



Principles of learning and how they apply to training and teaching

ELIXIR-GOBLET Train-the-Trainer - Session 1

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22 April 2024



GOBLET

Global Organisation for Bioinformatics
Learning, Education & Training



1

DIVERSITY



3

FOSTER
TRUST AND
COLLABORATION



2

ACT ETHICALLY
AND WITH
INTEGRITY



4

RESPECT
AND SHOW
COURTESY TO
EACH OTHER



<https://elixir-europe.org/events/code-of-conduct>

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Learning outcomes

By the end of this session, learners will be able to:

- **List** the steps of good instructional design.
- **Define** cognitive load.
- **Distinguish** between bad and good cognitive load.
- **Clarify** why we start with learning outcomes.
- **Give examples of** effective learning strategies.
- **Connect** learning strategies to the cognitive processes they promote.
- **Select** appropriate learning outcomes within the learning constraints.
- **Assess** your teaching outlook/practices in relation to what you've learned.
- **Design** learning experiences that align with learning outcomes.

[Shared notes for Session 1](#)

Evidence-based learning principles

P1: Students' **differences** influence their world view, their learning, and their performance.

P2: **Prior knowledge** can help or hinder learning.

P3: The **organization of knowledge** influences how students learn and apply what they know.

P4: **Motivation** determines, directs, and sustains what students do to learn.

P5: To develop **mastery**, students must:

- acquire **component skills**
- practice **integrating** them
- know when to **apply** what they've learned

P6: **Goal-directed practice** with **targeted feedback** enhances the quality of learning.

P7: The **classroom environment** we create profoundly affects learning, positively or negatively.

P8: To become self-directed learners, students must learn to **monitor and adjust** their approaches.

What is learning?

permanence

permanence



1. you today



2. you tomorrow
(no pressure)





Challenge 1.1 (3 min + 3 to discuss)

How do you approach learning?

What approach do you find most effective for learning new things?

For example:

- read about it
- attend a training session
- try it out yourself
- a method to reflect, process or further understand
- something else?

Think about what works for you and **write** about it in the shared document.

Traditional approaches



Why should we learn about learning?

Intuitive ≠ effective

~~transmission (lecturing)~~

~~taking notes~~

~~summarizing~~

~~highlighting~~

~~rereading~~

?

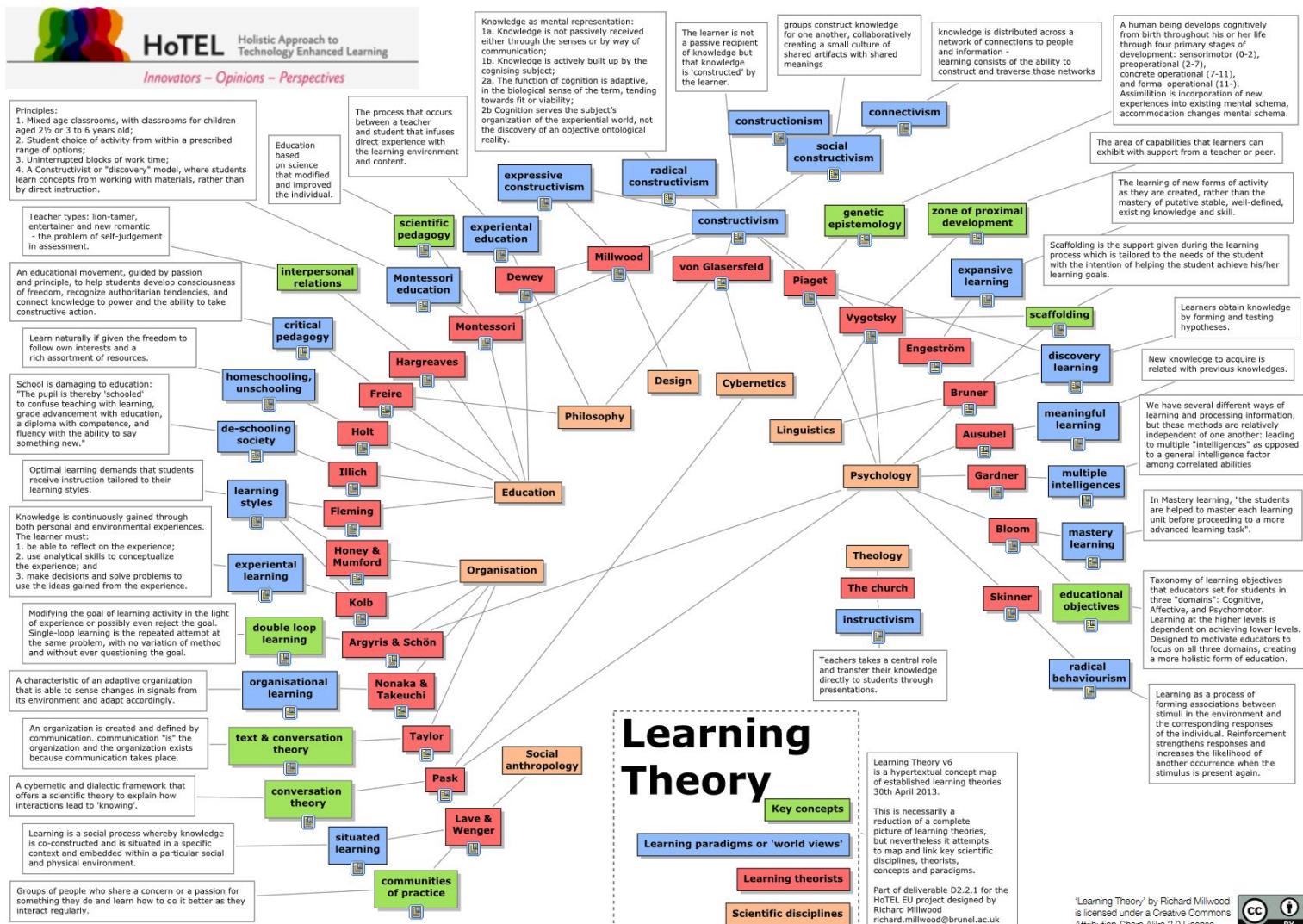
“The value of an education.. is not the learning of many facts but the training of the mind to think something that cannot be learned from textbooks.”

- Einstein (actually)

BREAK (10 min)



Landscape of available learning theories



LEARNING THEORIES SIMPLIFIED

...and how to apply them to teaching

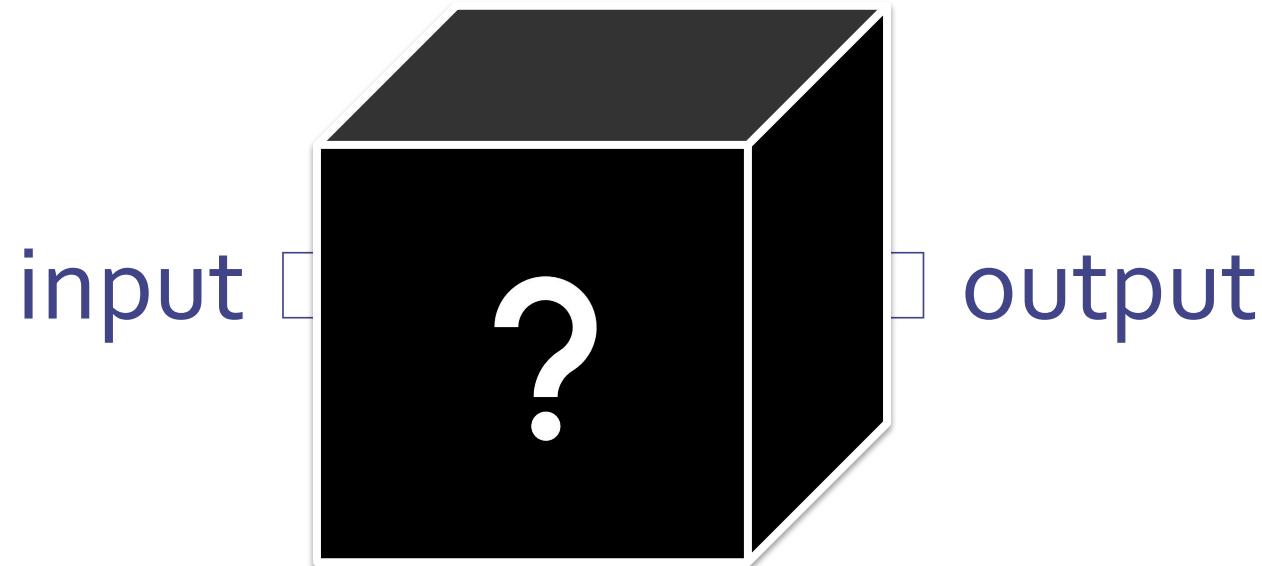


BOB BATES

S

behaviorism
constructivism
cognitivism

Behaviorism: overview



learning: a change in observable behavior

Classical conditioning

bell (neutral)



bell (neutral)
food salivation
bell + food salivation
bell salivation



Operant conditioning

Behaviorism: positive reinforcement

good stimuli increase behavior

Behaviorism: negative reinforcement

escaping or avoiding bad stimuli
increases behavior

Behaviorism: punishment

bad stimuli decrease behavior

Limitations of behaviorism

limited application

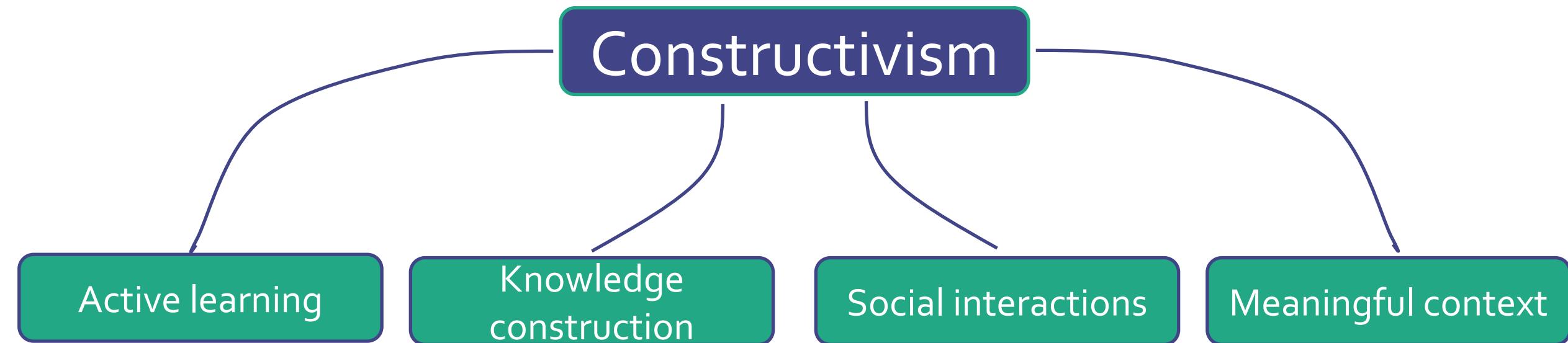
based on objective observation

no interest in “why”

hard to implement

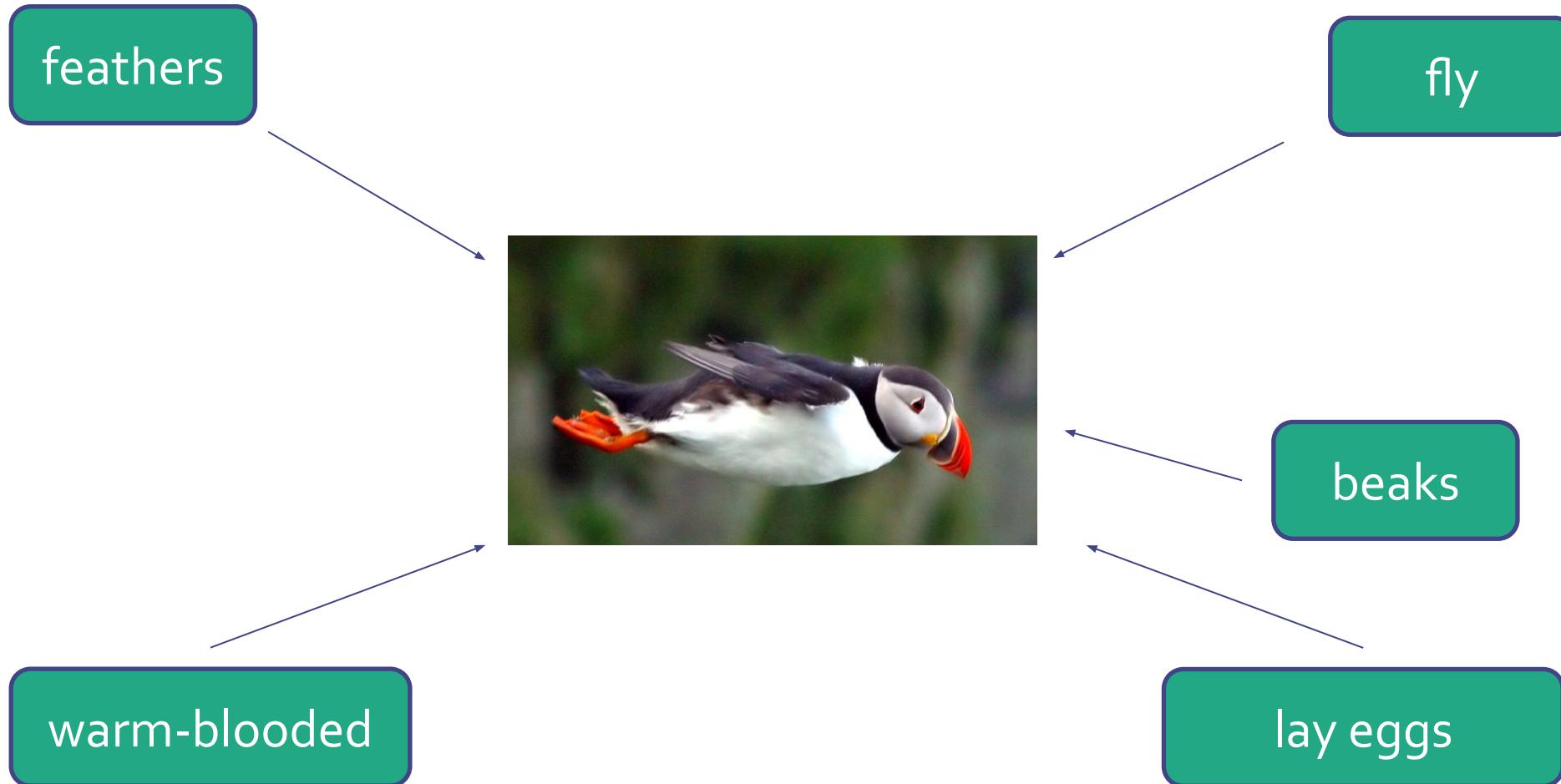
hard to maintain

Constructivism: overview



learning: making sense of experiences

Psychological constructivism



Psychological constructivism

feathers



fly

warm-blooded

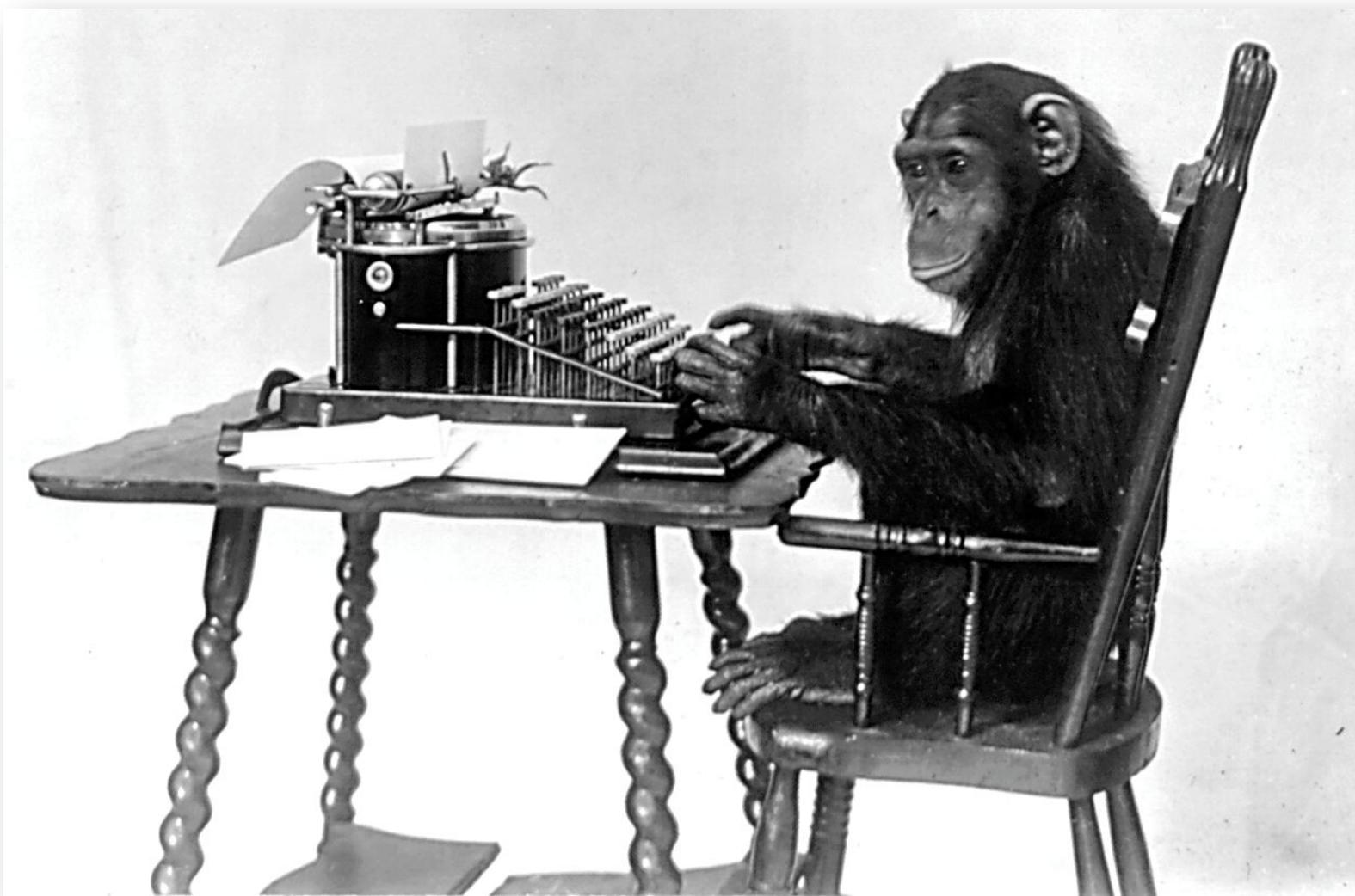
beaks

lay eggs

Social constructivism

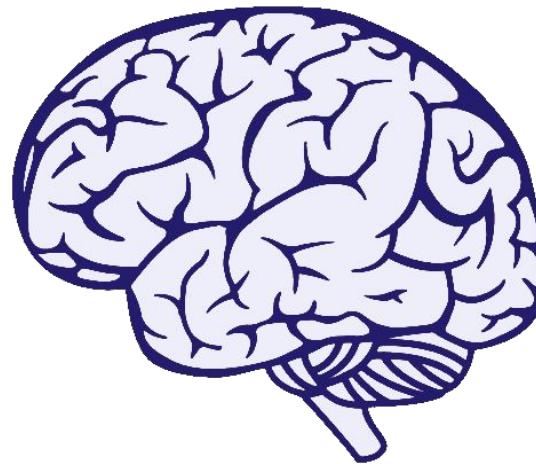


Limitations of constructivism



Cognitivism: overview

input



output

learning: a change in mental structures and schemas

Evidence-based learning principles

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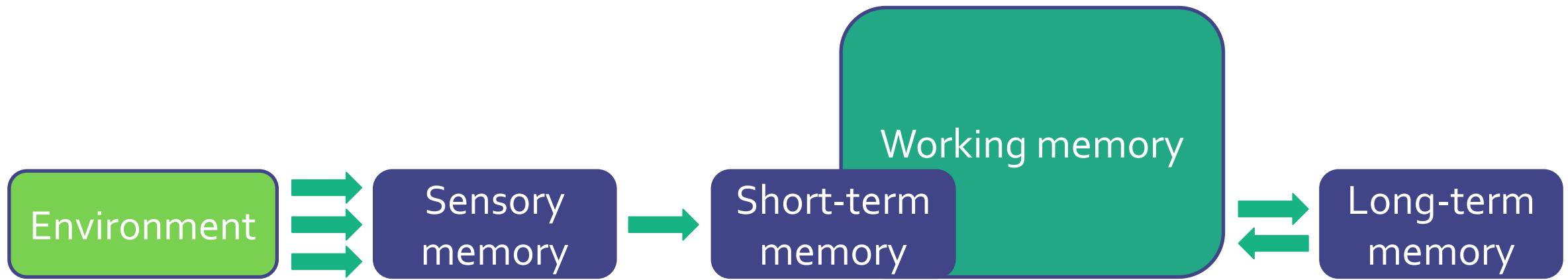
Metacognition

P8: To become self-directed learners, students must learn to **monitor and adjust** their approaches.

BREAK (10 min)



Types of memory



Short-term vs long-term memory





Challenge 1.2 (3 min + 3 to discuss)

Memory in daily life

Give an example from your day-to-day life where you use **working memory** and **long-term memory**.

Examples:

- working memory: keeping a phone number in your head while you dial it
- long-term memory: remembering your parents' phone number(s) without checking

Challenge 1.3

How short is short-term memory?

APH D BDNA CKG B DCIA

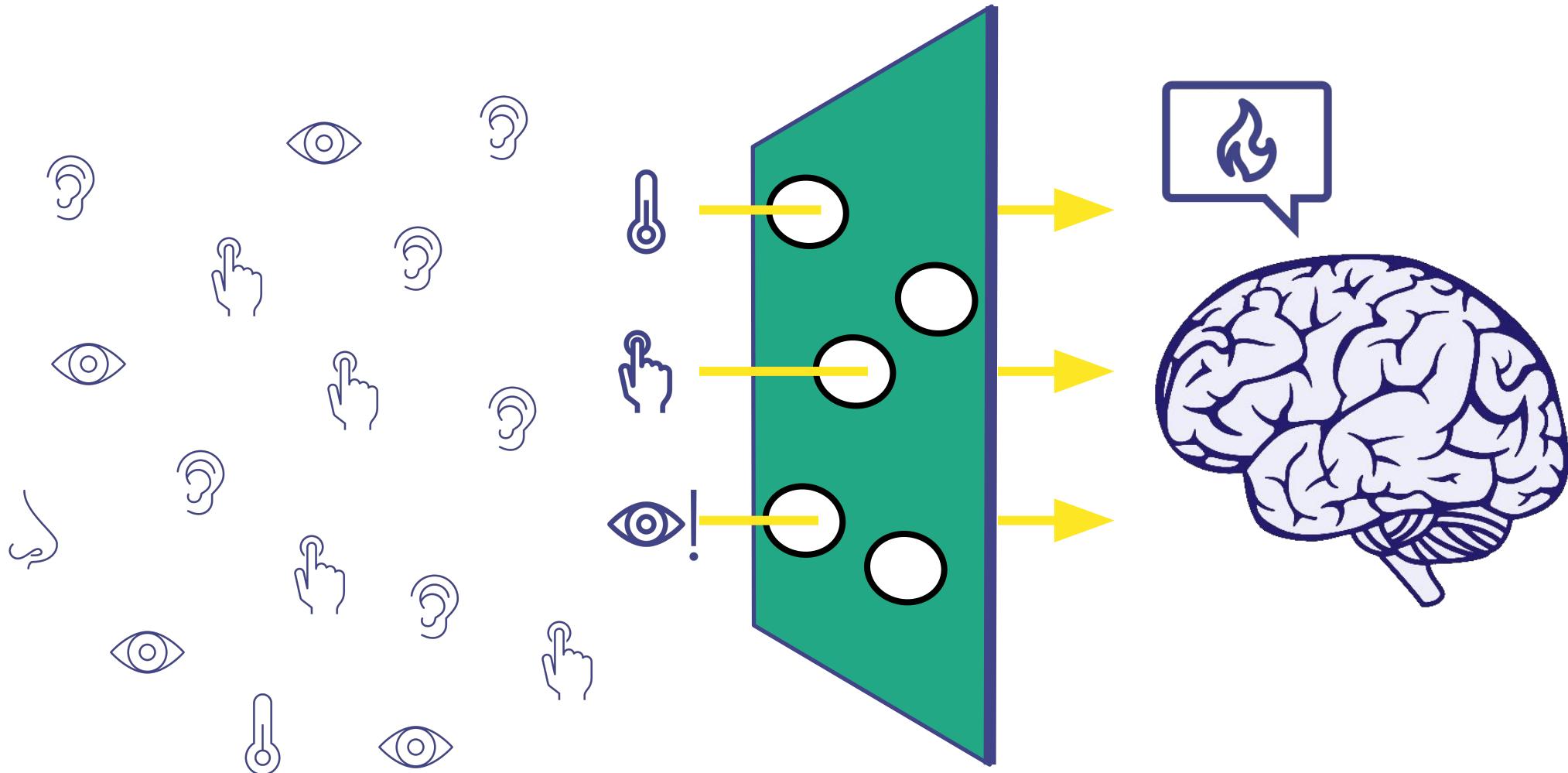


Challenge 1.3 (1 min)

How short is short-term memory?

Write them down :)

The attention filter for sensory input



C M L X D

H C θ 馳也 x

Perception



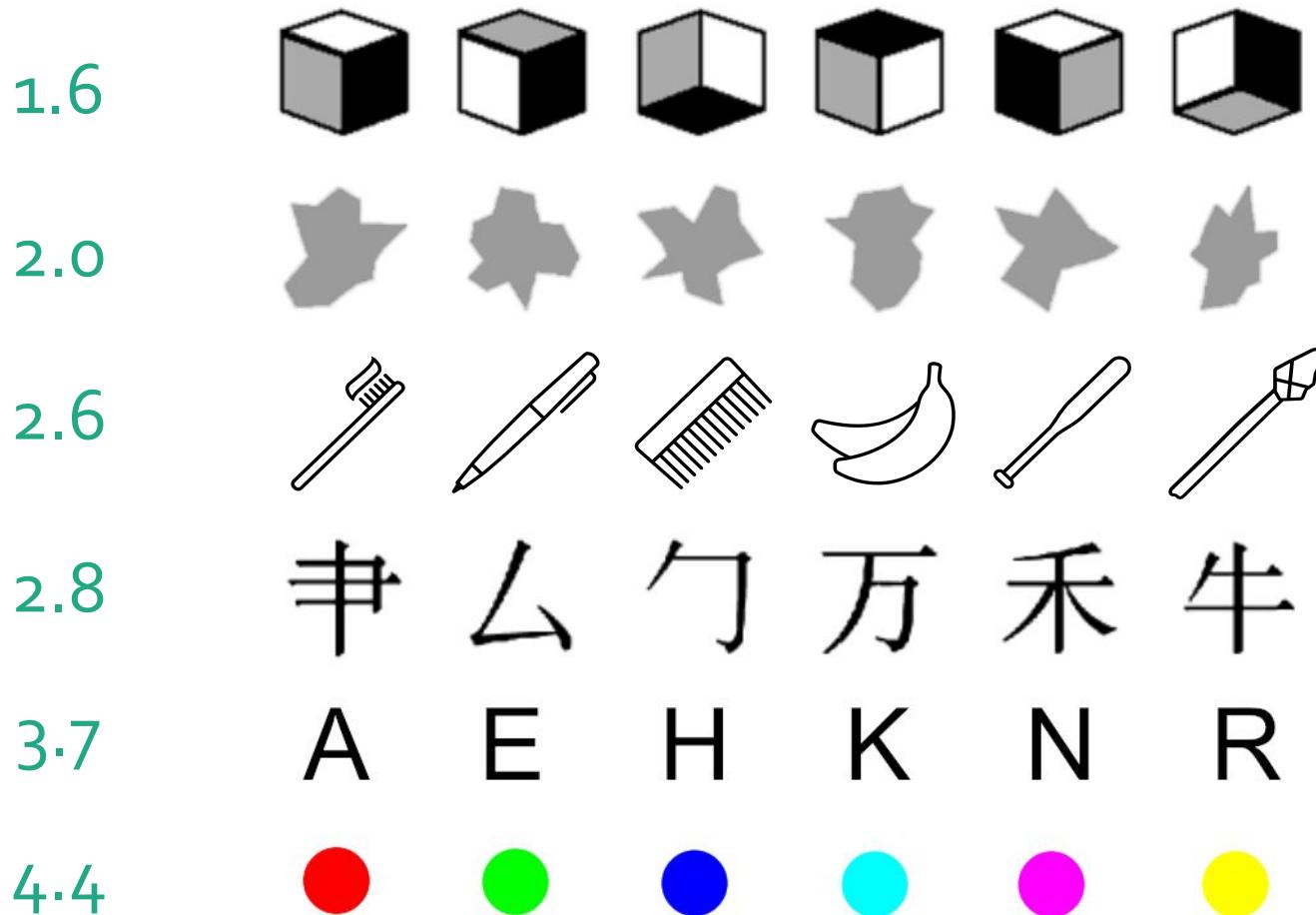
C M L X D

Knowledge organization

P₂: Prior knowledge can help or hinder learning.

P₃: The organization of knowledge influences how students learn and apply what they know.

How short is short-term memory?



BREAK (5 min)





Challenge 1.4 (5 min + 3 to discuss)

How can you avoid overloading working memory?

In groups, discuss something a teacher could do to avoid overloading their students' working memory.

Write your proposal in the shared notes.

Cognitive load

the total amount of mental effort
used in working memory

<https://www.mindtools.com/pages/article/cognitive-load-theory.htm>

Managing intrinsic load

segmentation

pretraining

advance organizers

other ideas?



Challenge 1.5 (1 min)

Short-term memory: revisited

A PHD B DNA C KGB D CIA

How many **letters** do you remember?

Chunking

4684026000

+46 8 402 6000

(this is the king's number)



Challenge 1.6 (5 min + 3 to discuss) **Extraneous cognitive load**

Think about the following learning environments:

- lectures
- group work
- classroom exercises

Discuss **examples of extraneous load** that might interfere with the experience and how you (the instructor) could **avoid** it. Add your thoughts to the shared document.

Extraneous load

coherence: exclude extra material

signaling: highlight essential material

spatial/temporal contiguity: integrated presentation

redundancy: avoid redundant text and other distractions

Temporal and spatial (dis)contiguity



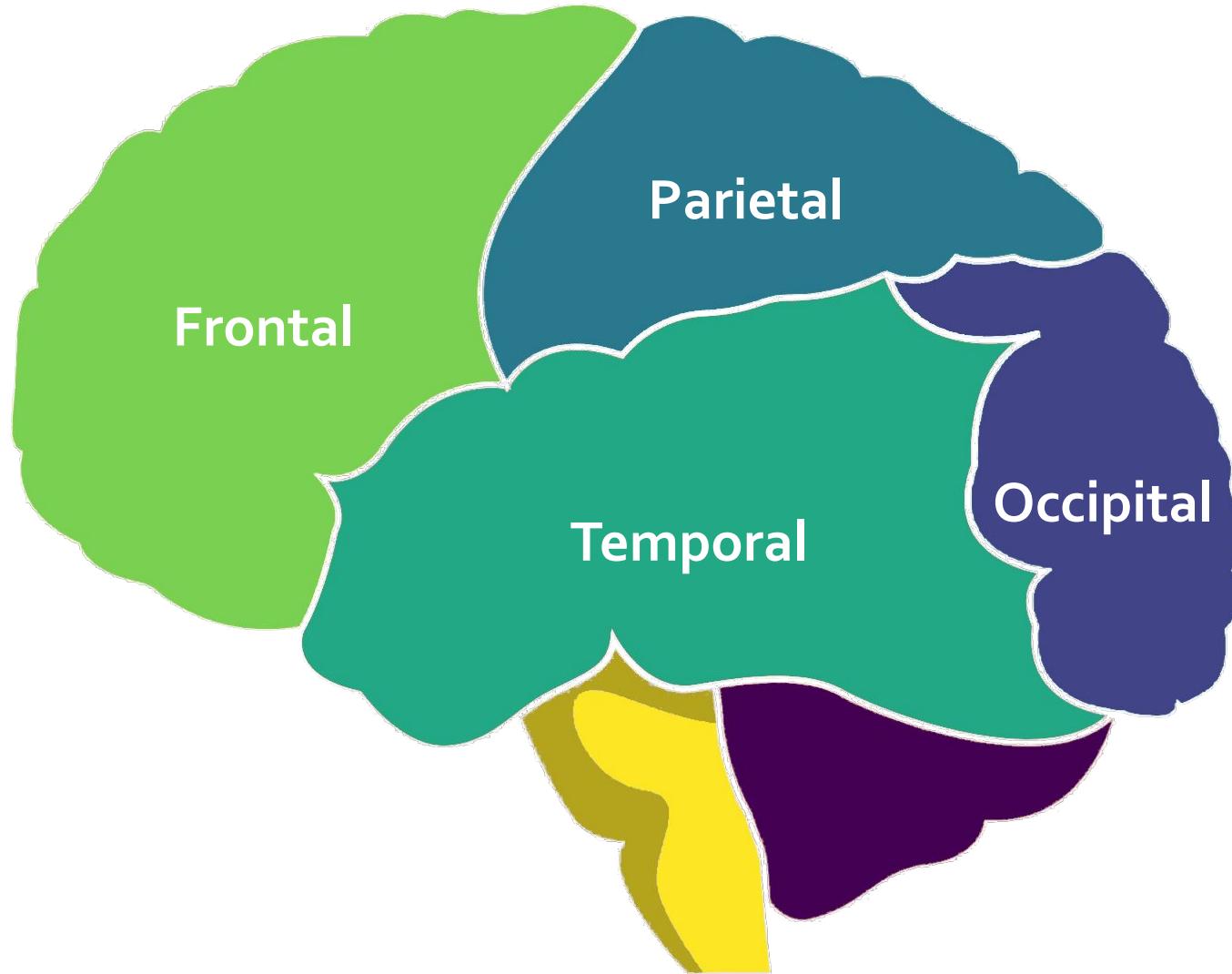
Occipital

Parietal

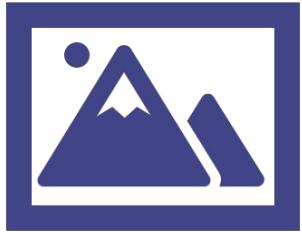
Temporal

Frontal

Split-attention



Redundancy

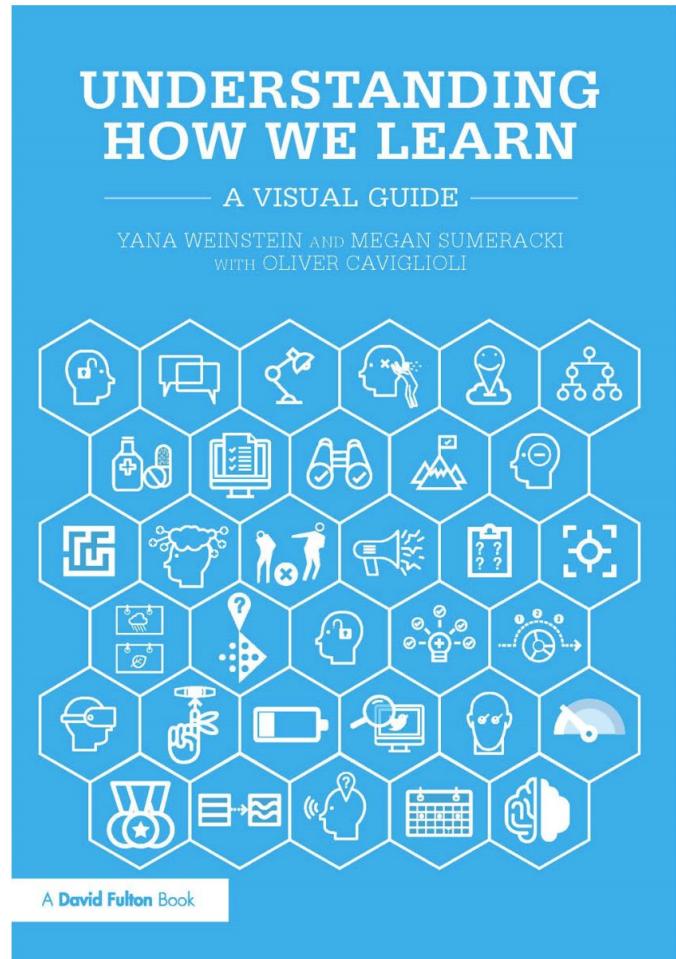


The **redundancy effect** describes when the same information is presented in multiple formats at the same time or too much text is available (when a summary or outline would work just as well). People learn better from narration alone (compared to narration and printed text). This is especially true when narration is accompanied by graphics, possibly because the picture and the text are processed by the same visual “channel”.

BREAK (5 min)

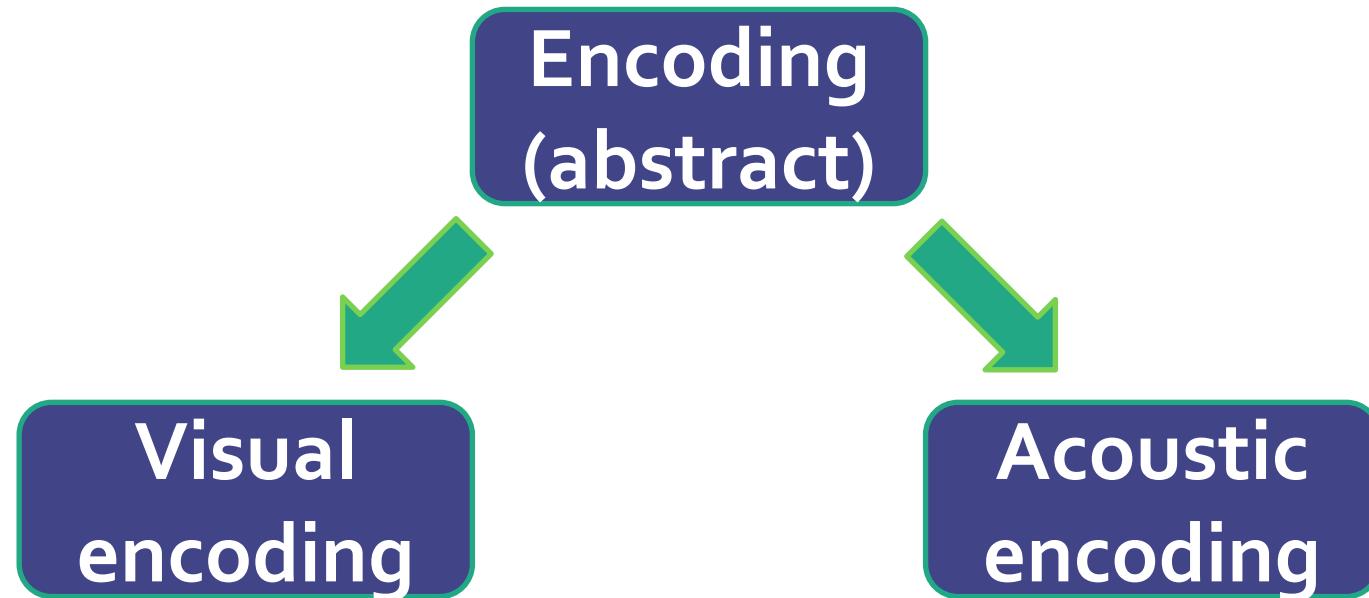


Germane load: 6 strategies

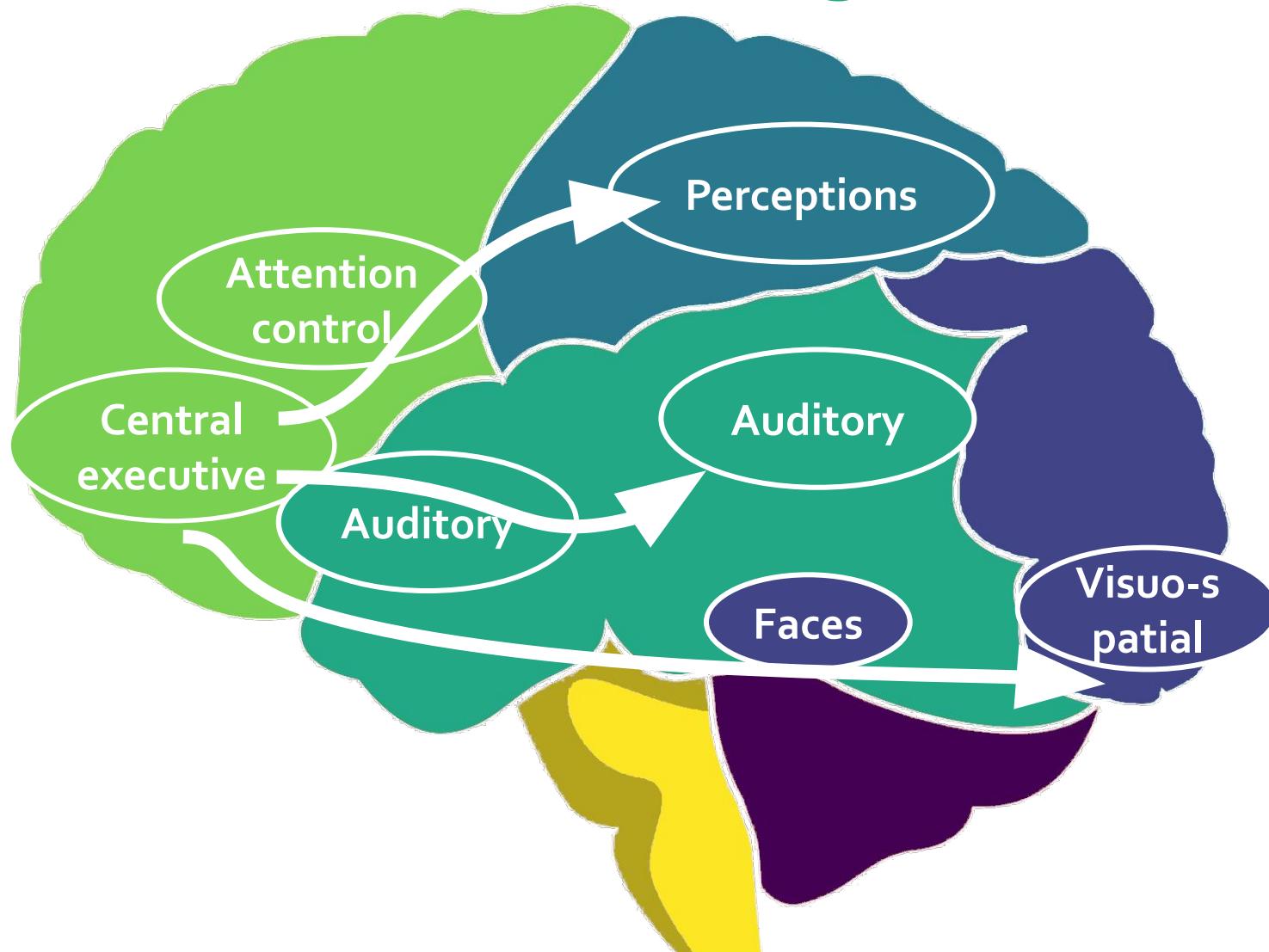


concrete examples
dual coding
interleaving
elaboration
spaced practice
retrieval practice

Concrete examples



Dual coding



Adapted from 2010 Baddeley

Blocked vs interleaved practice

Blocked practice

defining core concepts

highlighting common aspects

comparing highly dissimilar abstract categories

identifying similar items in diverse categories

listing similarities within one category

=

best for **novices**

Interleaving

practicing core concepts (motor behaviors)

relating concepts for problem-solving

distinguishing highly similar abstract categories

finely discriminating similar items

classifying

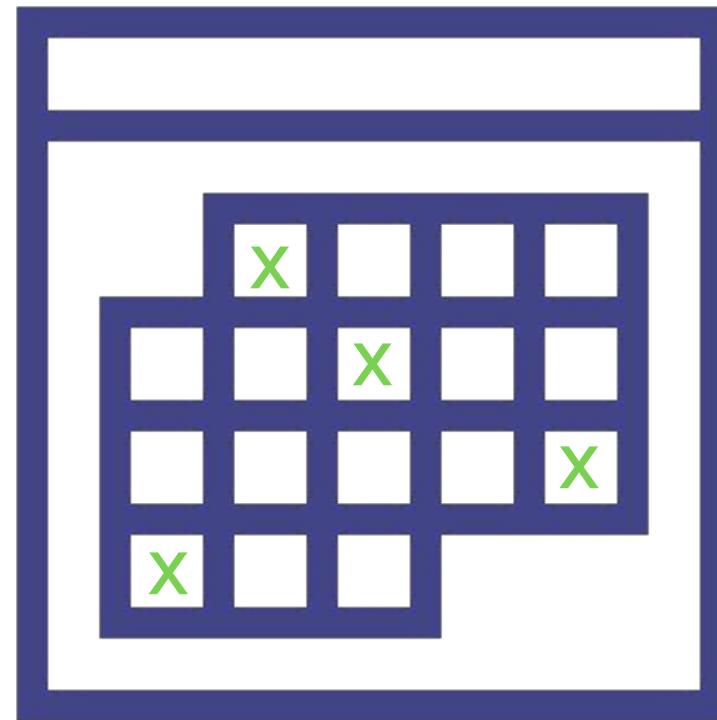
=

best for **experienced learners** and **experts**

Elaboration

Why?

Spaced practice



Retrieval practice

P5: To develop **mastery**, students must:

- acquire **component skills**
- practice **integrating** them
- know when to **apply** what they've learned

P8: To become self-directed learners, students must learn to **monitor and adjust** their approaches.



Challenge 1.7 (8 min + 3 to discuss)

How do you understand the 6 strategies?

concrete examples | dual coding | interleaving | elaboration | spaced practice | retrieval practice

Work in groups of 2 to discuss a learning strategy.

Did you understand it the same way? Do you have questions?

Provide examples of how you could implement it as an instructor.

BREAK (5 min)



But why mental models?

understanding

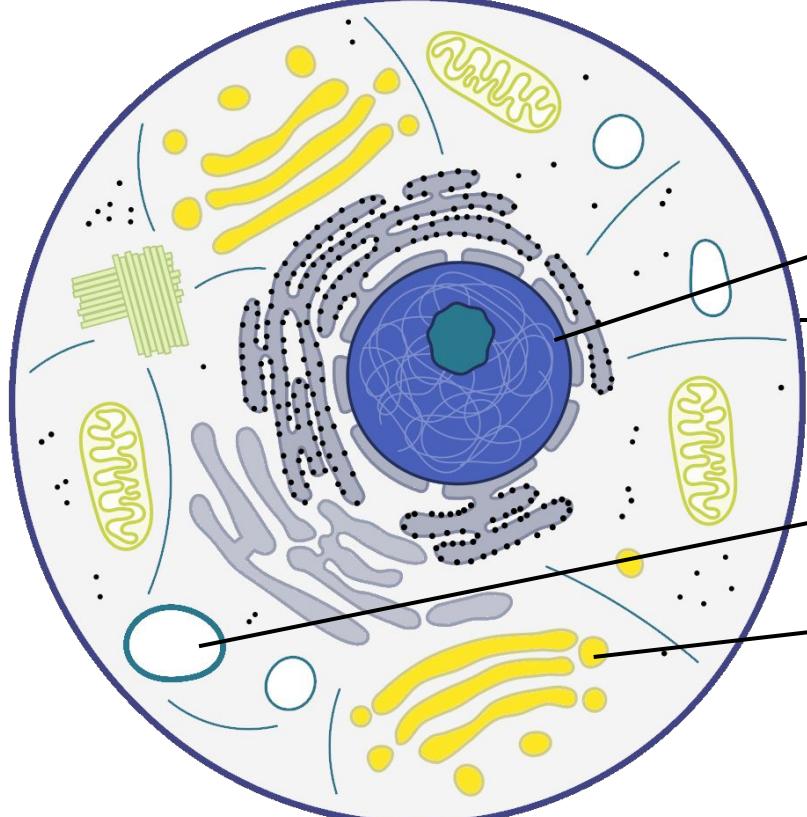
problem-solving

decision-making

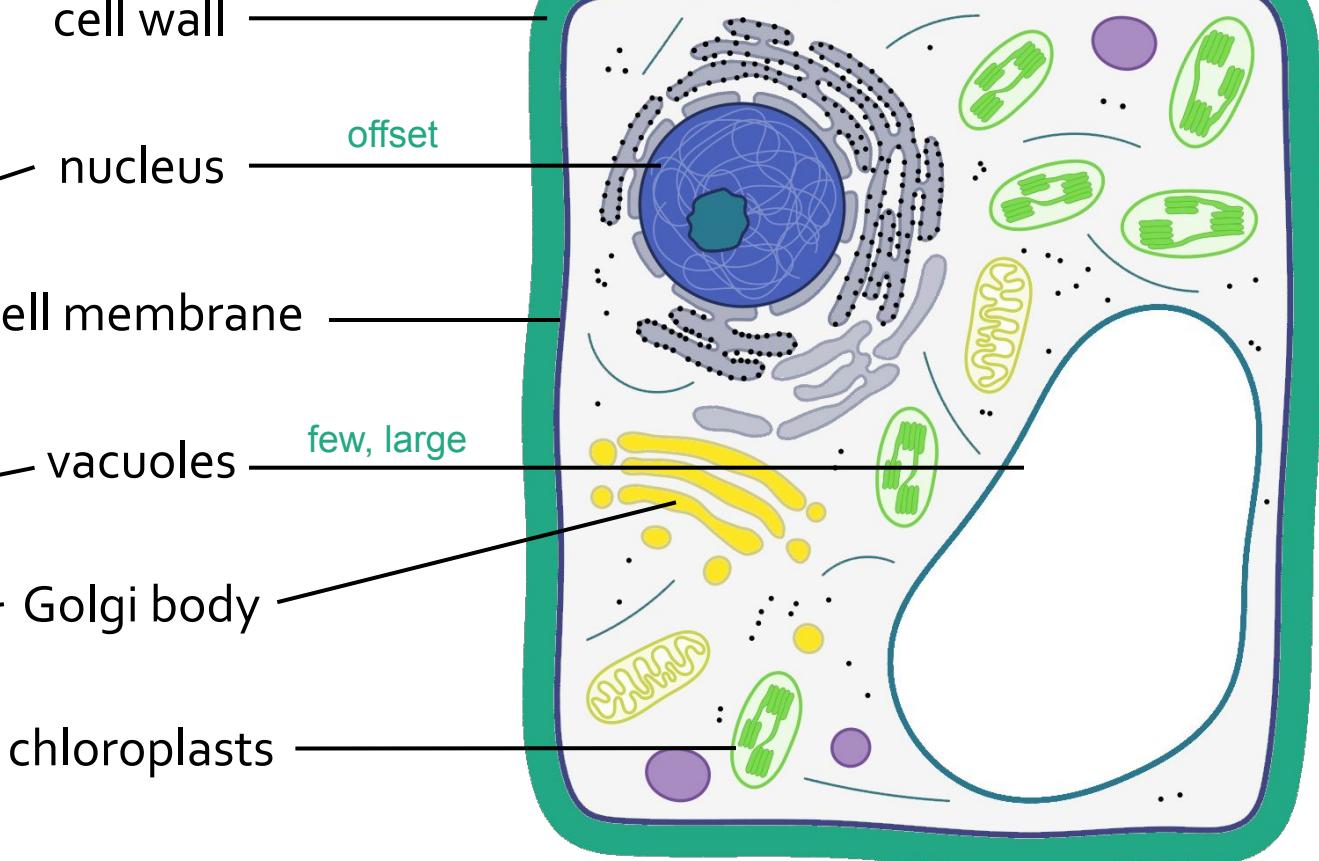
learning

communication

Knowledge representation: schemas



animal



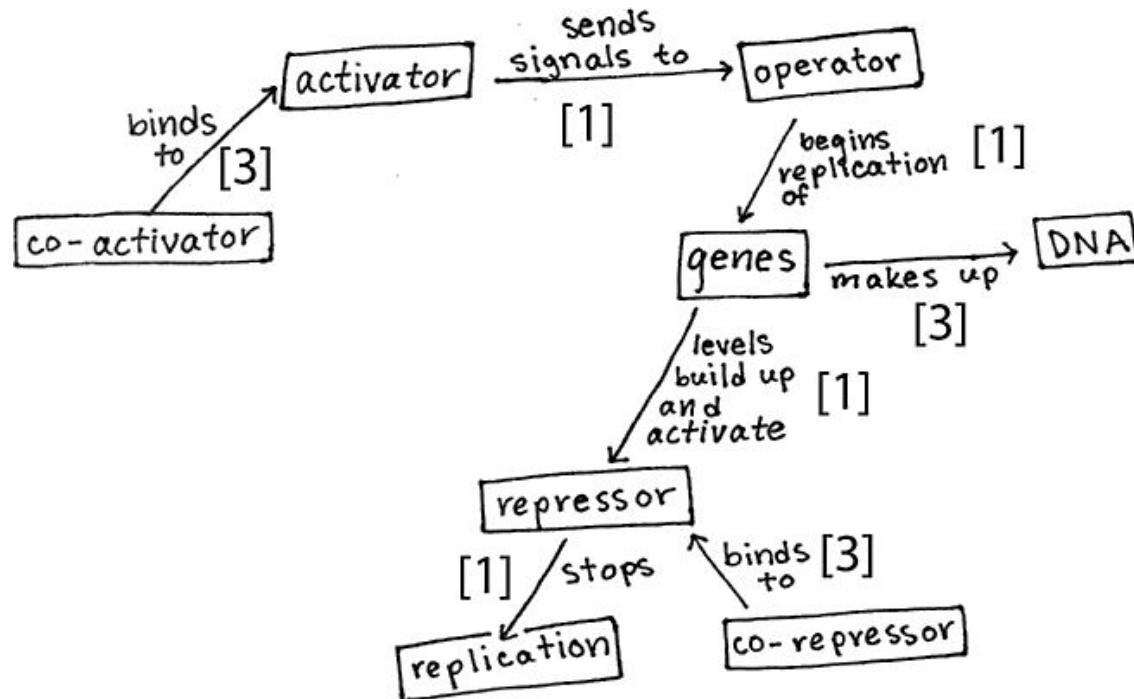
plant

cell wall
central nucleus
cell membrane
many, small vacuoles
Golgi body
chloroplasts

offset

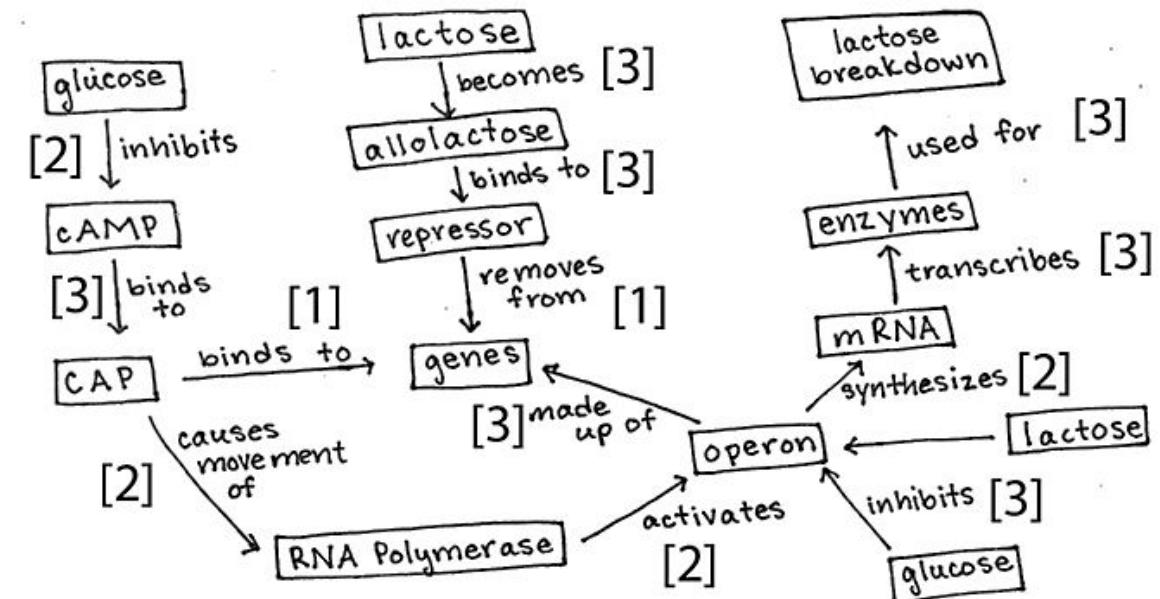
few, large

Concept mapping of a mental model



before lesson

average correctness = 1.9



after lesson

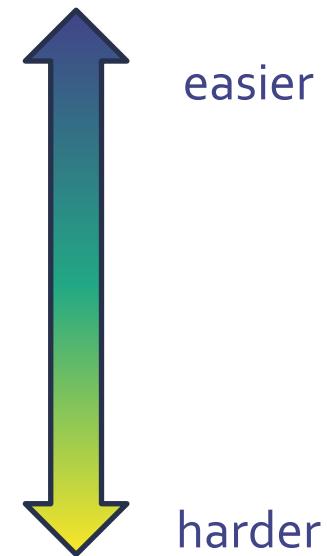
average correctness = 2.4

Broken mental models: misconceptions

simple factual errors

broken models

fundamental beliefs



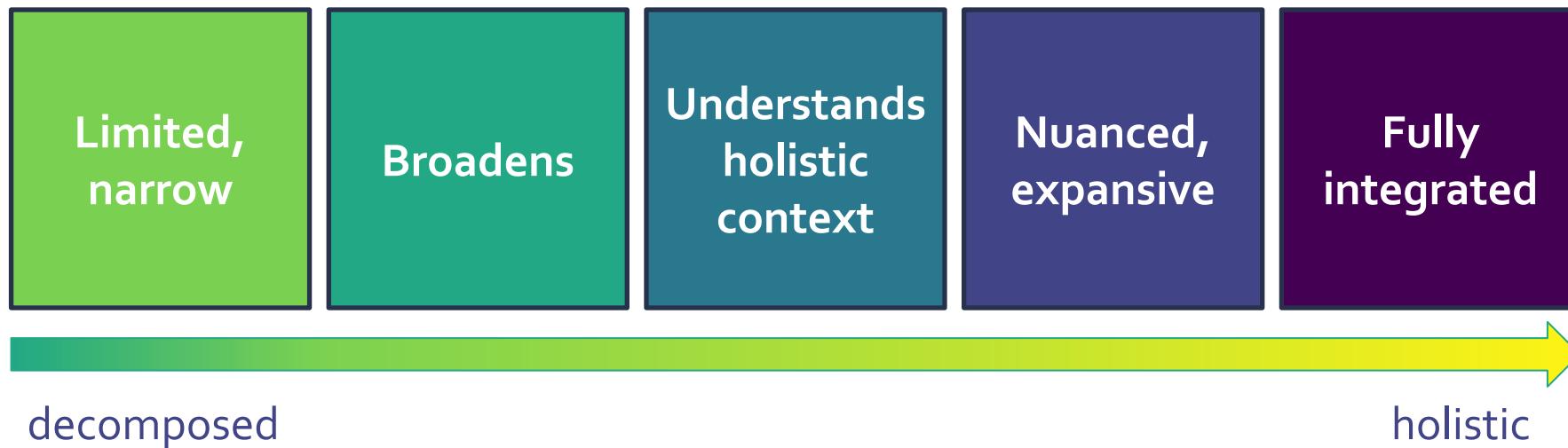
Dreyfus model of skills acquisition



Progression: components



Progression: perspective



Progression: decision



Progression: commitment



Integrating the Dreyfus model

Principles of knowledge

Learning theories

Memory, attention, and cognitive load

Strategies for effective learning

Instructional design

Nicholl's 5-step model

Knowledge, skills, abilities

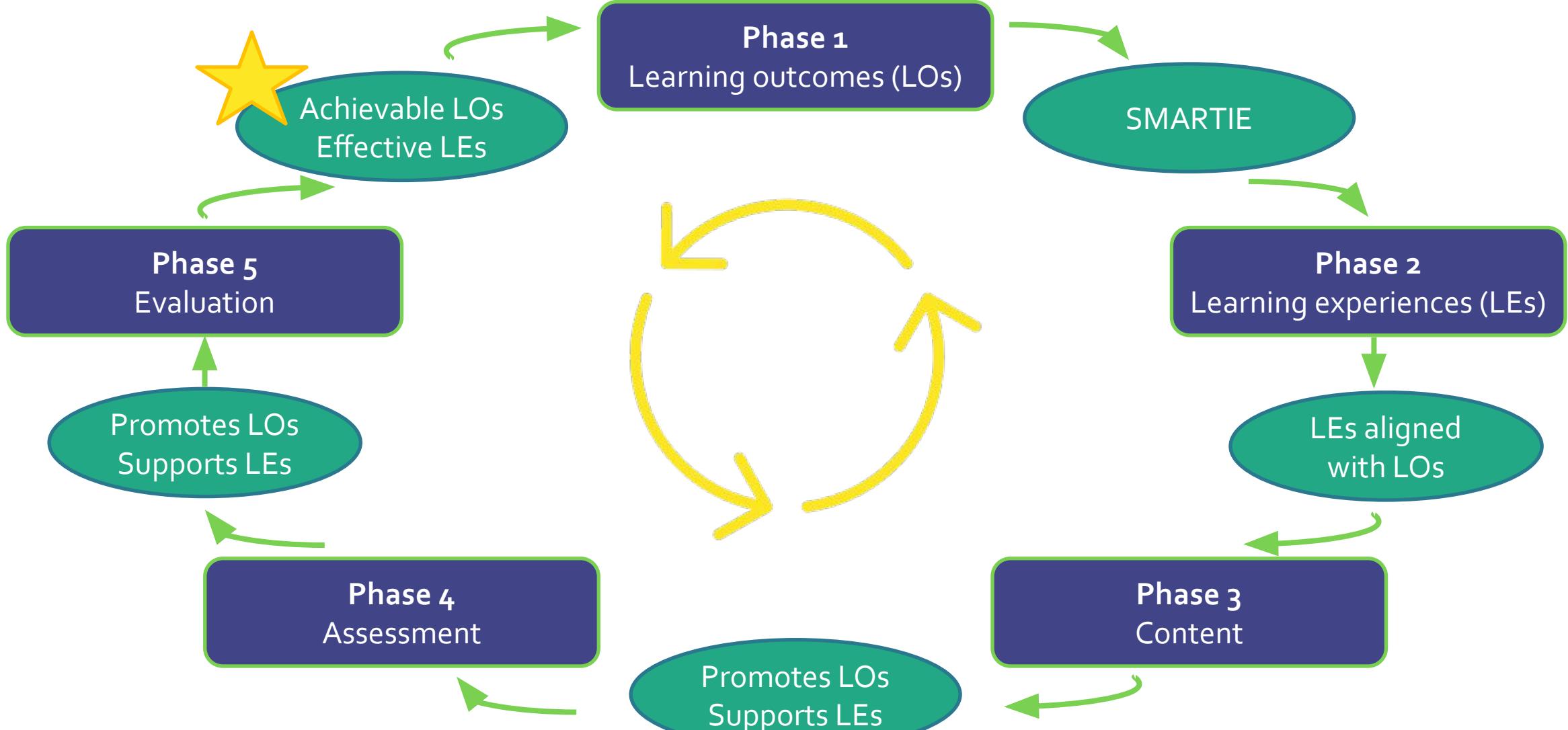
Learning outcomes and assessable verbs

Bloom's taxonomy

BREAK (5 min)



Nicholl's 5-steps



Phase 1

1. Define the learning outcomes (LOs)

Specificity of objectives

| | Teaching goals | KSAs | Learning outcomes |
|----------------|----------------------|---------------------------|------------------------|
| Scope | broad | moderate | narrow |
| Time needed | year(s) | weeks/months | hours/days |
| Purpose | provide vision | design curriculum | prepare lesson plans |
| Example of use | plan a learning path | plan units of instruction | plan daily experiences |

Knowledge, Skills, Abilities (KSAs)

Identify the set of KSAs

Example:

- knowledge of learning principles
- skills to adapt your curriculum based on what you've learned
- ability to evaluate prior knowledge in your students

Operational definitions of LOs

- : statements expressing the KSAs that can be **demonstrated** upon LE completion
- : what learners will learn and the instructor can **assess**

<https://irds.stanford.edu/assessment/assessment-overview/assessment-tools>

Writing SMARTIE learning outcomes

Specific
Measurable
Achievable
Relevant
Time-limited
Inclusive
Equitable

Writing LOs with assessable verbs

Avoid verbs that are:

unassessable

unmeasurable

open to interpretation

Challenge 1.8 (3 min + 3 to discuss)

Identify assessable and nonassessable actions

In the shared document, write which of the following verbs describe **observable actions** and which are **open to interpretation**.

To classify verbs, focus on how you would assess the action.

Example: "identify

Q: How would I assess whether a learner is able to identify something?

A: Ask them to do this challenge.

**compare | classify | distinguish | explain | believe | give examples of | define | learn |
describe | list | recognize | know | connect | measure | identify | have faith in**

Frameworks and taxonomies

framework: distinct categories

taxonomy: continuum of categories

Bloom's taxonomy: cognitive complexity



Taxonomy of verbs

| | |
|------------|--|
| Create | assemble, build, collect, combine, compile, compose, constitute, construct, design, develop, devise, formulate, generate, hypothesize, integrate, invent, make, manage, modify, organize, perform , plan, prepare, produce, propose, rearrange, reconstruct, reorganize, revise, rewrite, synthesize, write |
| Evaluate | advise, appraise, argue, assess, compare, conclude , consider, contrast, convince, correct, criticize, critique, decide, defend , determine, discriminate, grade, judge, justify, measure, rank, rate, recommend, review, score, select, standardize, support, test, validate |
| Analyze | arrange , break down, categorize, classify, compare, conclude , connect, contrast , deconstruct, deduce, detect, diagnose, diagram, differentiate, discriminate, distinguish , divide, examine, explain , identify, integrate, inventory, list , order, organize , relate, separate, structure |
| Apply | calculate, carry out, change, choose, classify, complete, compute, construct, demonstrate, dramatize, employ, examine, execute, experiment, generalize, illustrate, implement, infer, interpret, manipulate, modify, operate, organize, outline, perform , predict, solve, transfer, translate, use, verify |
| Understand | arrange , associate, categorize , clarify, classify, compare, conclude, contrast, defend , diagram, differentiate, discuss, distinguish , estimate, exemplify, explain , express, extend, extrapolate, generalize, give examples of, illustrate, infer, interpret, match, outline, paraphrase, predict, rephrase, represent, restate , summarize, transform, translate |
| Remember | cite, define, describe, identify, inventory , label, list , match, name, outline, quote, recall, recognize, report, reproduce, restate , retrieve, show, state, tell |

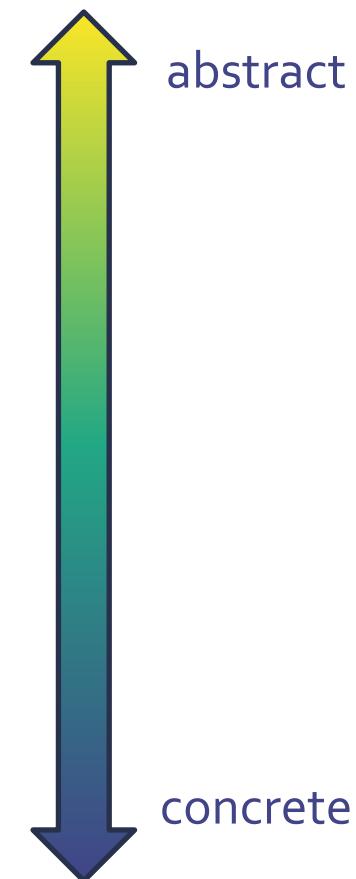
Expanded taxonomy: knowledge dimension

metacognition

procedures

concepts

facts



A taxonomy table

| | | | | | | |
|---------------|----------|------------|-------|---------|----------|--------|
| Metacognitive | | | | | | |
| Procedural | | | | | | |
| Conceptual | | | | | | |
| Factual | | | | | | |
| | Remember | Understand | Apply | Analyze | Evaluate | Create |

A taxonomy table

| | | | | | | |
|---------------|----------|------------|-------|---------|----------|--------|
| Metacognitive | | | | | | |
| Procedural | | | | | | |
| Conceptual | | | | | | |
| Factual | 1 | | | | | |
| | Remember | Understand | Apply | Analyze | Evaluate | Create |

1. List the steps of good instructional design

A taxonomy table

| | | | | | | |
|---------------|----------|------------|-------|---------|----------|--------|
| Metacognitive | | | | | | |
| Procedural | | | | | | |
| Conceptual | | 2 | | | | |
| Factual | 1 | | | | | |
| | Remember | Understand | Apply | Analyze | Evaluate | Create |

1. List the steps of good instructional design.
2. Distinguish between good and bad cognitive load.

A taxonomy table

| | | | | | | |
|---------------|----------|------------|-------|---------|----------|--------|
| Metacognitive | | | | | | |
| Procedural | | | | 3 | | |
| Conceptual | | 2 | | 3 | | |
| Factual | 1 | | | | | |
| | Remember | Understand | Apply | Analyze | Evaluate | Create |

1. List the steps of good instructional design.
2. Distinguish between good and bad cognitive load.
3. Connect learning strategies to the cognitive processes they promote.

A taxonomy table

| | | | | | | |
|---------------|----------|------------|-------|---------|----------|--------|
| Metacognitive | | | | | 4 | |
| Procedural | | | | 3 | | |
| Conceptual | | 2 | | 3 | | |
| Factual | 1 | | | | | |
| | Remember | Understand | Apply | Analyze | Evaluate | Create |

1. List the steps of good instructional design.
2. Distinguish between good and bad cognitive load.
3. Connect learning strategies to the cognitive processes they promote.
4. Assess your teaching outlook in relation to what you've learned.

Implications for classroom teaching

learning

instruction

assessment

alignment

Learning experiences

lecture: remember, understand

exercise: apply, analyze

group discussion: analyze, evaluate

?

Challenge 1.9 (3 min + 3 to discuss)

Identify LEs and assessments aligned with LOs

Pick one learning outcome and identify a learning experience and an assessment aligned with that LO. Write them in the shared document.

By the end of this course, you should be able to:

list the planets of the solar system

explain the difference between a nut and a berry

develop a short programming script (in x language)

Questions and feedback

Homework Reflection

How do you understand the 6 strategies for effective learning?

How do you understand the 8 principles of learning?

Reflect over night :)

Choose a topic to demonstrate your training in 3 minutes; you'll prepare tomorrow.

Examples:

how to make an origami bird

intro to biochemistry

how bats recognize obstacles

the second law of Newton

how to draw a comic strip

Resources

Bob Bates. Learning theories simplified... and how to apply them to teaching. 3rd ed (2023).

James M. Lang. Small teaching: everyday lessons from the science of learning. 2nd ed (2021).

Marsha C Lovett, Michael W Bridges, Michele DiPietro, Susan A Ambrose, Marie K Norman. How learning works: 8 research-based principles for smart teaching. 2nd ed (2023).

[PDF overview of How learning works](#)

The carpentries: instructor training. <https://carpentries.github.io/instructor-training/>

Yana Weinstein, Megan Sumeracki, Oliver Caviglioli. Understanding how we learn: a visual guide. 1st ed (2018).

See you at Session 2!

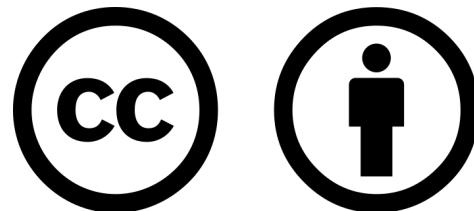
Kindly fill out minute cards (before you go)

Thank you!

 elixir.no

 @elixirnorway

 support@elixir.no



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