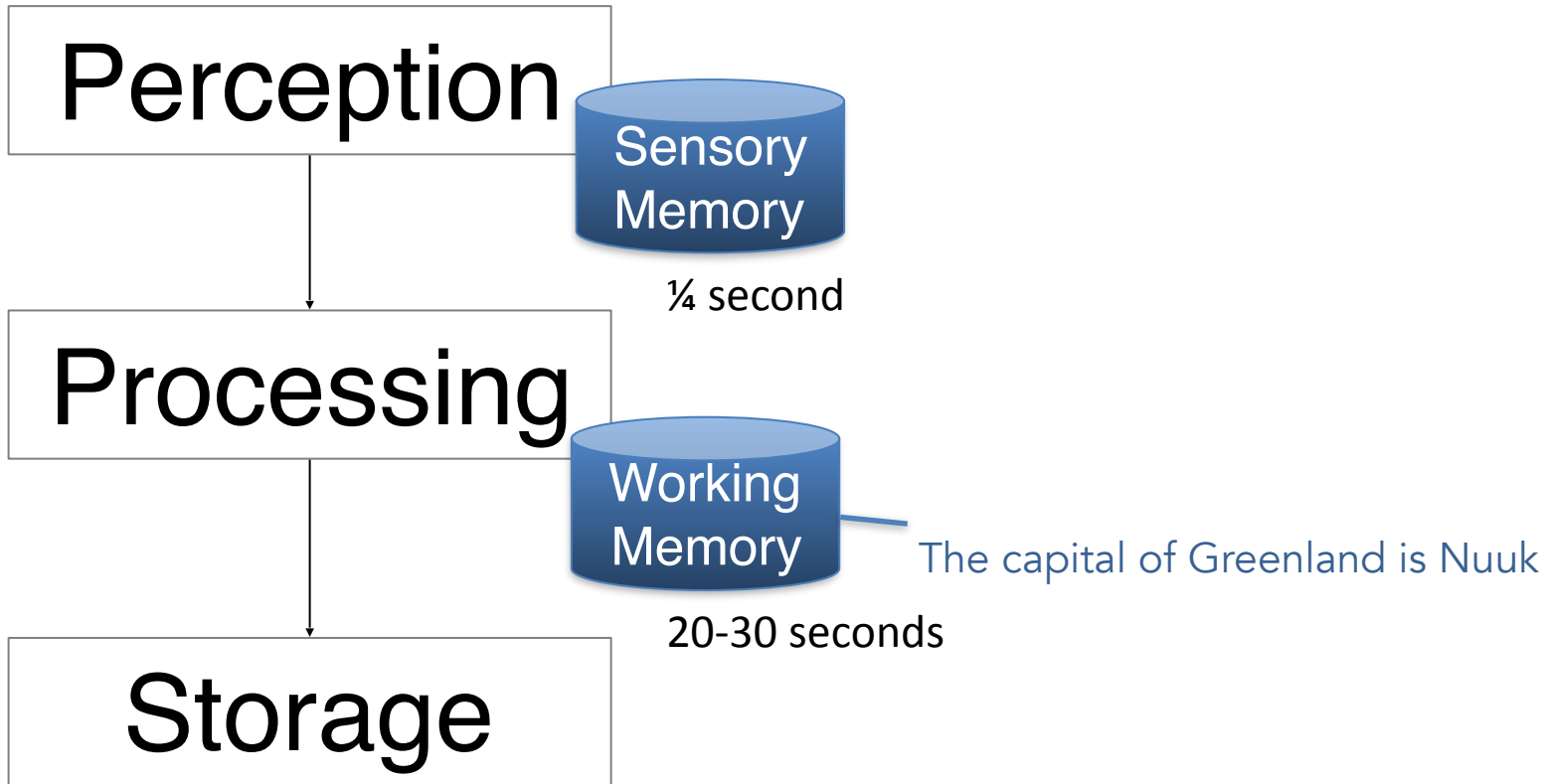


As you can guess, the Danish name of this city is Godthåb

What is the capital of Greenland ?

The Lecture Model

Information



Knowledge

My phone number is 079 474 48 99

Remember it and call me after the video (1 min)

Don't write it !!!

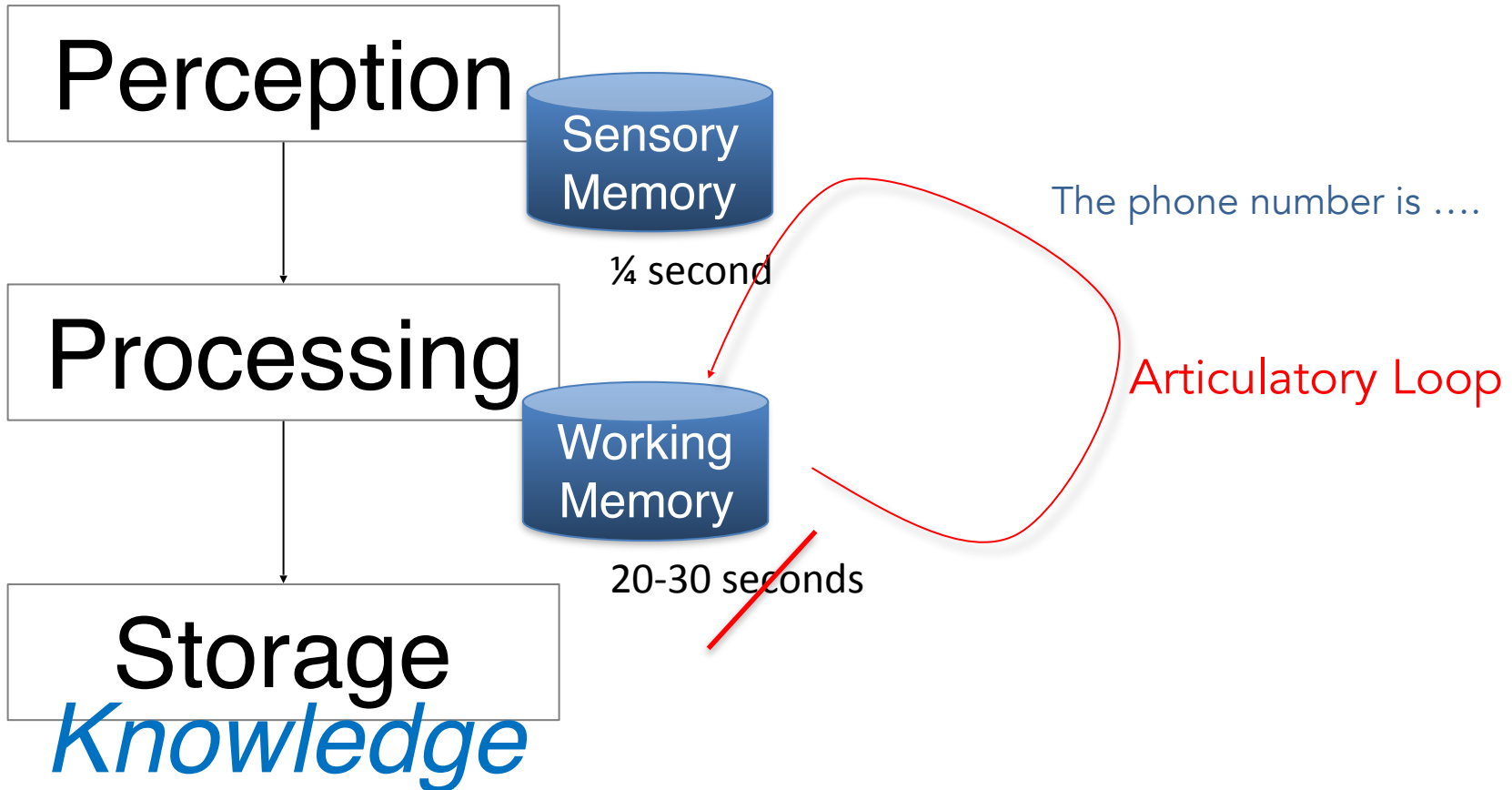


My phone number is xxx xxx xx xx

Call me now

The Lecture Model

Information



My phone number is 078 676 48 55

Remember it and call me after the next activity

READ ALOUD

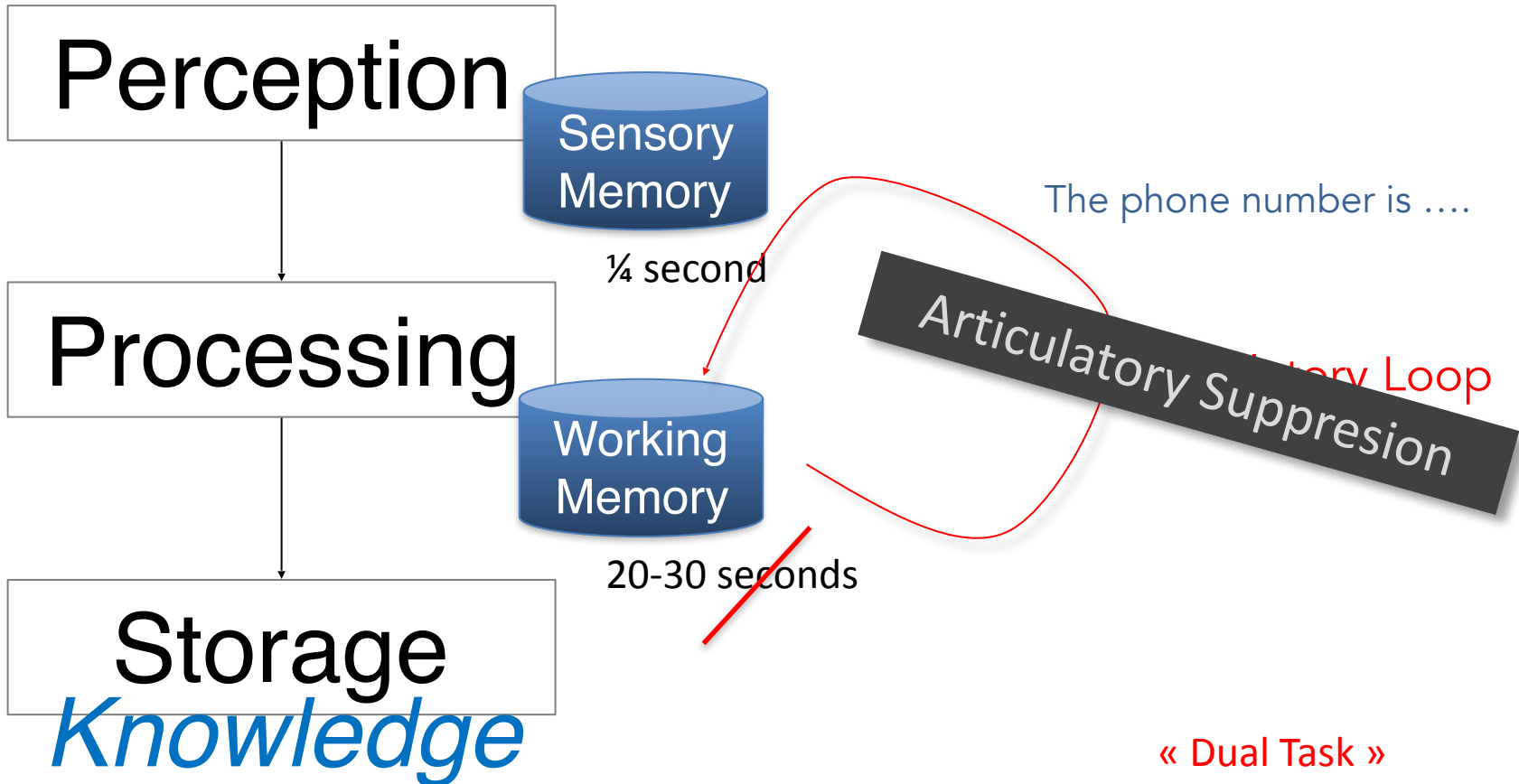
Nuuk has a long history of habitation. The area around Nuuk was first occupied by the ancient pre-Inuit, Paleo-Eskimo people of the Saqqaq culture as far back as 2200 BC when they lived in the area around the now abandoned settlement of Qoornoq.

My phone number is xxx xxx xx xx

Call me now

The Lecture Model

Information



My password is 32 45 80

Remember it and call after reading this text aloud



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

Working
Memory

Storage
Knowledge

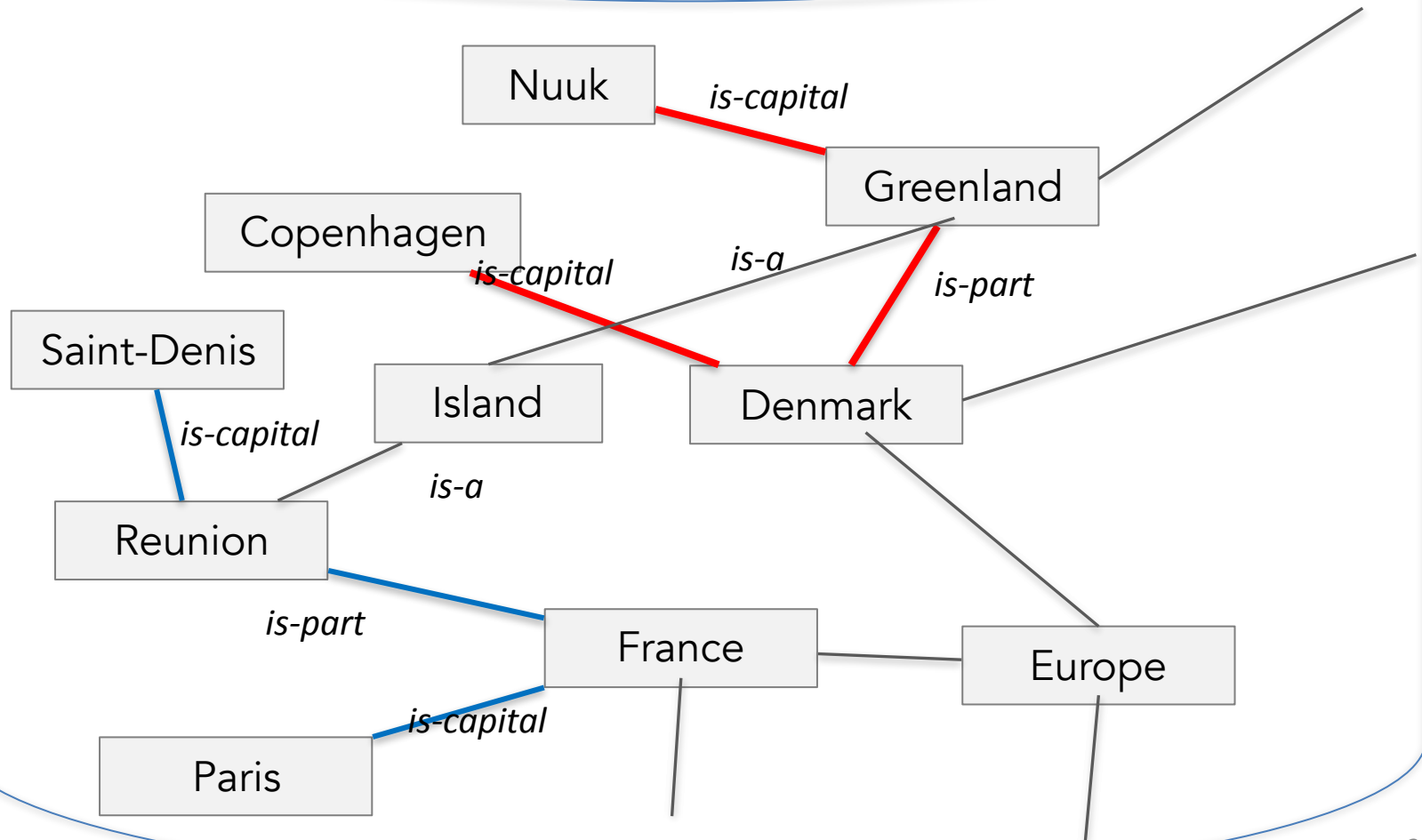
Long Term
Memory

Nuuk is to Copenhagen,

what

Saint-Denis is to ?

Nuuk is to Copenhagen
What Saint-Denis is to



Information

Experience

Perception

UNLIMITED, MULTIMODAL

Processing

MOSTLY VERBAL
LIMITED in SIZE (7 ± 2)
LIMITED In Time (20-30 s)

Working
Memory

Storage
Knowledge

EXTREMELY LARGE, SEMANTIC

Long Term Memory

Working Memory

Manuel is the son of Liam
Liam is the father of Elenna
Liam is the brother of Walter
Who is the uncle of Elenna?

Faites glisser la croix sur la zone que vous souhaitez capturer.

Liam

Walter

Manuel

I don't know!

Genealogy Game



Cognitive overload

Michel est le père de Martine
Martine est la sœur de Serge
Serge est le père de Tristan
Luc est le frère de Tristan
Lucie est la mère de Serge
Nadine est la fille de Tristand

Marc est le frère de Michel
Michel est le père de Martine
Martine est la sœur de Serge
Serge est le père de Tristan
Luc est le frère de Tristan
Lucie est la mère de Serge
Nadine est la fille de Tristand

Lena est la sœur de Lucie
Marc est le frère de Michel
Michel est le père de Martine
Martine est la sœur de Serge
Serge est le père de Tristan
Luc est le frère de Tristan
Lucie est la mère de Serge
Nadine est la fille de Tristand

Sophie est la sœur de Serge
Lena est la sœur de Lucie
Marc est le frère de Michel
Michel est le père de Martine
Martine est la sœur de Serge
Serge est le père de Tristan
Luc est le frère de Tristan
Lucie est la mère de Serge
Nadine est la fille de Tristand

$$7 \pm 2$$

Michel is the father of Martine

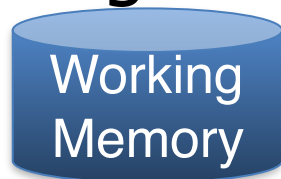
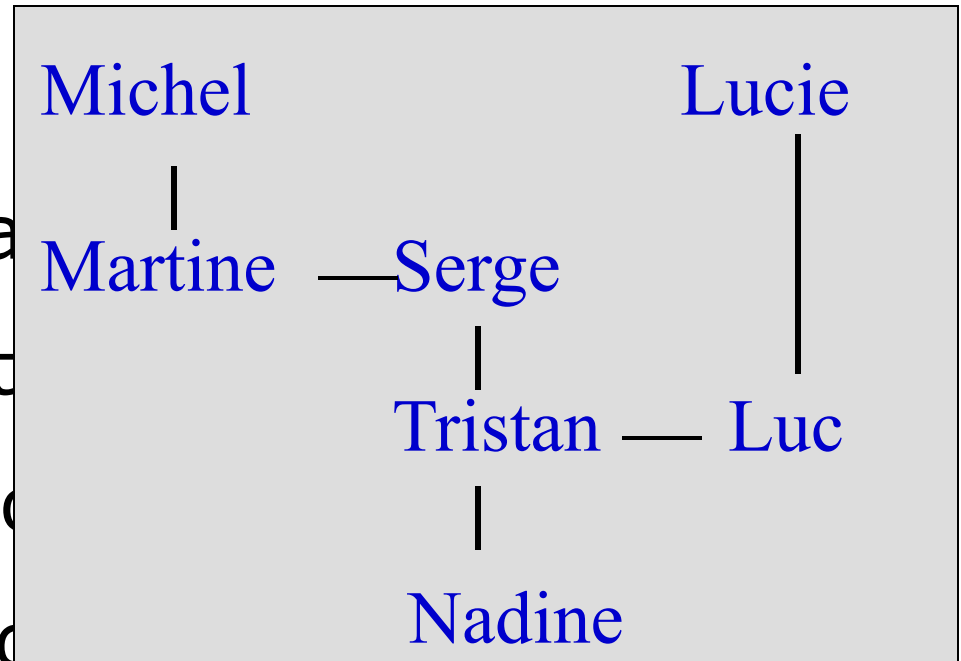
Martine is the

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 ?







Who will win the next race ?

Intrinsèque

CHARGE COGNITIVE

Extrinsèque

Germane



The diagram illustrates the flow of information between different memory systems. At the top is a large blue cylinder labeled 'Experience'. A dotted line connects it to a smaller blue cylinder labeled 'Working' in the middle. Another dotted line connects 'Working' to a large blue cylinder at the bottom labeled 'Long Term Memory'.

Experience

Working

Long Term Memory

Intrinsic Cognitive Load: some things are harder to learn

Extrinsic Cognitive Load: due to bad design

Germane Cognitive Load : the effort to create schemas

Intrinsic Cognitive Load

$$\sum_{n=0}^{N-1} a_n e^{-2\pi i n k / N} = \sum_{n=0}^{N/2-1} a_{2n} e^{-2\pi i (2n) k / N}$$

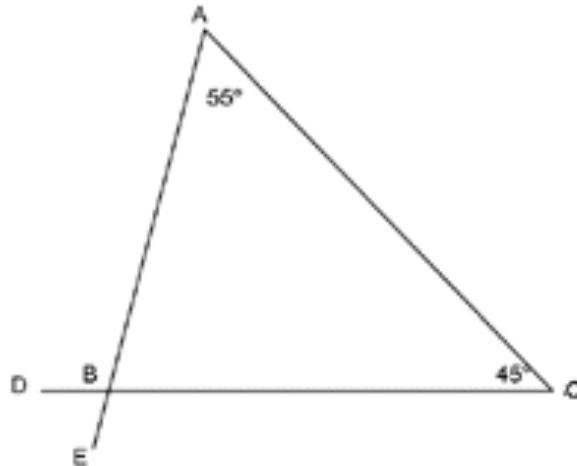
$$+ \sum_{n=0}^{N/2-1} a_{2n+1} e^{-2\pi i (2n+1) k / N}$$

$$= \sum_{n=0}^{N/2-1} a_n^{\text{even}} e^{-2\pi i n k / (N/2)}$$

$$+ e^{-2\pi i k / N} \sum_{n=0}^{N/2-1} a_n^{\text{odd}} e^{-2\pi i n k / (N/2)},$$

Extrinsic Cognitive Load

Example demonstrating split attention



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°)

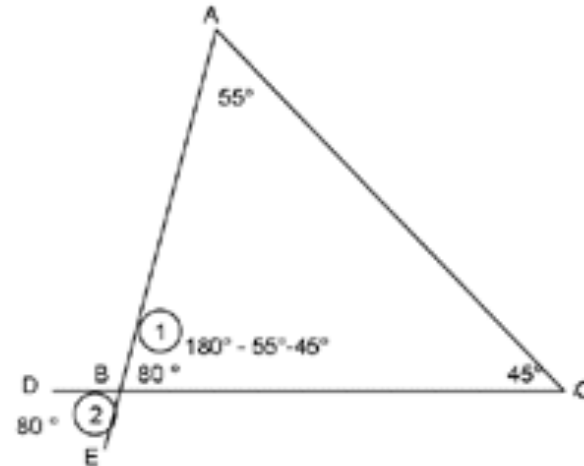
$$= 180^\circ - 55^\circ - 45^\circ$$

$$= 80^\circ$$

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

$$= 80^\circ$$

Integrated example

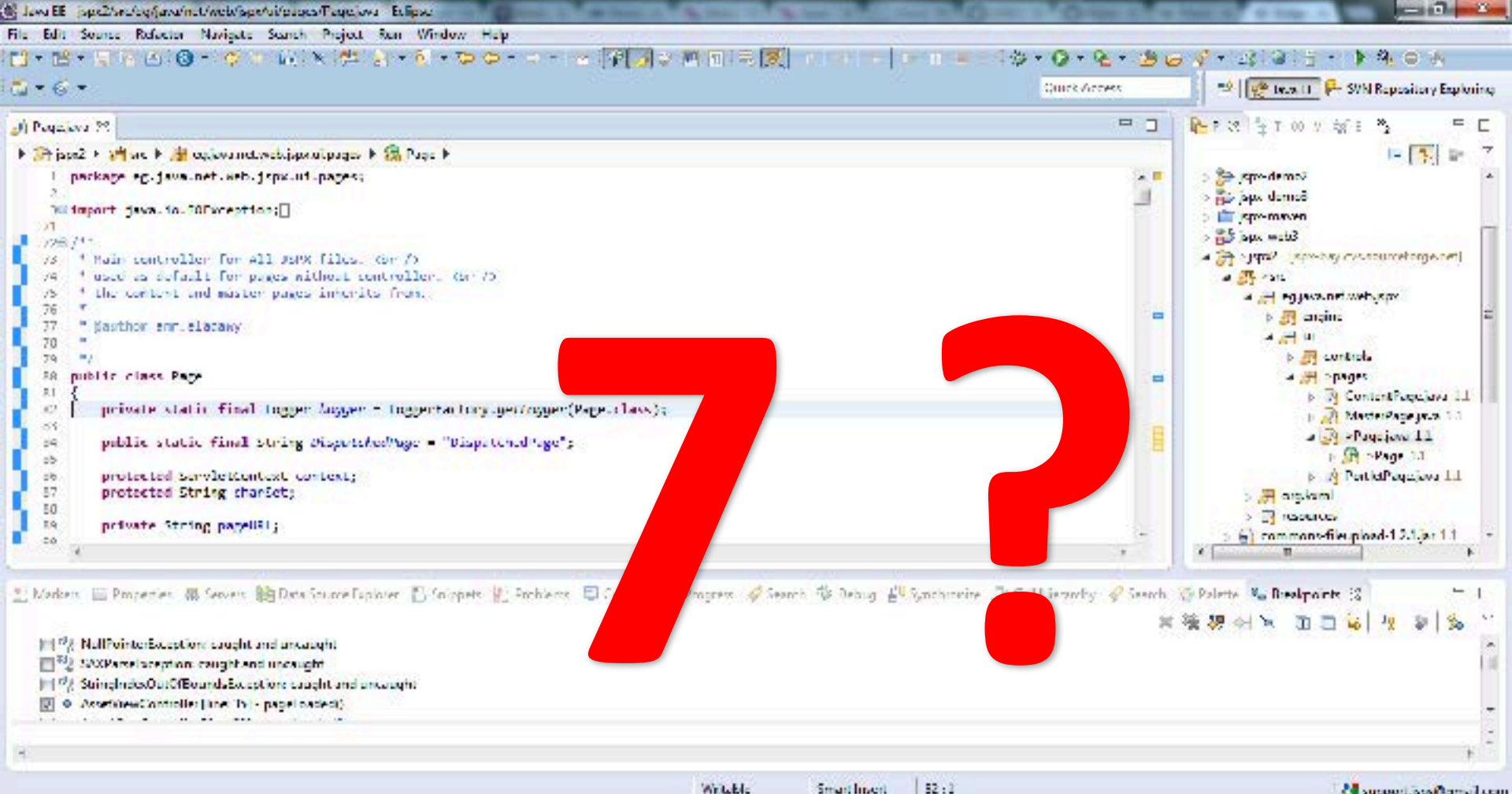


Split Attention Effect

Cognitive load

Which statements are correct?

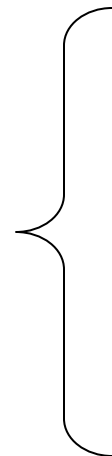
- ① Cognitive load prevents learning
- ② There is no learning without cognitive load
- ③ Cognitive over-load prevents learning
- ④ There is no learning without over-load



Working
Memory

Reducing cognitive load: Compilation

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



Freiner
Embrayer
Changer
Débrayer
Freiner

Information

Perception



Processing



Storage

Knowledge

Is knowledge a simple recording of information ?

Is knowledge a copy of information ?

Information

Perception



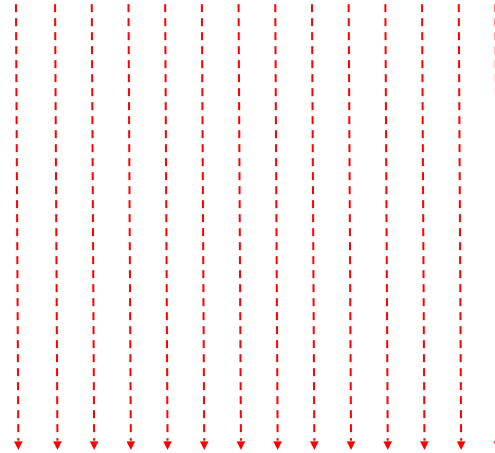
Processing



Storage

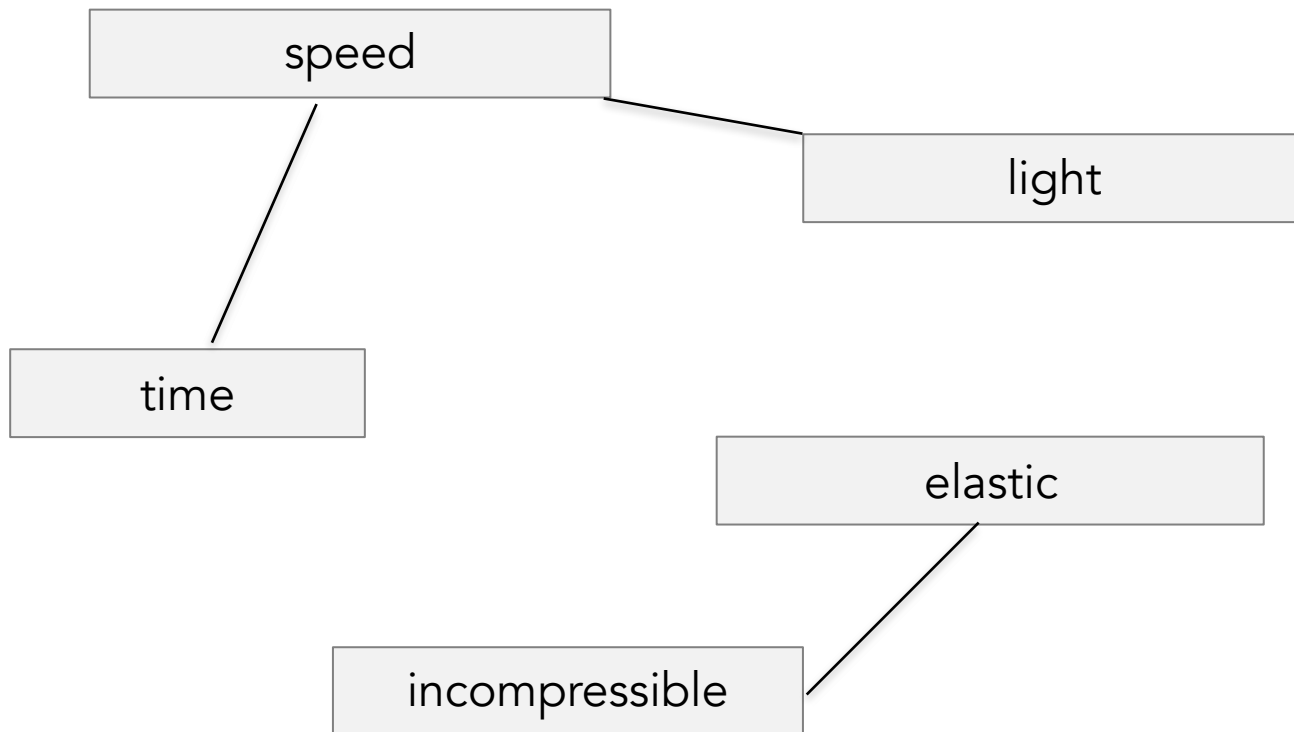
Knowledge

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

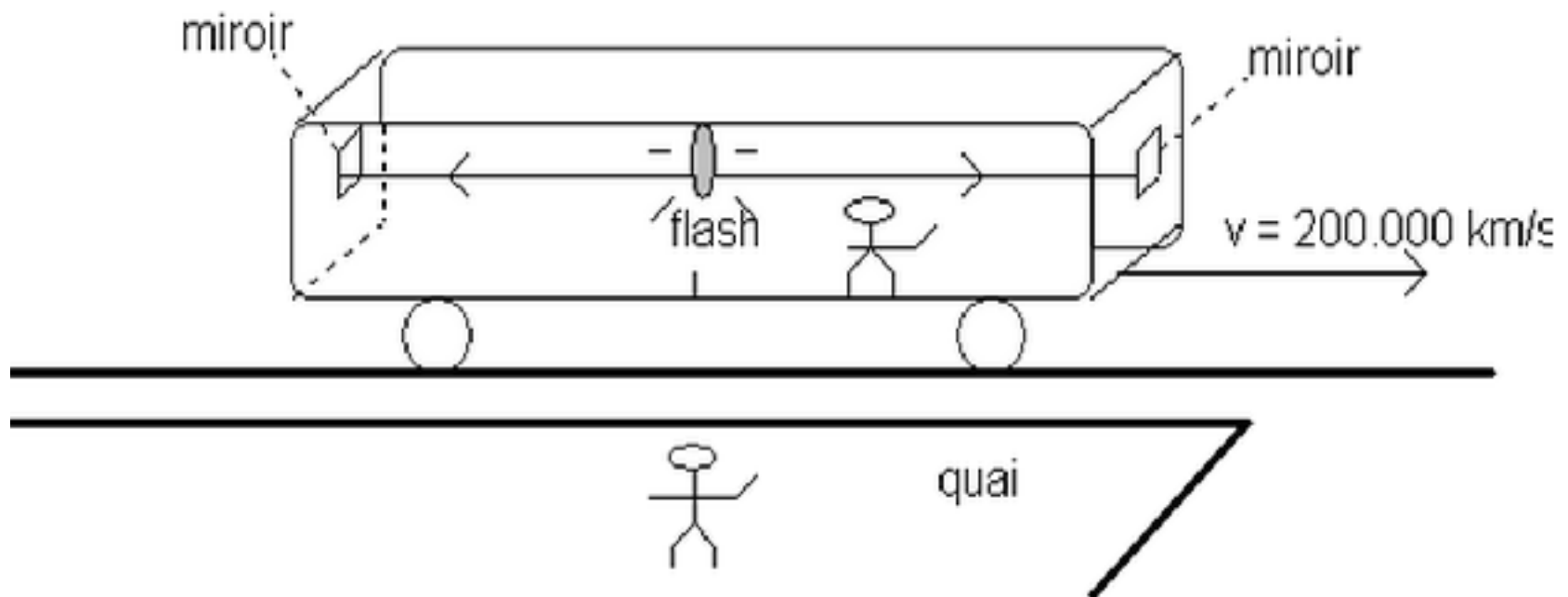


« If the speed of light is incompressible
then time is elastic »

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



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



Information

Processing

Knowledge



Generic attack

- $H: M \rightarrow \{0,1\}^n$. Collision finding algorithm:
1. Choose $2^{n/2}$ random elements in M : $m_1, \dots, m_{n/2}$
 2. For $i = 1, \dots, 2^{n/2}$ compute $t_i = H(m_i) \in \{0,1\}^n$
 3. Look for a collision $(t_i = t_j)$. If not found, got back to step 1.

Expected number of iteration =

2.2 Queries and Transformations on Sets

In this part, we are interested in functions used to make requests on elements of a set. The first function has the following signature:

```
def forall(s: Set, p: Int => Boolean): Boolean
```

Note that there is no direct way to find which elements are in a set. `contains` only allows to know whether we have to iterate over all integers, testing each one whether it is included in the set, and if so, to do our center to limit the search space.

1. Implement `forall` using linear recursion. For this, use a helper function nested in `forall`. Its structure is:

```
def forall(s: Set, p: Int => Boolean): Boolean = {  
  def iter(a: Int): Boolean = {  
    if (???) ???  
    else if (???) ???  
    else iter(???)  
  }  
  iter(???)  
}
```



École Polytechnique Fédérale de Lausanne
Functional Programming Principles in Scala

Ended 2 months ago

[course info](#) | [un-enroll](#) | [class archive](#)

[View course](#)

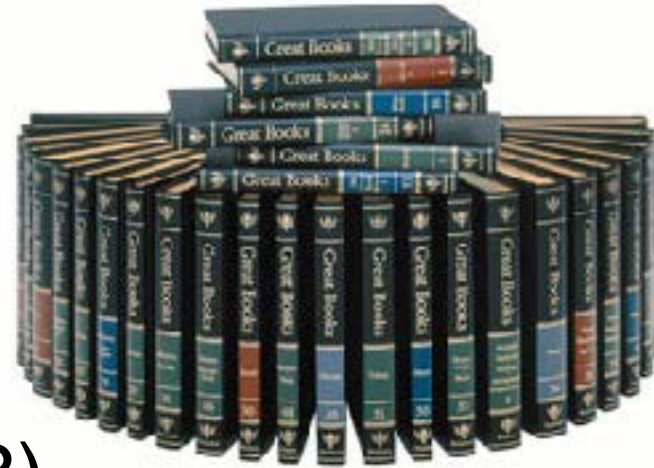
Where is there more knowledge ?

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/>

Information

Perception



Processing



Storage

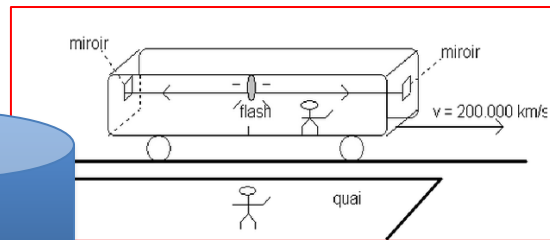
Knowledge

CS-411 Designing rich Learning Activities

Storage

Knowledge

Long
Term
Memory



The capital of
Greenland is Nuuk

*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

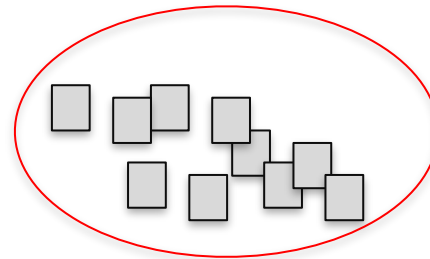
Restricted relativity

Knowledge Taxonomy

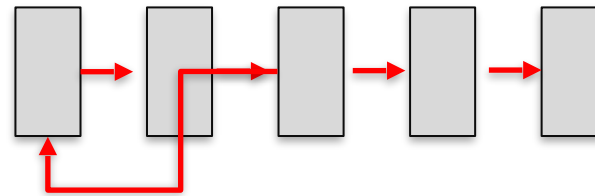
Facts



Classes, concepts



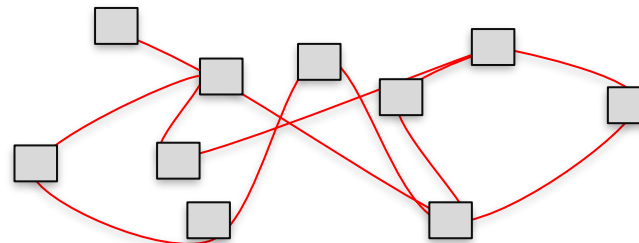
Procedures



Laws



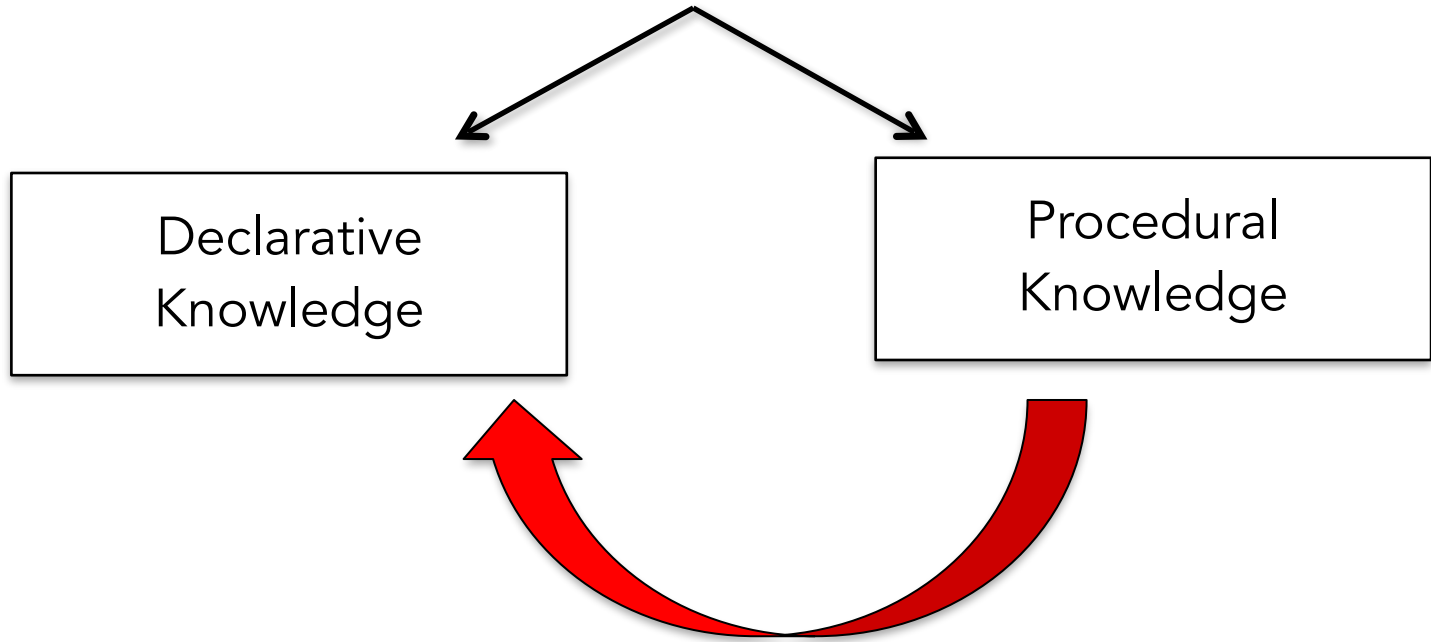
Theories, systems



Procédural **versus** Declarative Knowledge

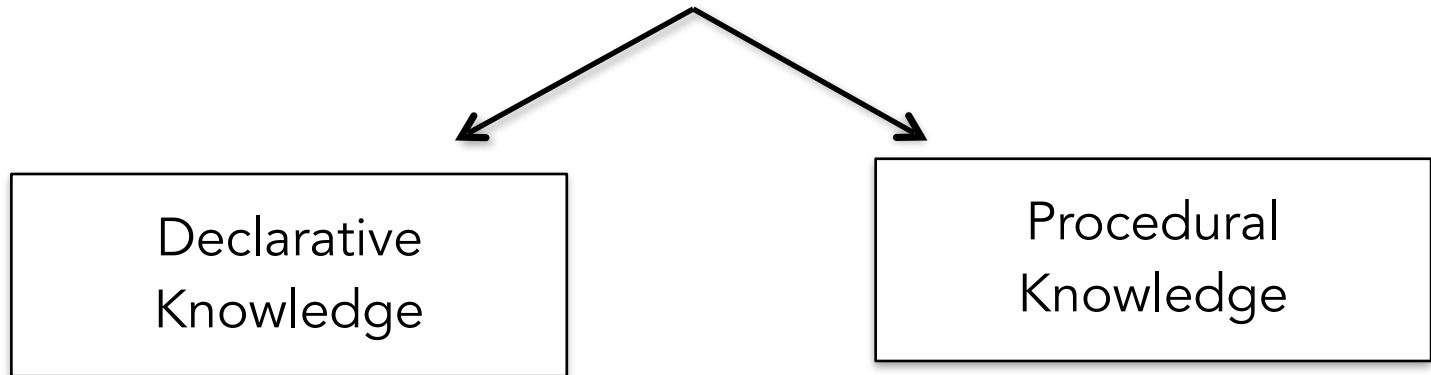


How to be a good manager?



Elicitation
Reflection
Self-explanation

How to be a good manager?

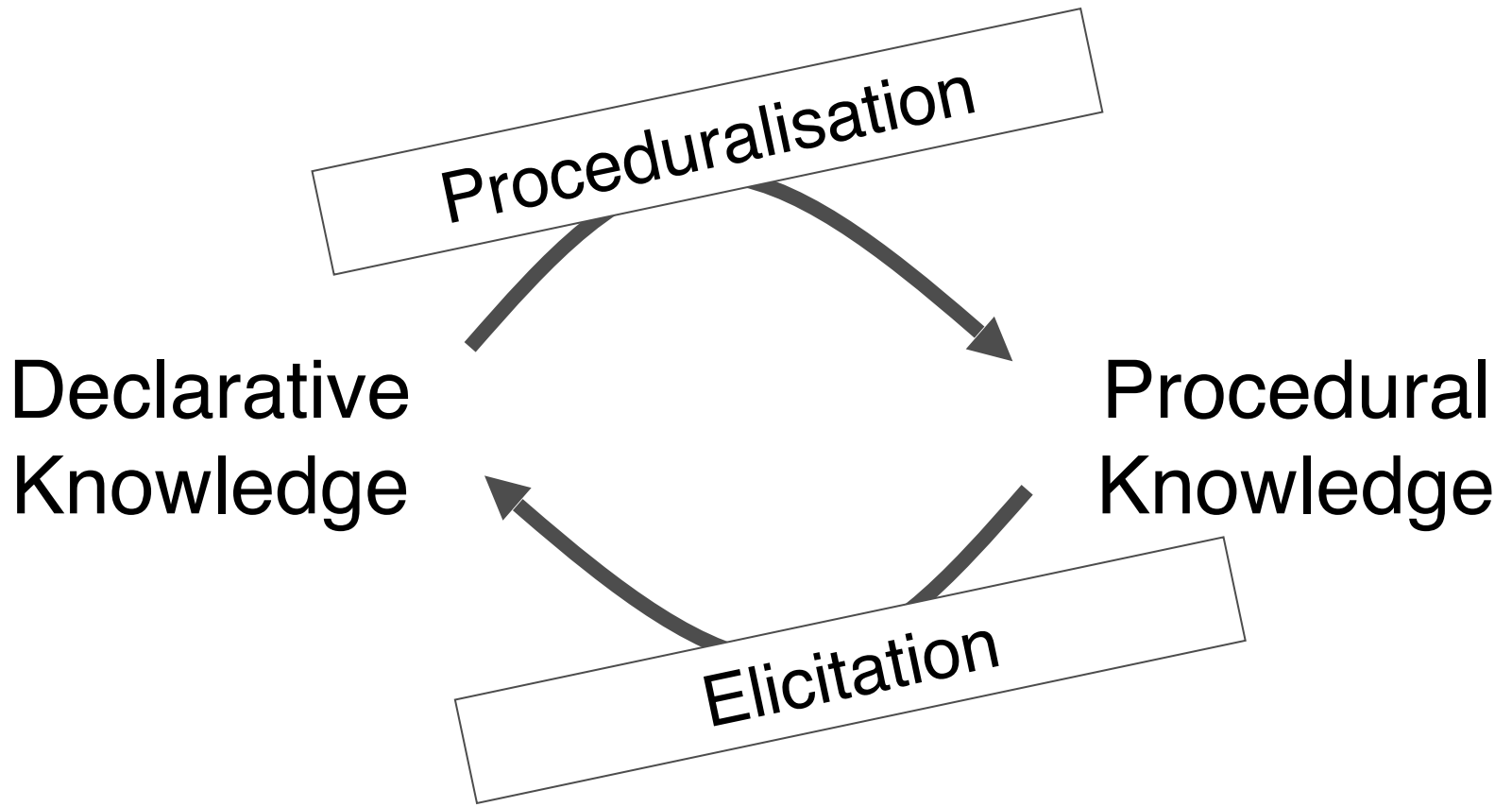


Top things to make a good manager

Acknowledge your staff :

When a member of staff does a job well, make sure you notice it, and acknowledge her or him for it. Don't let the opportunity to praise a piece of good work go by.

The illustration shows a male manager in a dark suit standing and presenting a large bouquet of red flowers to a female staff member. The staff member is sitting at a desk with a computer monitor, looking up at the manager with a smile. The office background includes a desk with a printer, a trash can, and a filing cabinet.



Information

Perception

Sensory
Memory

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

Processing

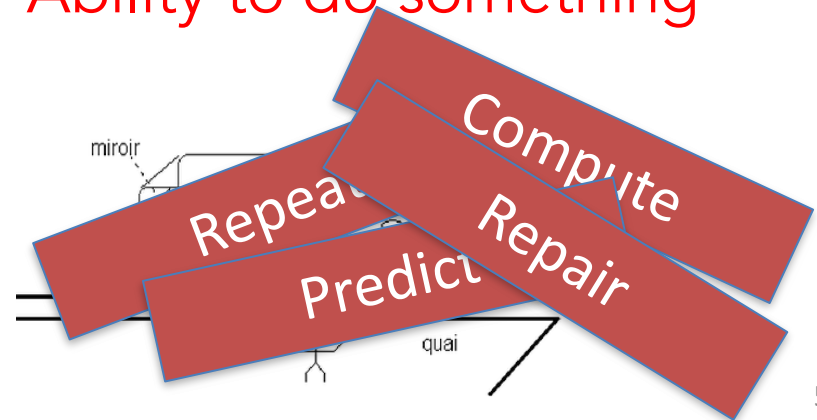
Working
Memory

Storage

Long
Term
Memory

Knowledge

Ability to do something



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?

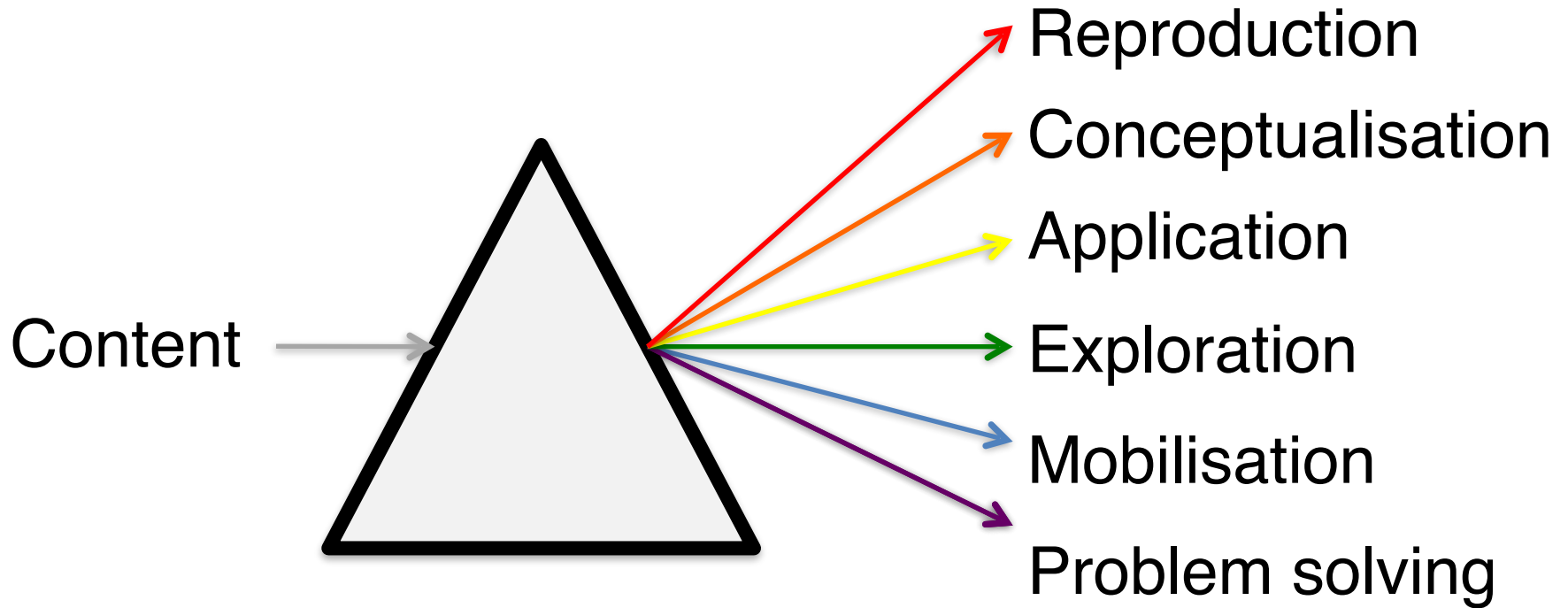
Classify, Describe, Discuss, Explain, Identify, Locate, Recognize, Report, Select, Translate,

Remembering: Can the student recall or remember the information?

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

Over-represented in exams

Cognitive Task



Taxonomy:
Bloom
D'Hainaut

Cognitive Task

Reproduction 

Conceptualisation

Application

Exploration

Mobilisation

Problem solving

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

Types of reproduction tasks

Free recall:

What is the capital of Greenland ?

.....

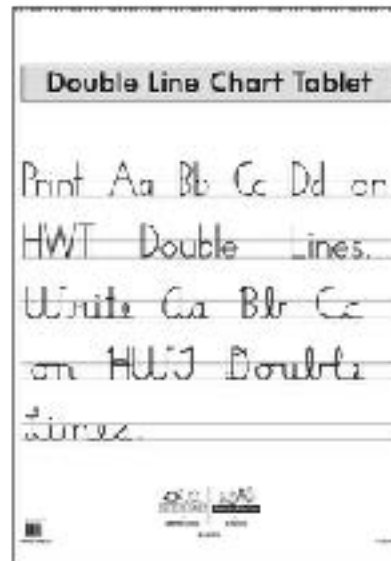
Recognition:

Which is the capital of Greenland ?

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

Imitation:

Copy « lines »



Cognitive Task

Reproduction

Conceptualisation →

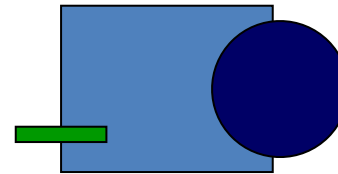
Does an object belong to a class ?

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

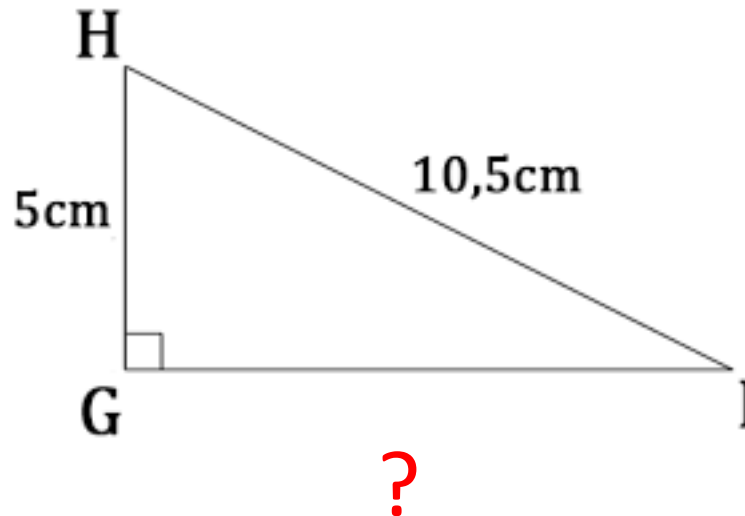


Apply an algorithm to the object produces the product

Exploration

Mobilisation

Problem solving



Cognitive Task

Reproduction

Conceptualisation

Application

Exploration



Mobilisation

Problem solving

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

- *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



Problem solving

Invent a product that matches criteria (object)

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

Cognitive Task

Reproduction

Conceptualisation

Application

Exploration

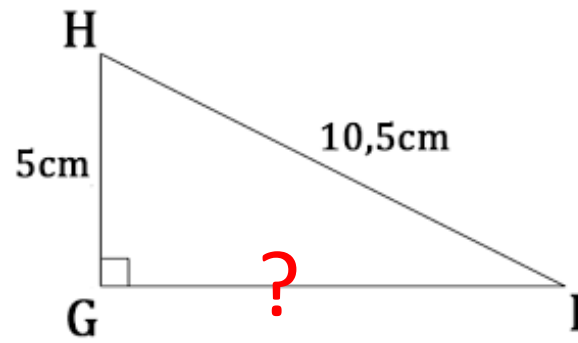
Mobilisation

Problem solving 

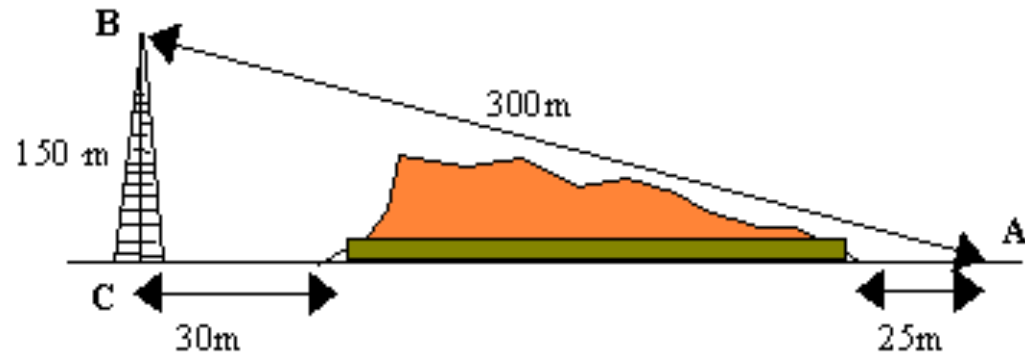
The learner has not the algorithm to compute the solution; this is a **novel** situation

The learner may combine segments of algorithm in a novel way

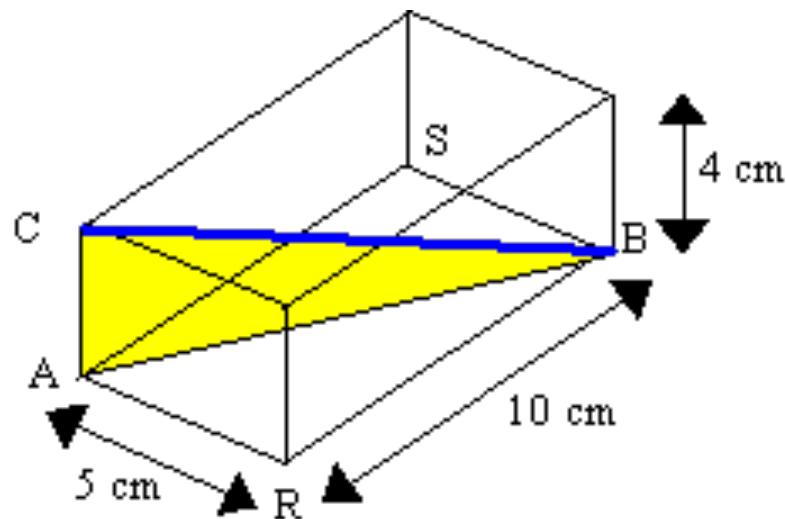
Application



Extrapolation



Problem



Heuristic knowledge

(Problem solving strategies)

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

CS-411 Goals

Reproduction

Conceptualisation

Application

Exploration

Mobilisation

Problem solving

- Describe the learning processes triggered by a technology-based activity
- Explain how a technology feature influences learning processes
- Elaborate a study that measures the learning effects of a digital environment
- Select appropriately a learning technology given the target audience and the expected learning outcomes
- Apply machine learning methods to educational traces
- *Design a learning environment based on orchestration graphs*

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")

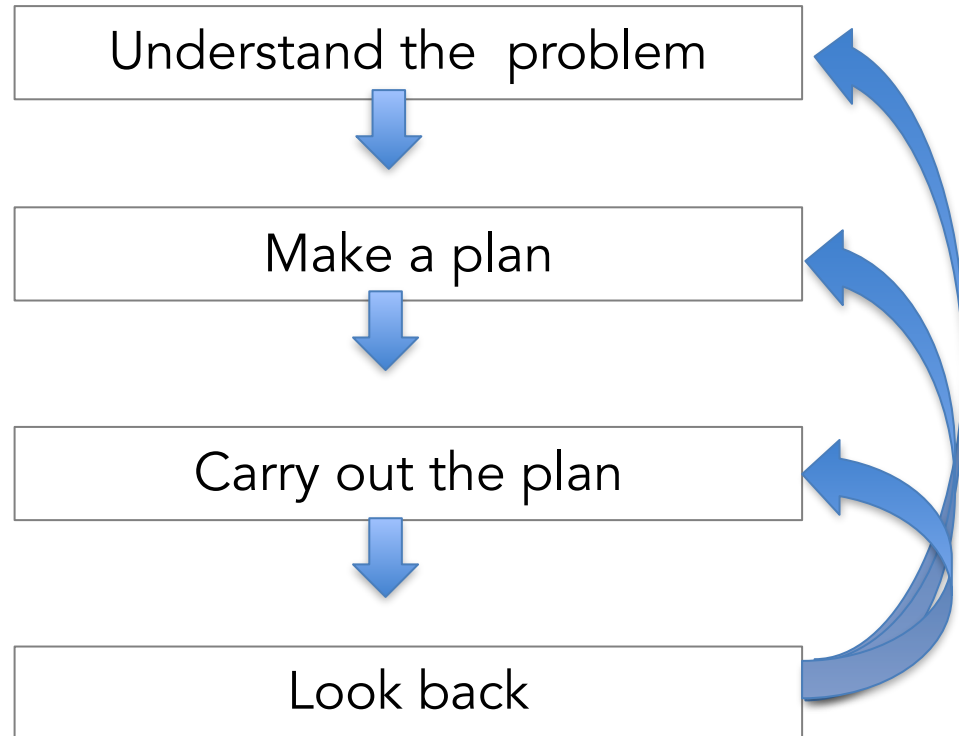
Transversal Skills

- Collaboration Skills
- Information appraisal skills
- Critical thinking skills
- Computational thinking skills
- Learning to learn
- Creativity
- Rigor
- ...
- Resilience
- ...
- ...

How to solve problems ?



George Polya



```
(defun m-length (list)
  (if (null list)
      0
      (+ 1 (m-length (cdr list)))))

(defun print-list (list)
  (if (not (null list))
      (progn
        (princ (car list))
        (print-list (cdr list)))))

(((1 5 x) o 1) a) 7 2 3)

(defun sum-numbers (list)
  (if
```



Transversal Skills

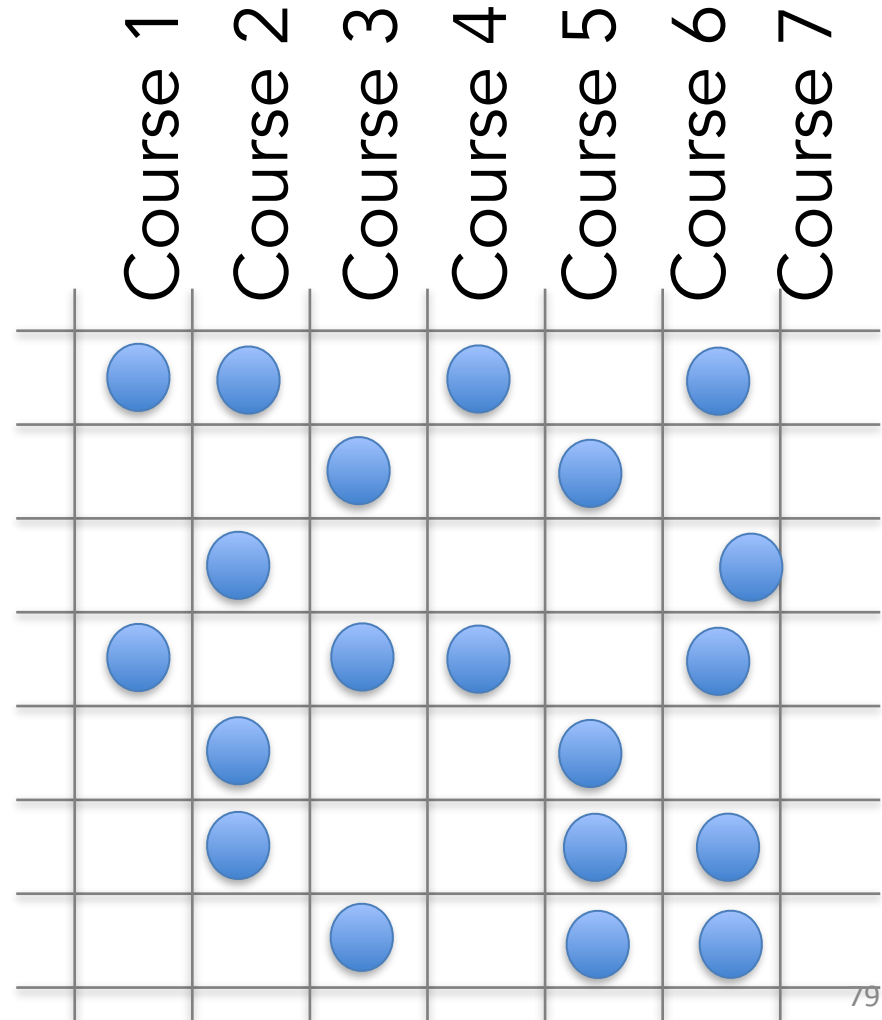
Are they domain-independent ? **Mostly, NOT**

Can they be taught ? **Mostly, NOT**

How can they be learned? **Transversally**

Transversal skills must be acquired transversally

- Collaboration Skills
- Information appraisal
- Critical thinking skills
- Computational thinking
- Learning to learn
- Creativity
- Rigor



Instructional design starts with :

~~What should learners know at the end ?
(which they did not know at the beginning)~~

What should learners be able to do at the end ?
(which they could not do at the beginning)

How will I know they are able to do it ?

What would be the exam questions or tasks ?

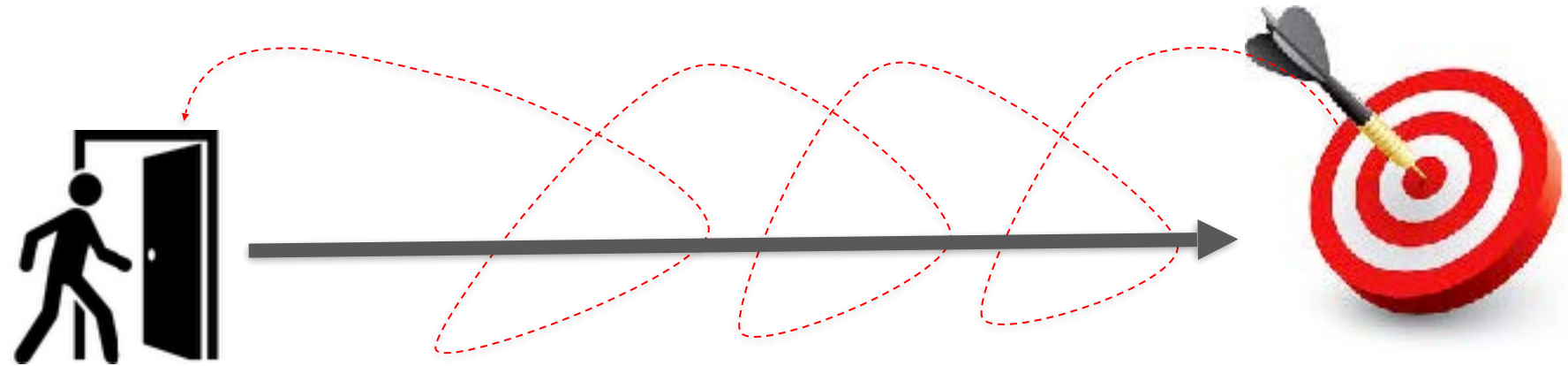
What should learners be able to do at the end ?

Pedagogical Objectives

Learning Goals

Learning Outcomes

Instructional design works backwards :



What are they able to do at the beginning

Pre-Requisites

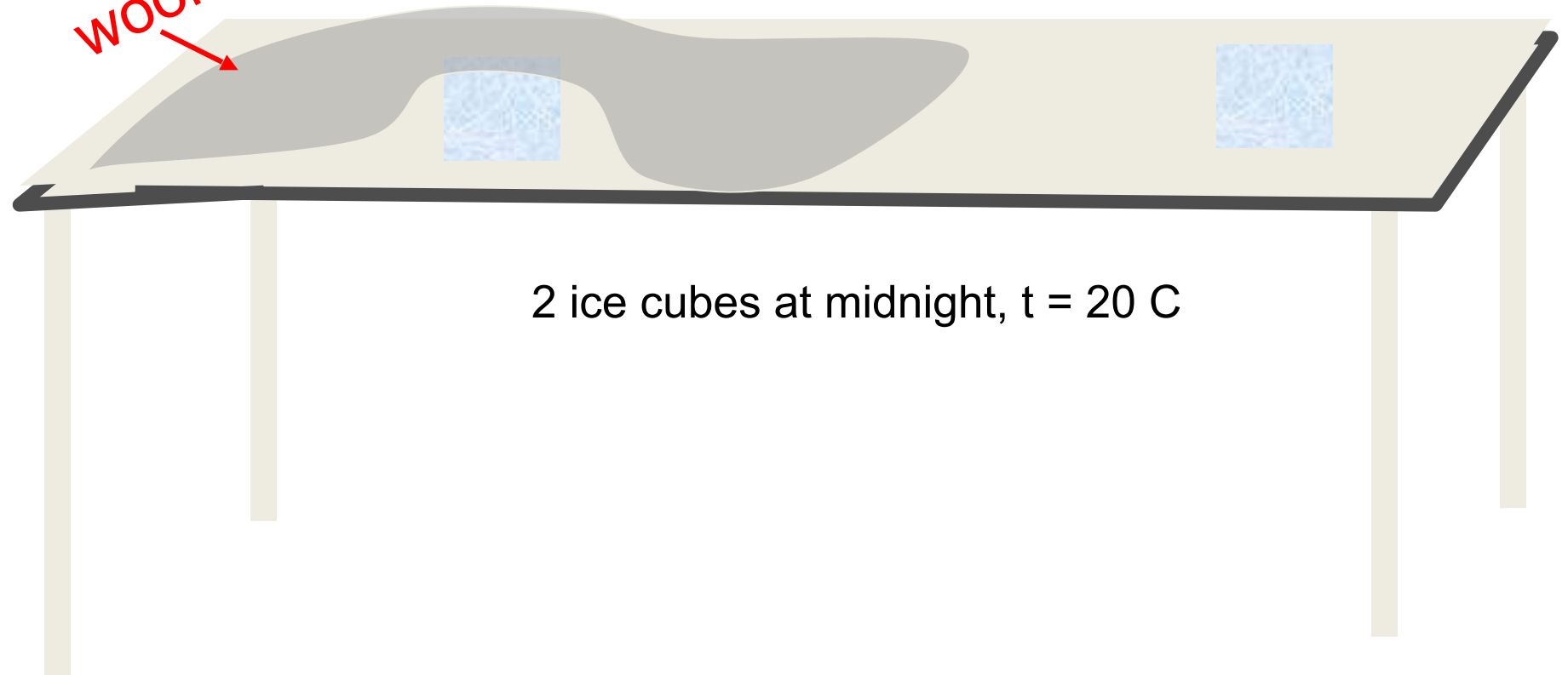
What should learners be able to do at the end ?

(which they could not do at the beginning)

Objectives

Prior Knowledge can be wrong

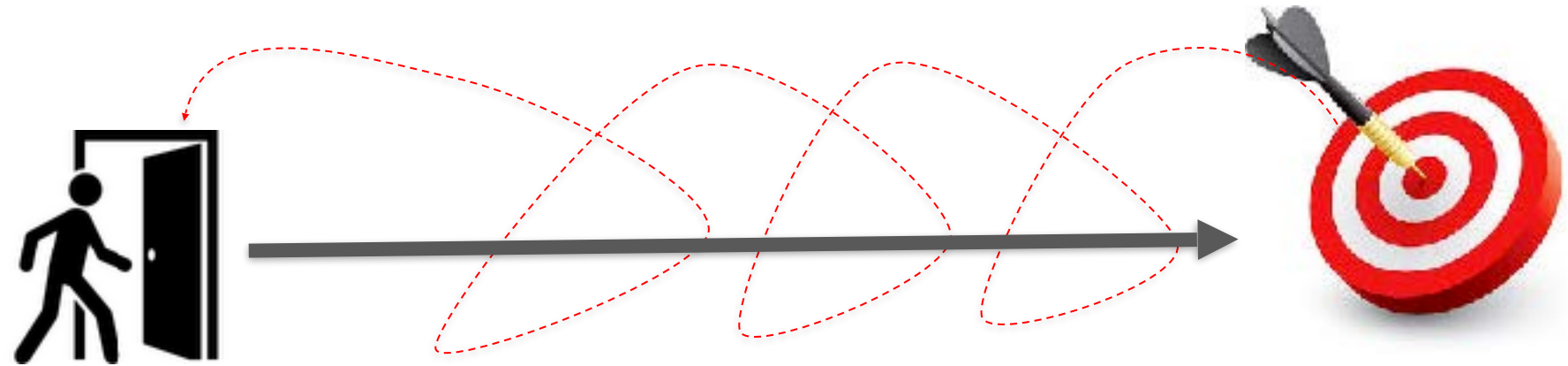
wool



2 ice cubes at midnight, $t = 20\text{ C}$

Which ice cube will melt faster ?

Instructional design works backwards :



What are they able to do at the beginning

Pre-Requisites

Pre-Representations

What should learners be able to do at the end ?

(which they could not do at the beginning)

Objectives