

Chapter 4:

Mastery learning and Instructional Design

How do people learn ?

 by exploration, trial and error

 **by incremental mastery**

- by verbal elaboration

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

Reproduction

Conceptualisation

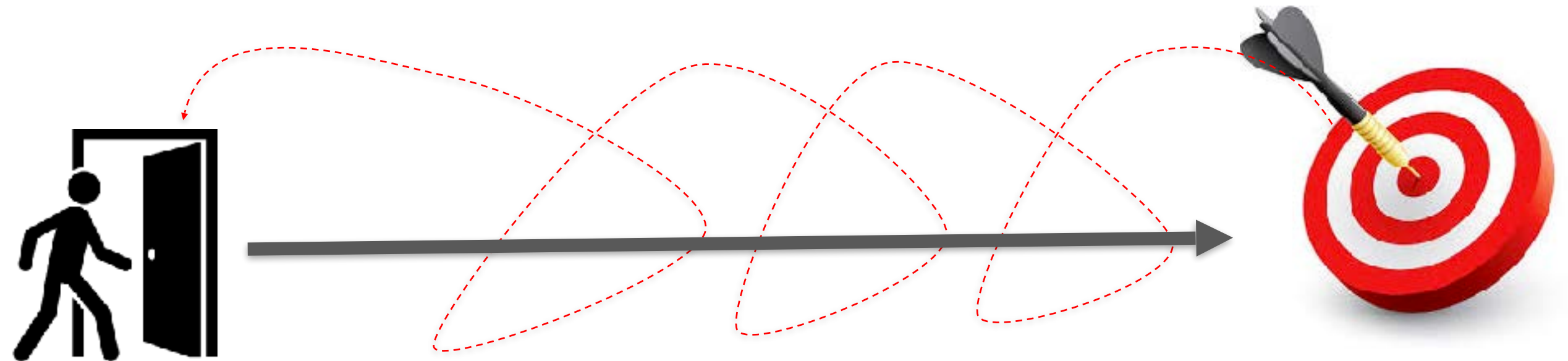
Application

Exploration

Mobilisation

Problem solving

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

Skill1 is pre-requisite to Skill2
if $p(\text{Skill2} \mid \sim \text{Skill1}) \ll p(\text{Skill2} \mid \text{Skill1})$

Skill1 : « 6 + 9 »

Skill2: « 26 + 39 »

Skill1: to find the verb

Skill2: to agree it with the subject

Skill1 : angle

Skill2: square

Skill1 : mean

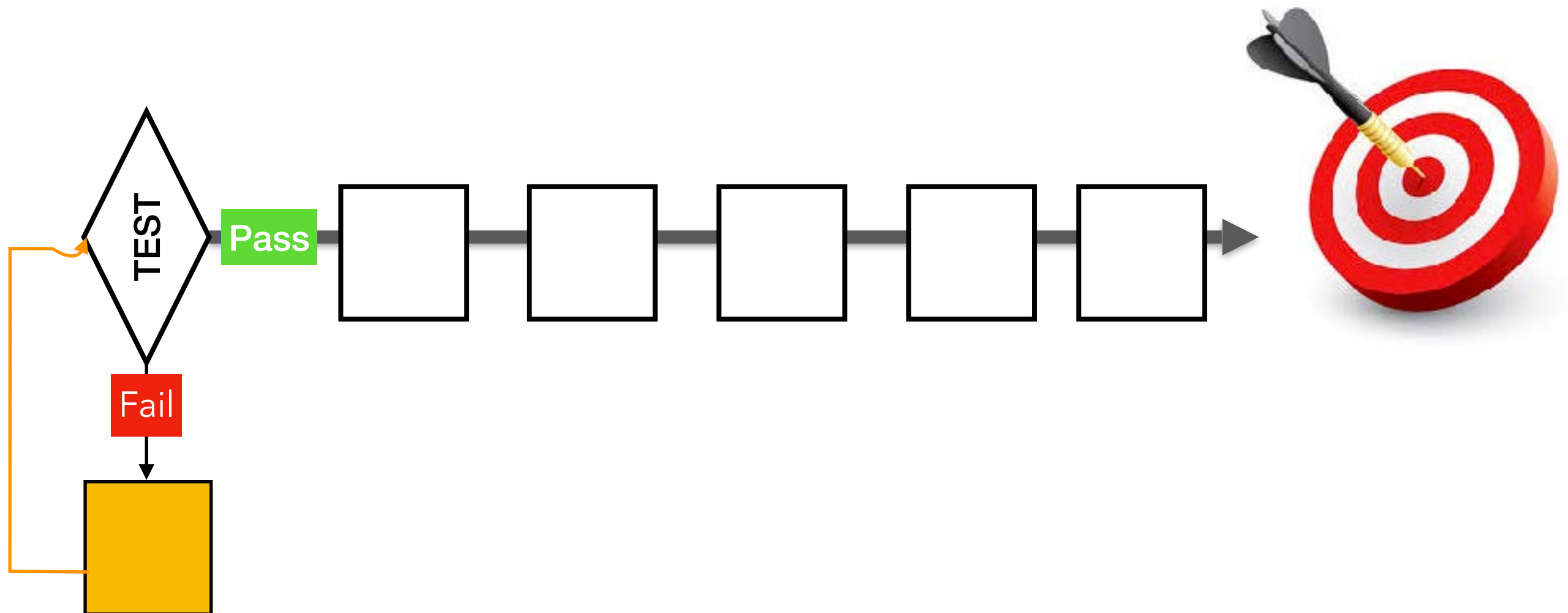
Skill2: standard deviation

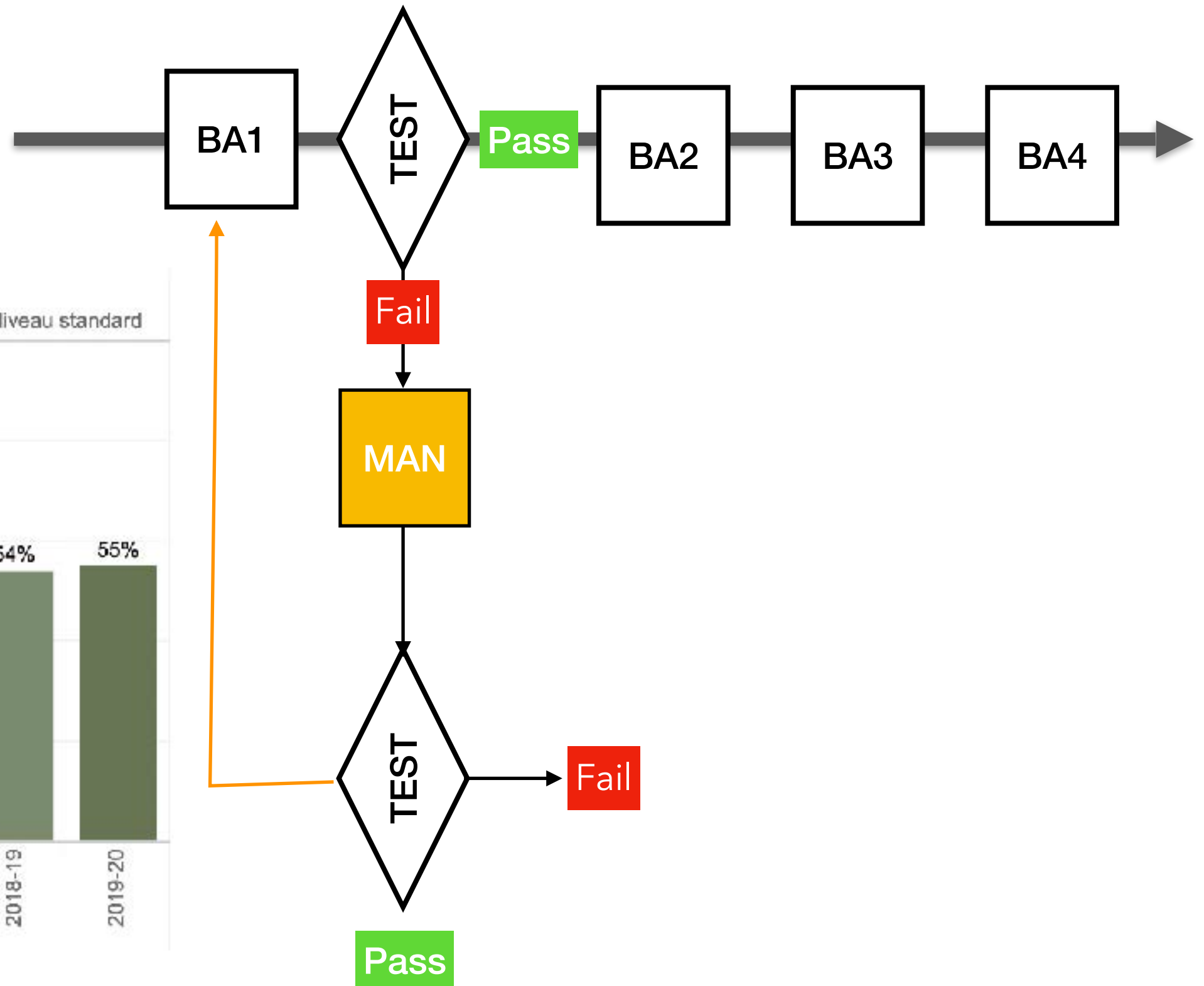
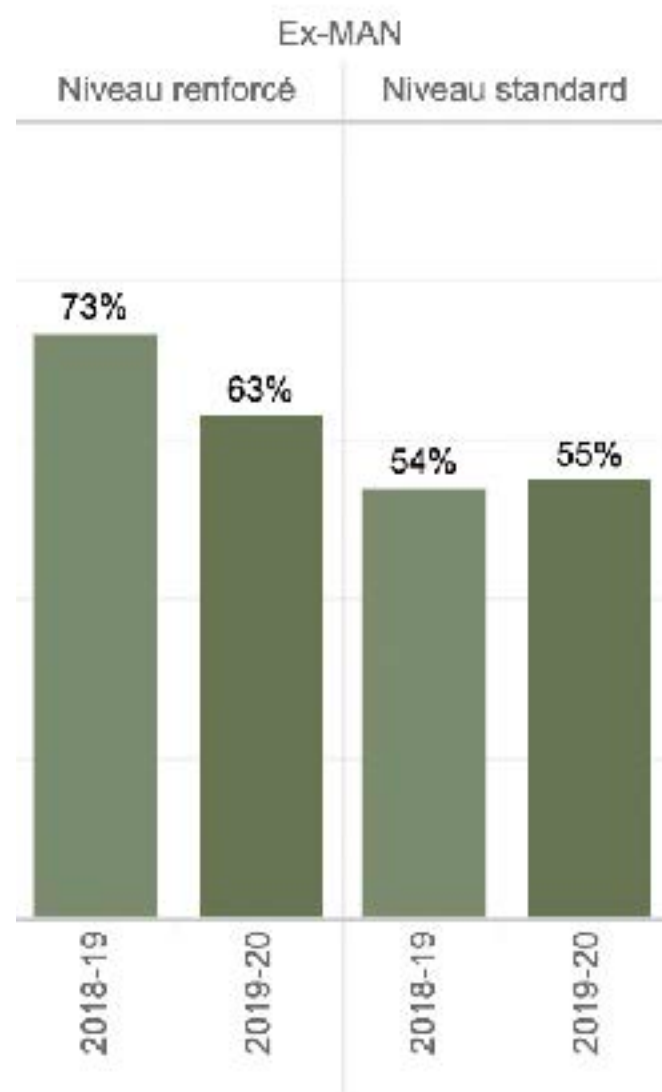
Skill1 : to read

Skill2: to code

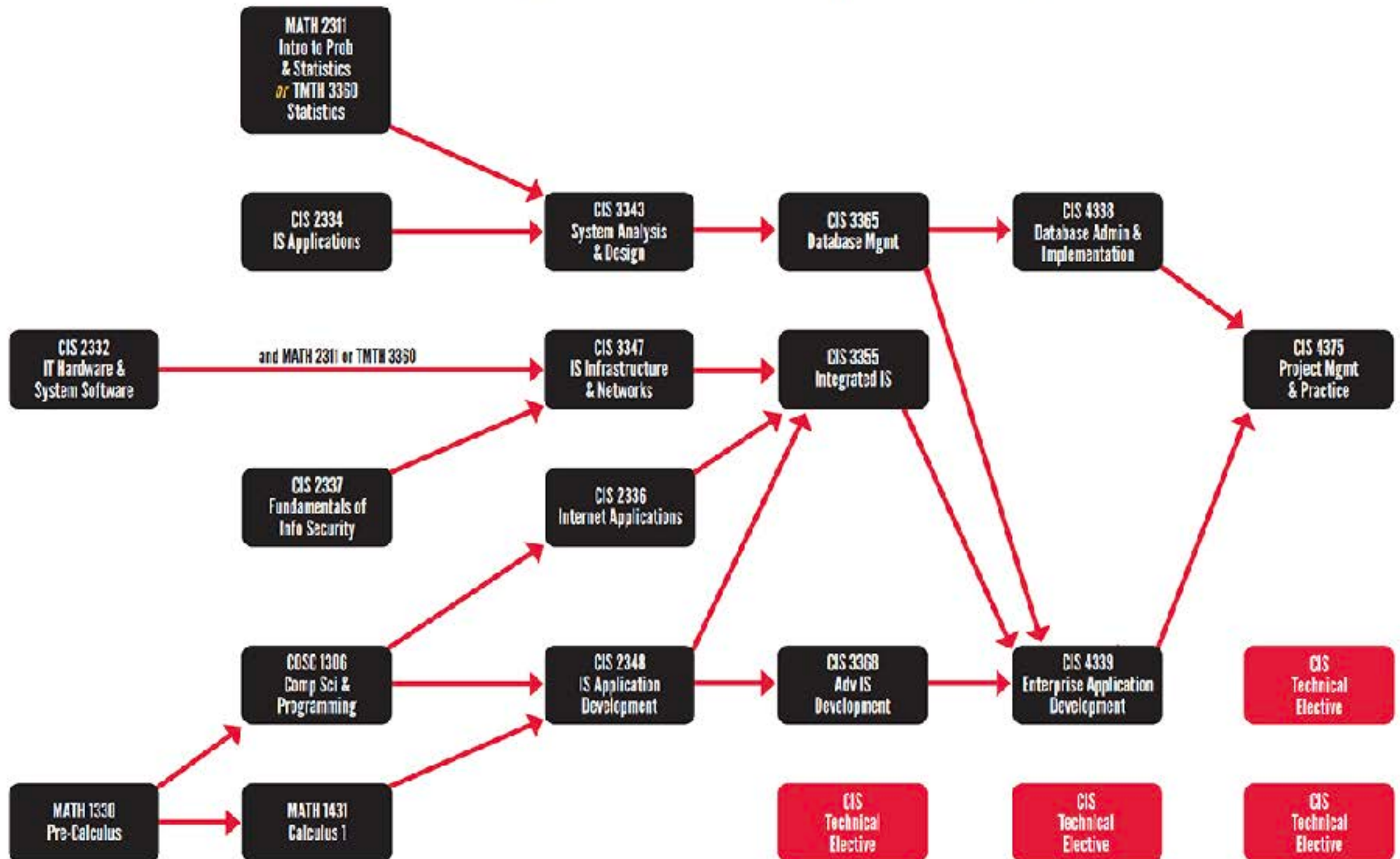
Mastery learning:

if pre-requisites are missing, remediate them before to go on



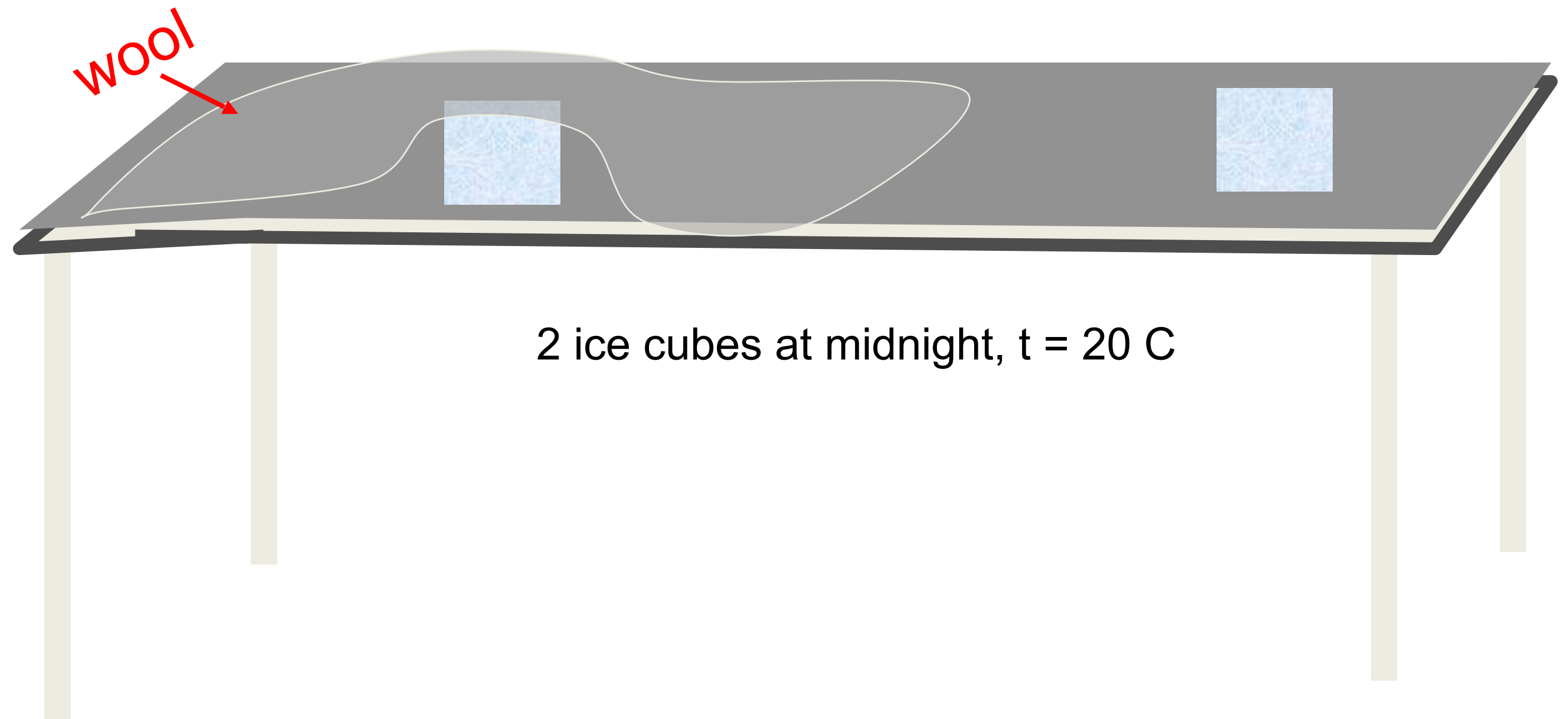


CLS Prerequisite/Course Sequence Map



Note: For a list of pre-approved Technical Electives, please visit:
uh.edu/cot/cis/technical-electives

Prior Knowledge can be wrong

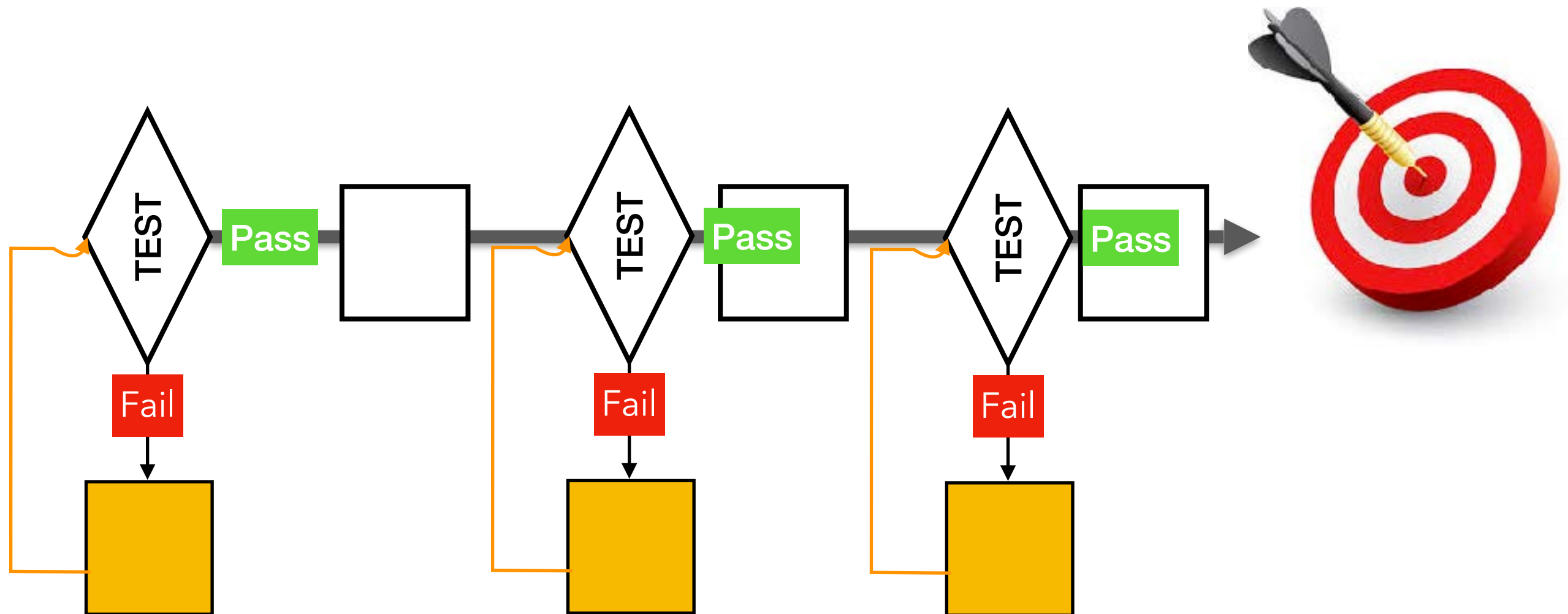


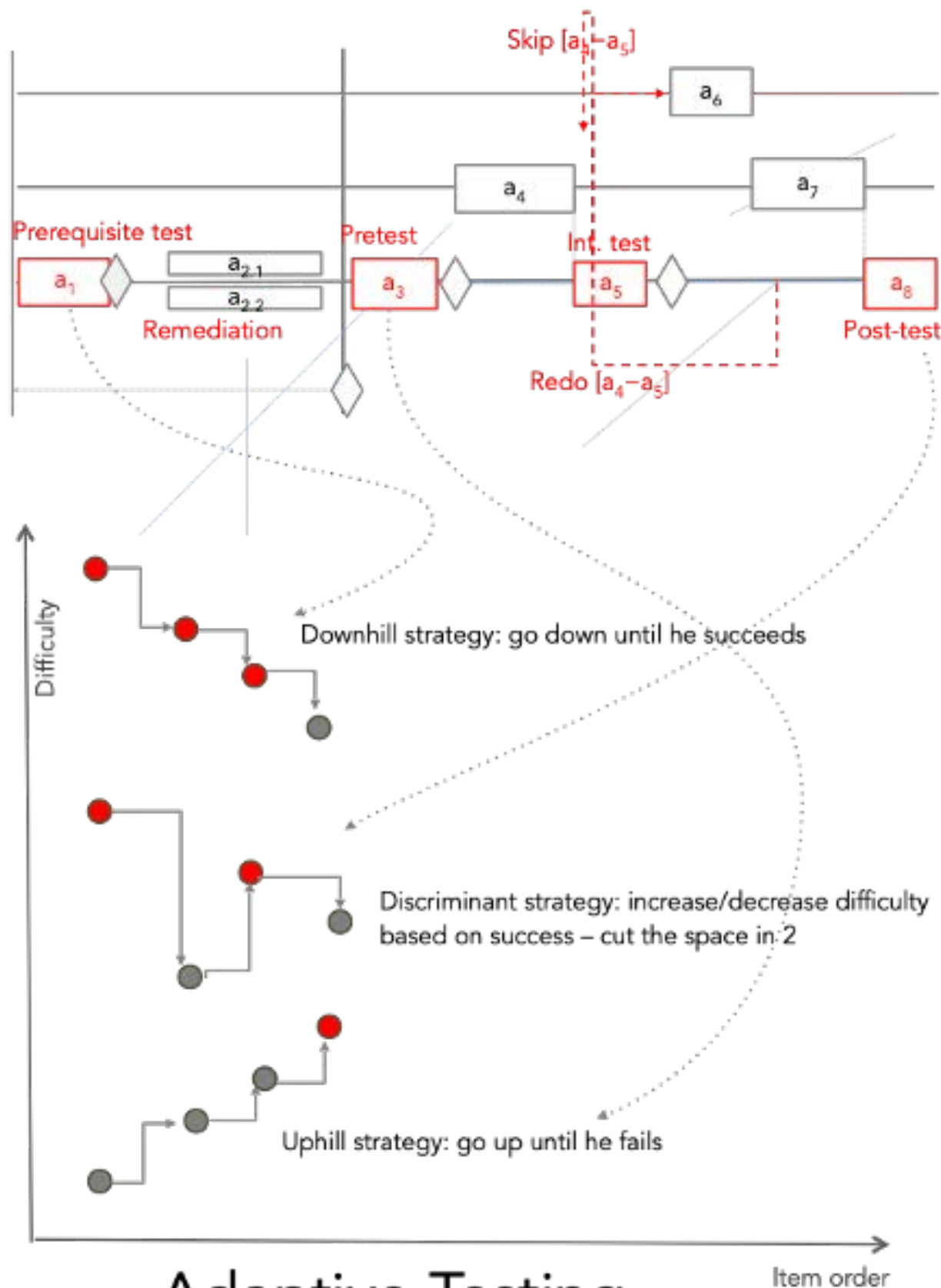
Which ice cube will melt faster ?

Misconceptions must be trapped
otherwise they survive teaching

Mastery learning:

Control mastery of skill_i before to go to skill_{i+1}





Adaptive Testing

Modular Instruction

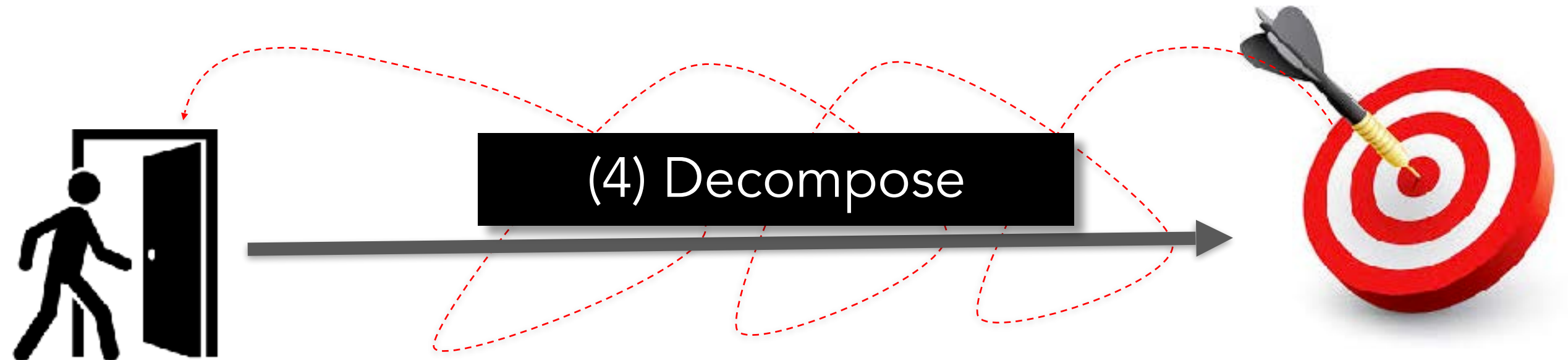
Pre-requisite test: Does the learner has the pre-requisite to start the course ?

Pre-test: Should the learner skip some modules ?

Intermediate-test: Did the learner reach the objectives of this module ?

Post-test: Did the learner reach the objectives of this course?

(1) Pick a topic on which one of you is expert



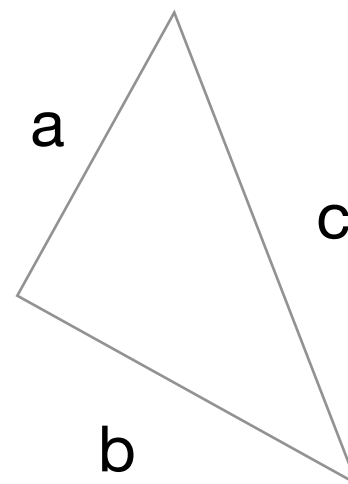
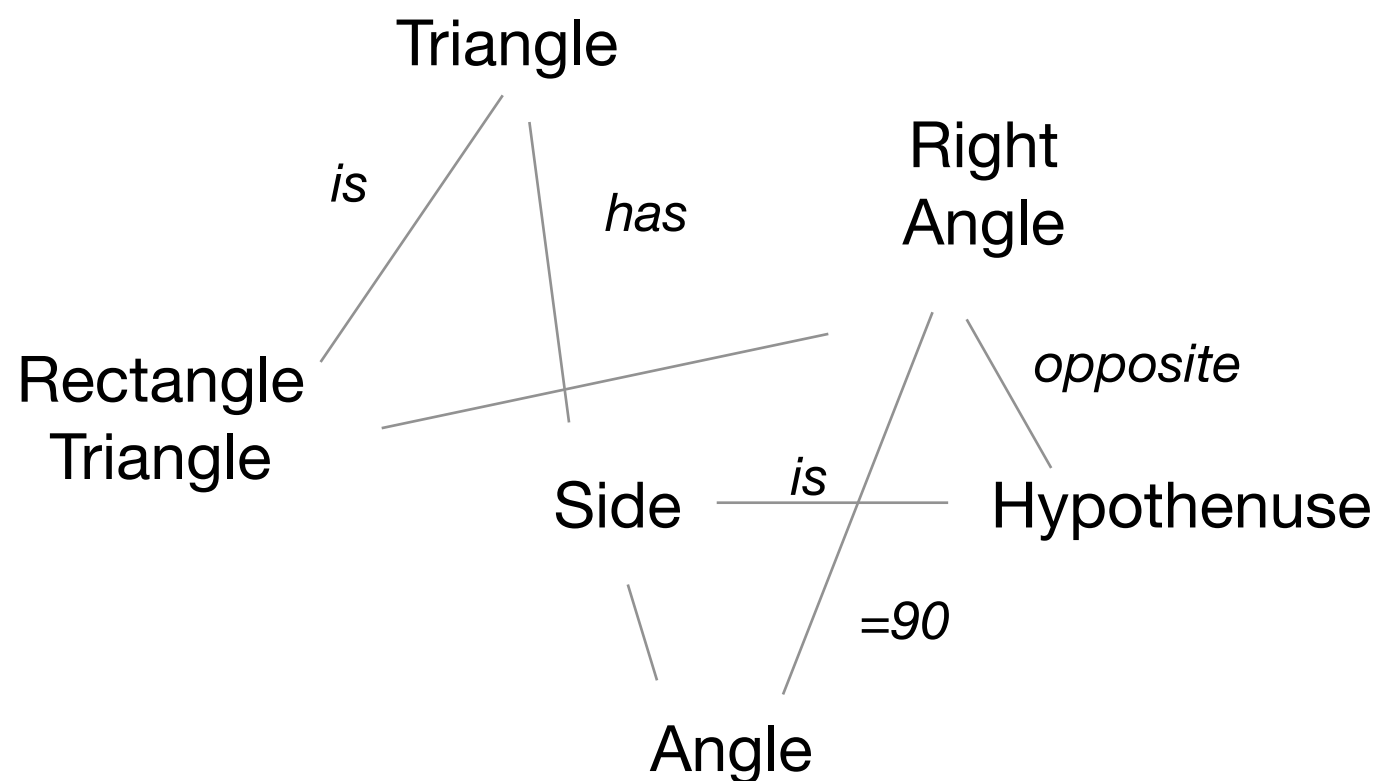
(3) Define target audience

(2) Specify Objectives

PROJECT

(4) Decompose

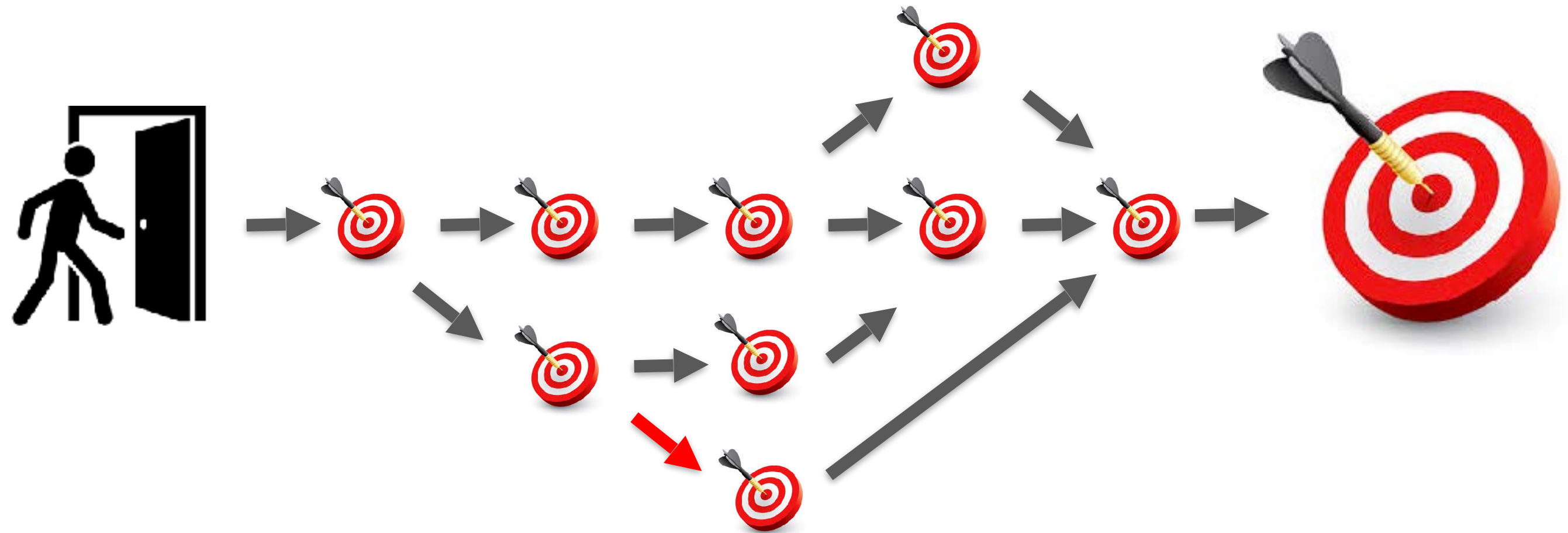
Knowledge Graph



Algorithm

1. Measure A
2. Compute A^2
3. Measure B
4. Compute B^2
5. $A^2 + B^2 = C^2$
6. $C = \text{SQRT}(C^2)$

Adaptive Instruction



Evaluations of Intelligent Tutoring Systems

- Study with 17,000 students showed that Cognitive Tutor Algebra (a curriculum + ITS) doubled students' algebra learning
(Pane et al., 2013)
- Meta-review indicates that ITSs are “nearly as effective as human tutoring” (VanLehn, 2011)
- Four meta-analyses show ITSs are often more effective than other forms of instruction

(Kulik & Fletcher, 2015; Ma, Adesope, Nesbit, & Liu, 2014; Steenbergen-Hu & Cooper, 2013; 2014)

Why is an activity a_i useful for an activity a_{i+1} ?

1. a_i is prerequisite to a_{i+1}
2. ...

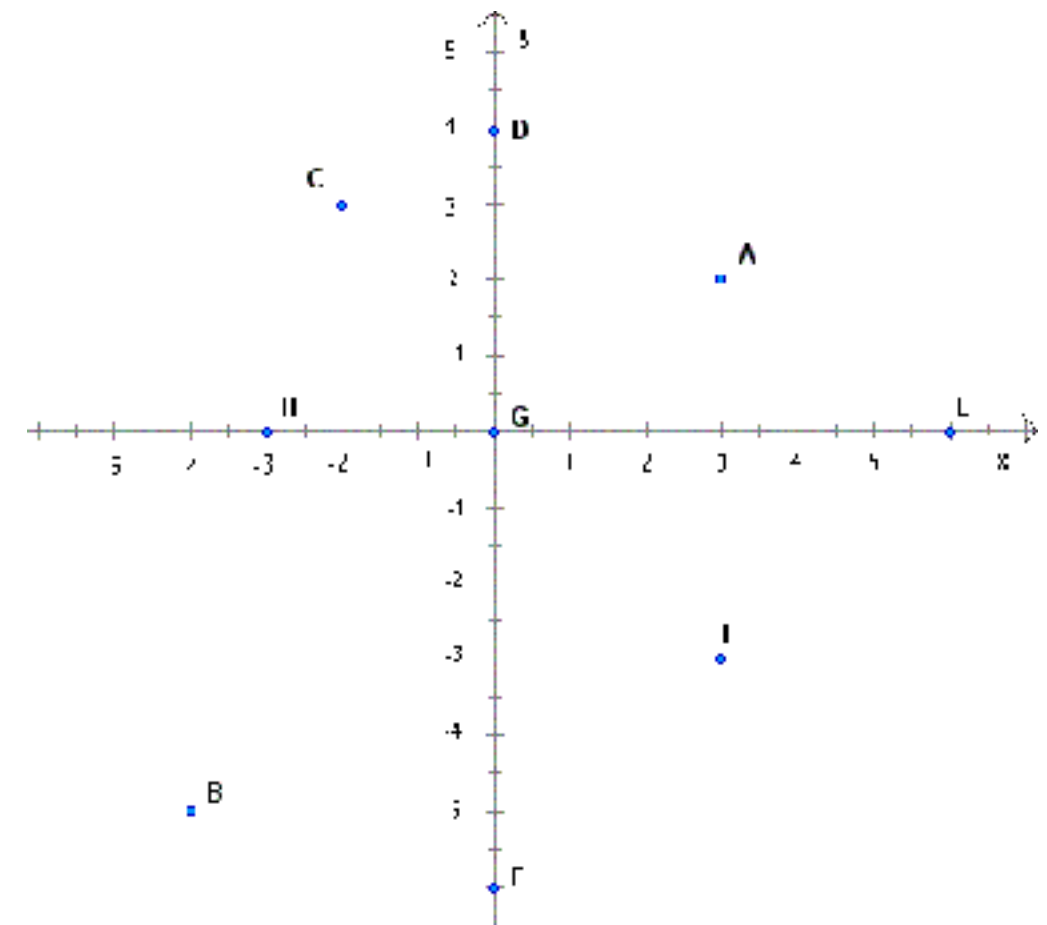
what fruits do people eat in winter ?

Why is an activity a_1 useful for an activity a_2 ?

Advance organizer :

a_1 pre-activates structures for a_2

	1	2	3	4	5	6	7	8	9	10
A										
B										
C										
D										
E										
F										
G										
H										
I										
J										



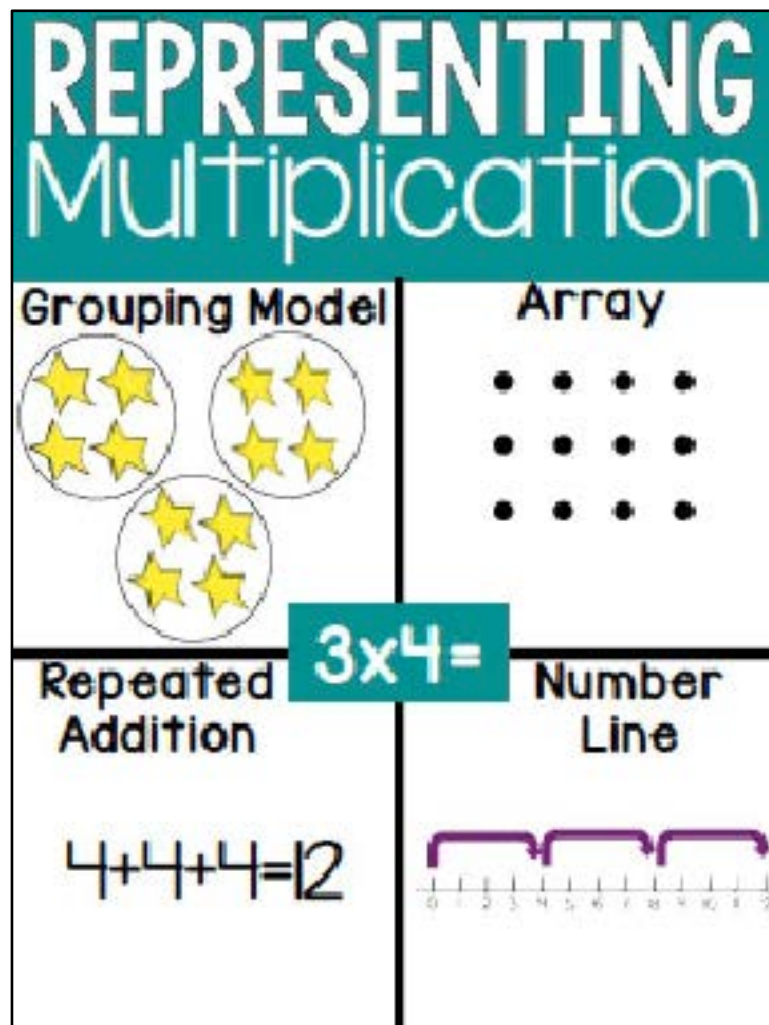
Why is an activity a_i useful for an activity a_{i+1} ?

1. a_i is prerequisite to a_{i+1}
2. a_i is pre-activates cognitive schema for a_{i+1}
3. ...

Why is an activity a_1 useful for an activity a_2 ?

Shift Representation:

a_2 represents contents differently from a_1



There is a large body of empirical studies that show that is beneficial for learners to **switch between multiple representations.**

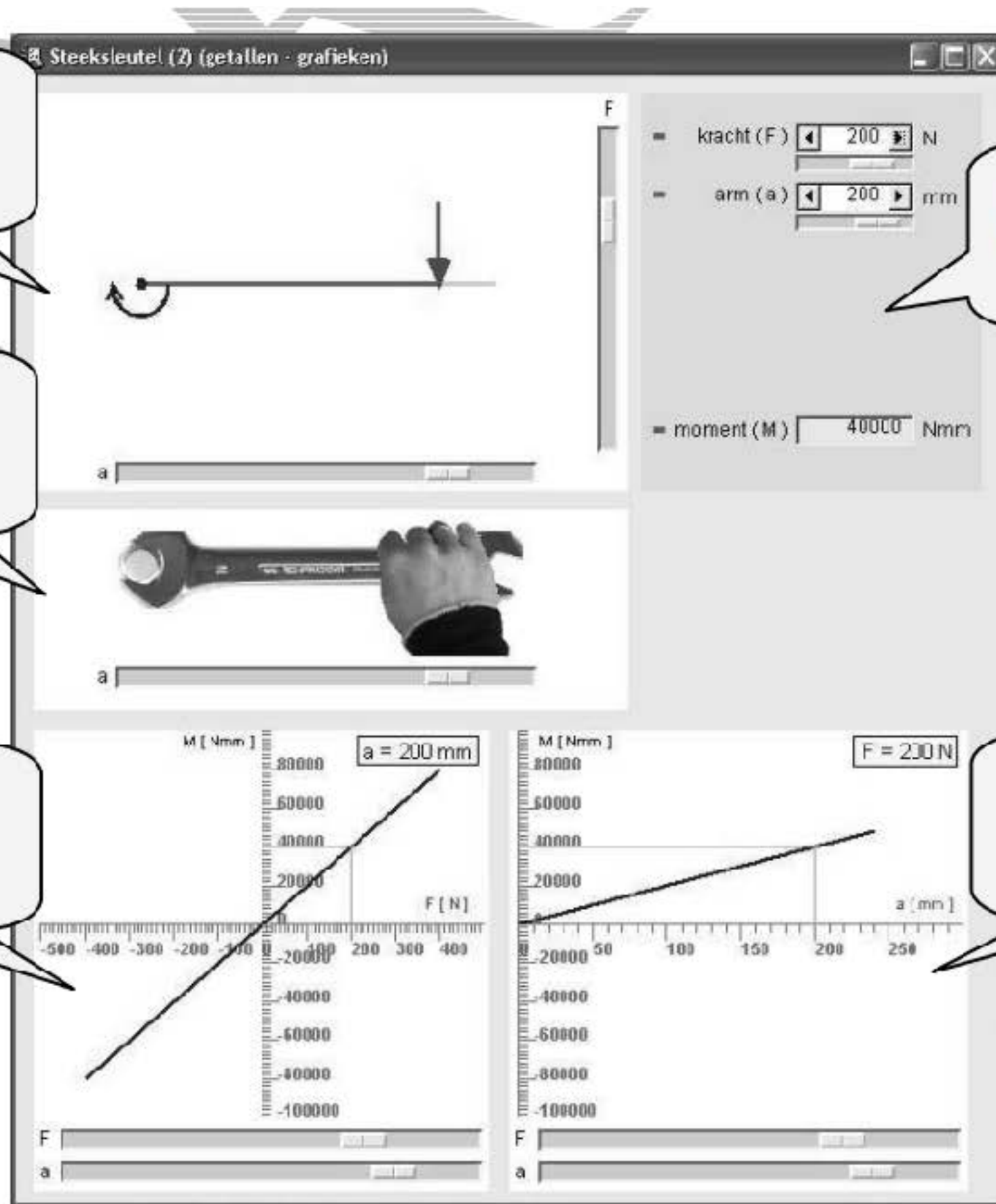
Diagrammatic
representation

Context
representation

Graph

Numerical
representation

Graph



1 Velocity scooter (without controls)

uniform varying motion

velocity of the scooter

simulation delay

scooter starting from stand still

initial velocity $v(0)$

0 m/s

acceleration a

0.50 m/s²

Assignment Image

Close

You have 1 attempt left

Assignment

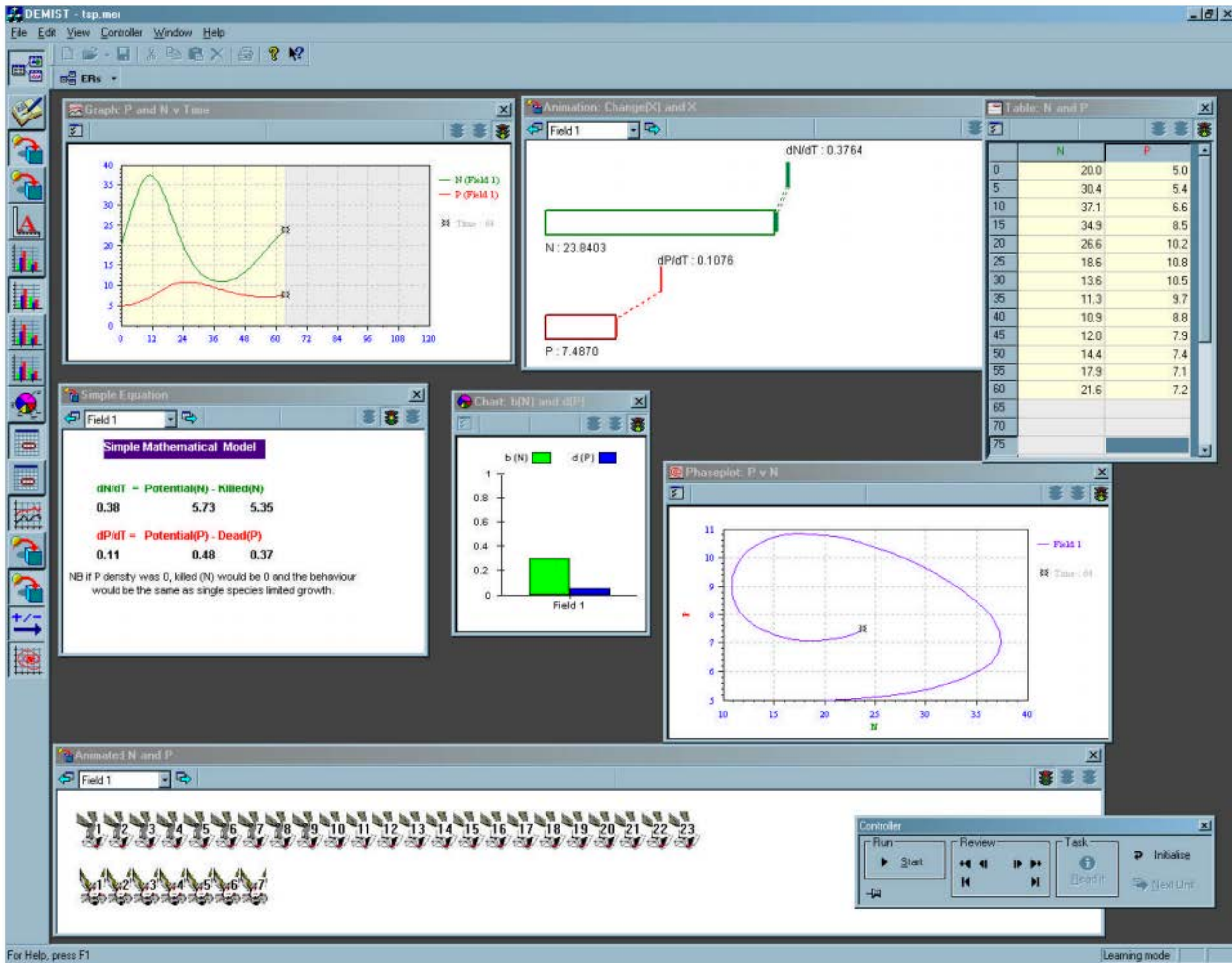
Try to make the velocity of the scooter 8 m/s in 4 seconds.

You've to do this by giving the right value to the **acceleration**.

You may try two times.

Start

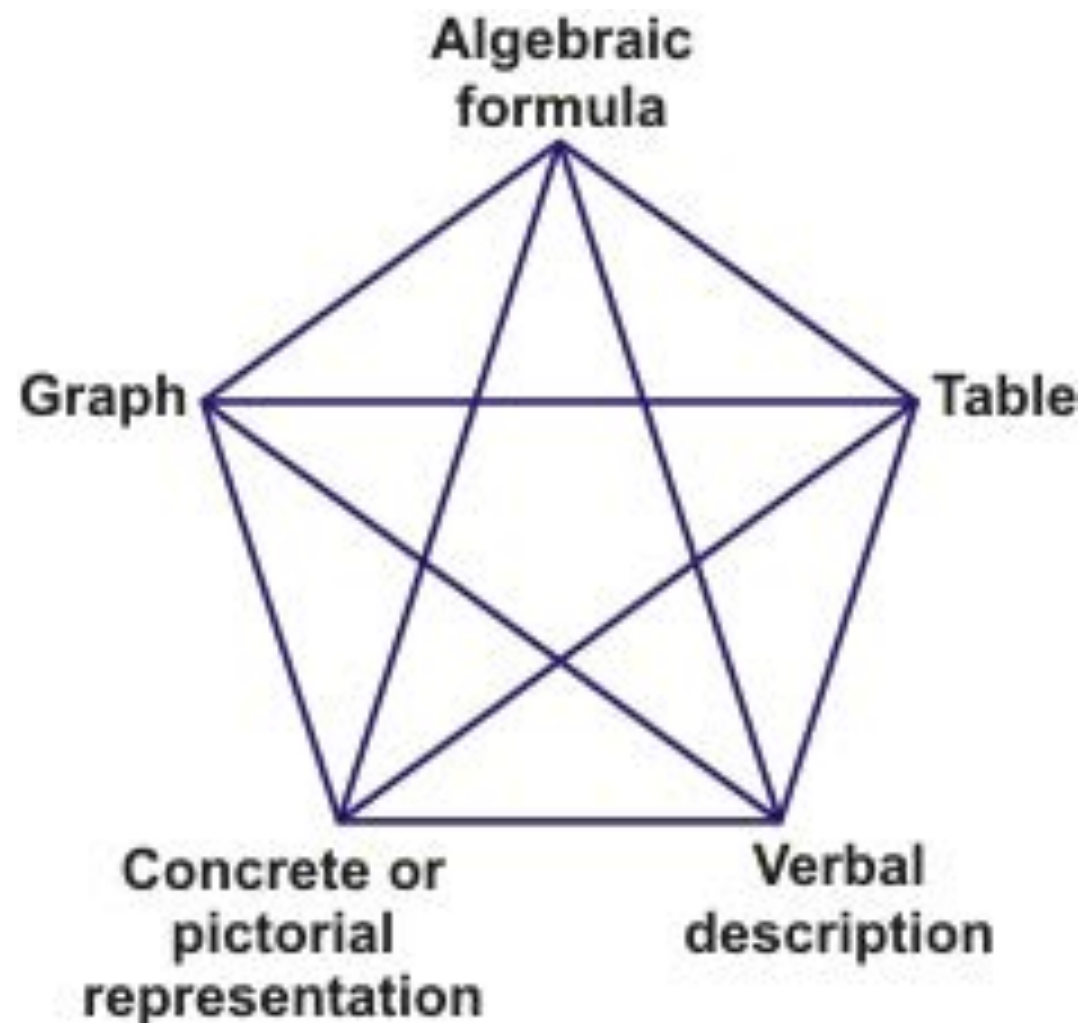
Close



Why is an activity a_1 useful for an activity a_2 ?

Shift Representation:

a_2 represents contents differently from a_1

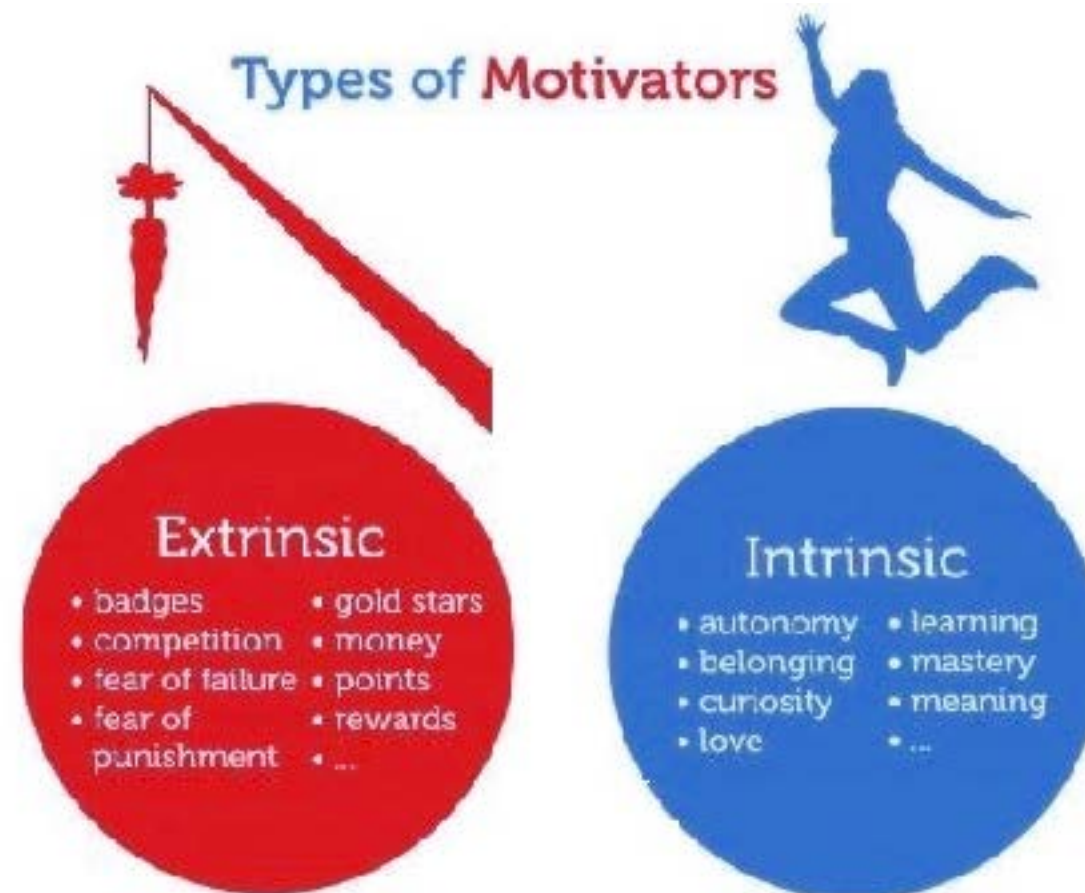


Why is an activity a_i useful for an activity a_{i+1} ?

1. a_i is prerequisite to a_{i+1}
2. a_i pre-activates cognitive schema for a_{i+1}
3. a_{i+1} varies the representations used in a_i
4. ...

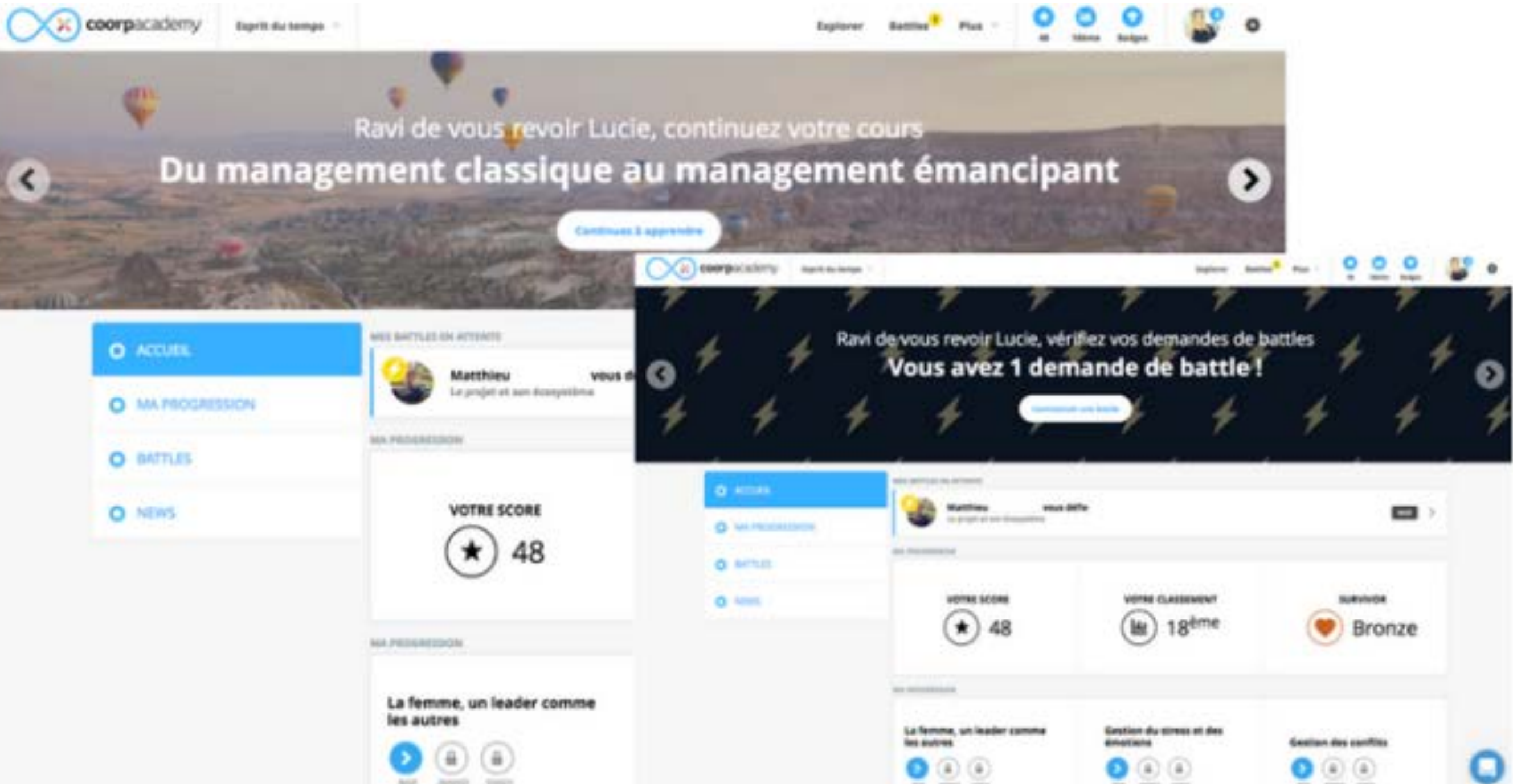
Why did you take this class ?

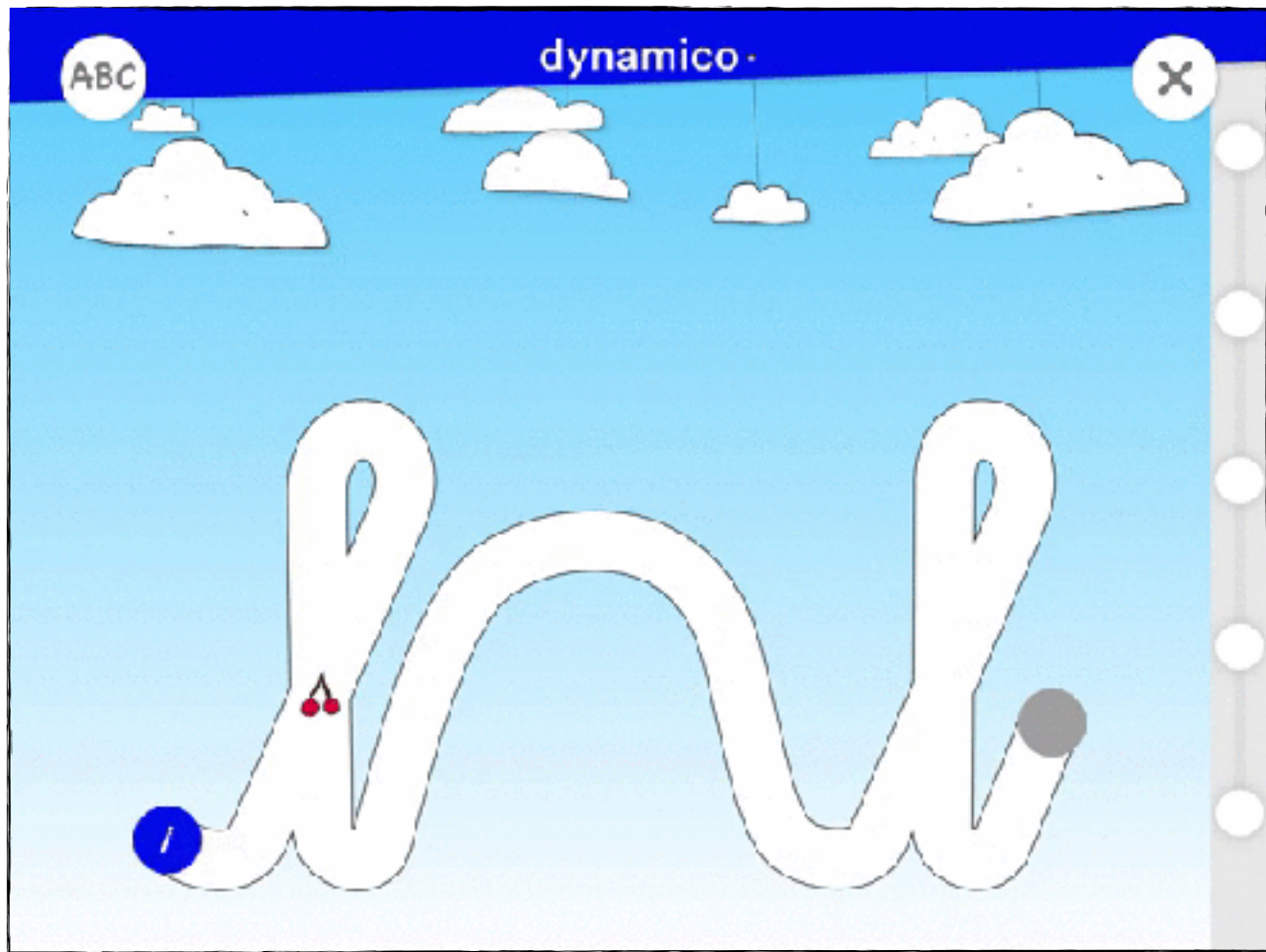
- A. I am passionate about education
- B. I have been told it's an easy one
- C. I had nothing on Tuesday morning
- D. I would like to create an EdTech start-up



Gamification

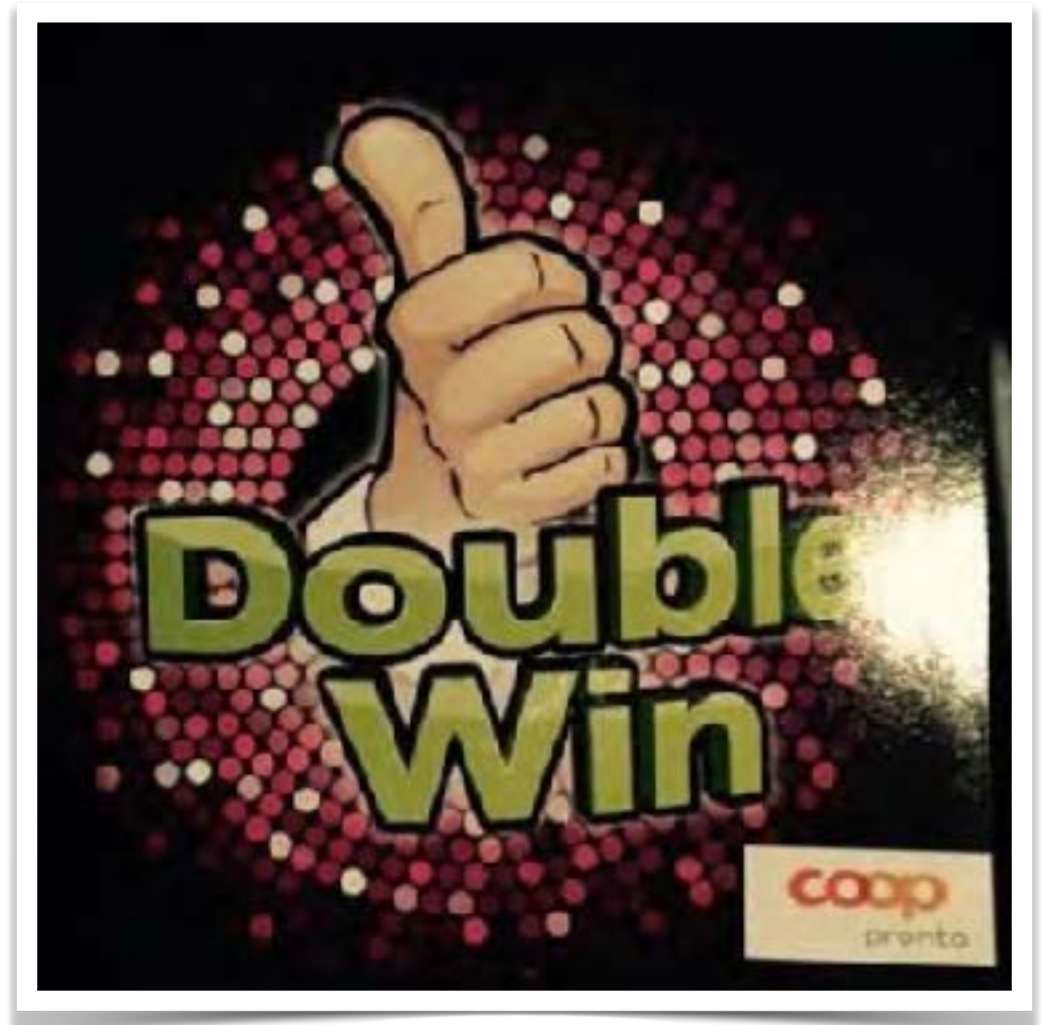
(even in corporate training)





Game

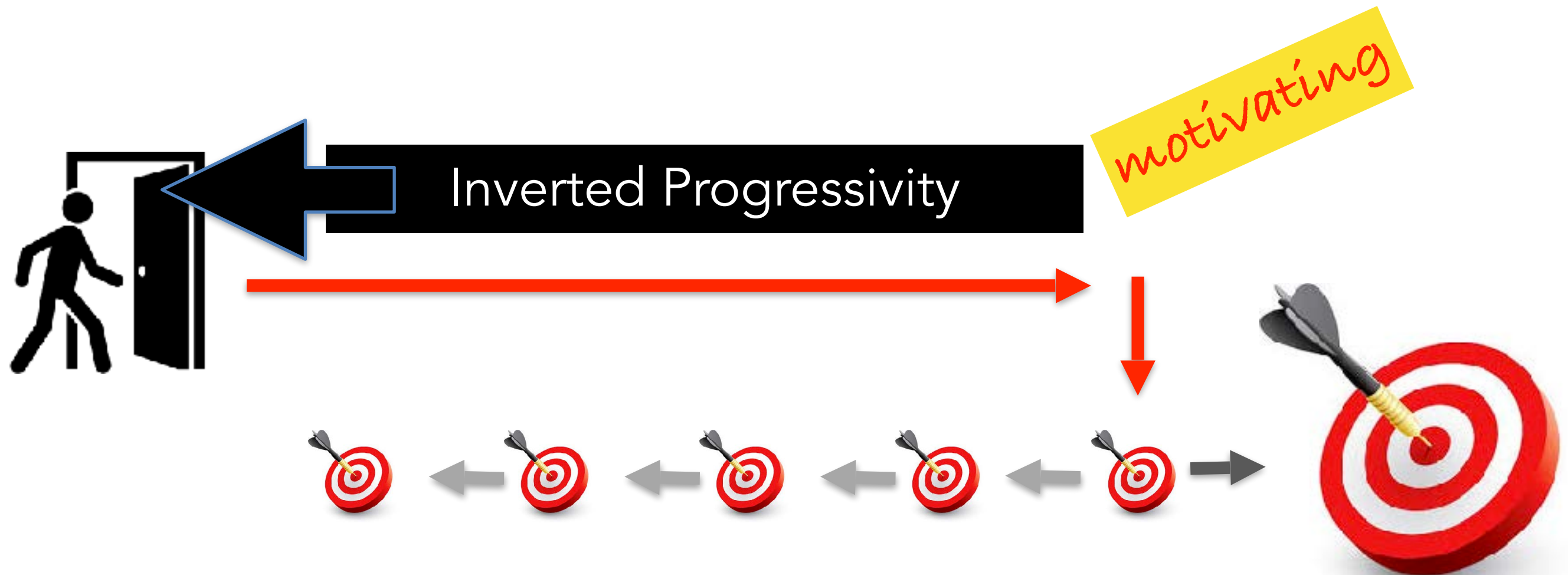
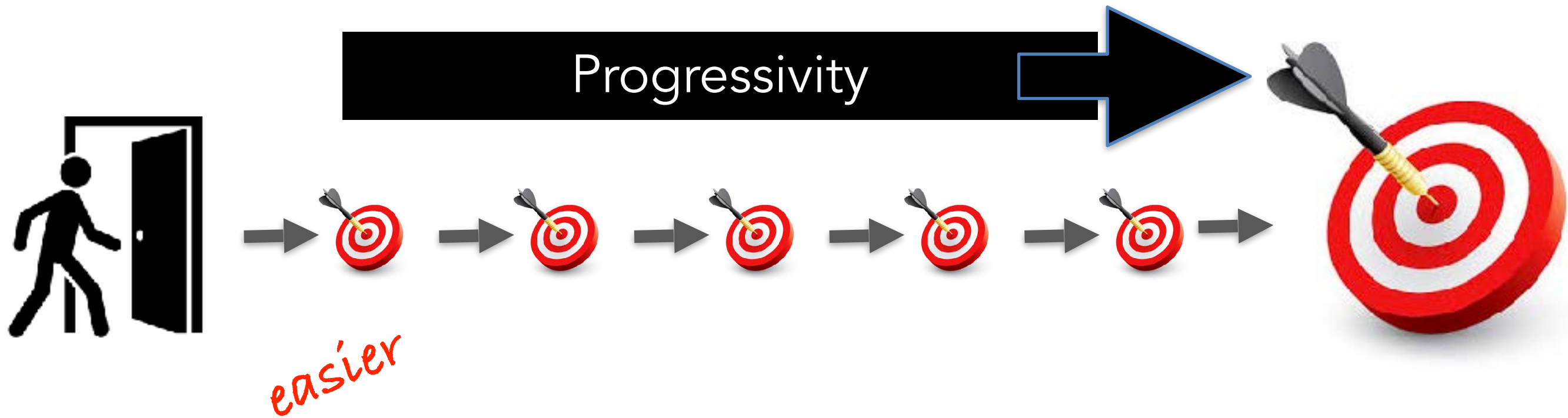
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Gamification



Gamification



Why is an activity a_1 useful for an activity a_2 ?

Motivation:

a_1 frustrate learners so that they want to do a_2

« what you learned before enabled you to solve problems so far, but here are new problems »

Why is an activity a_i useful for an activity a_{i+1} ?

1. a_i is prerequisite to a_{i+1}
2. a_i pre-activates cognitive schema for a_{i+1}
3. a_{i+1} varies the representations used in a_i
4. a_i brings motivation for a_{i+1}
5. ...

Why is an activity a_1 useful for an activity a_2 ?

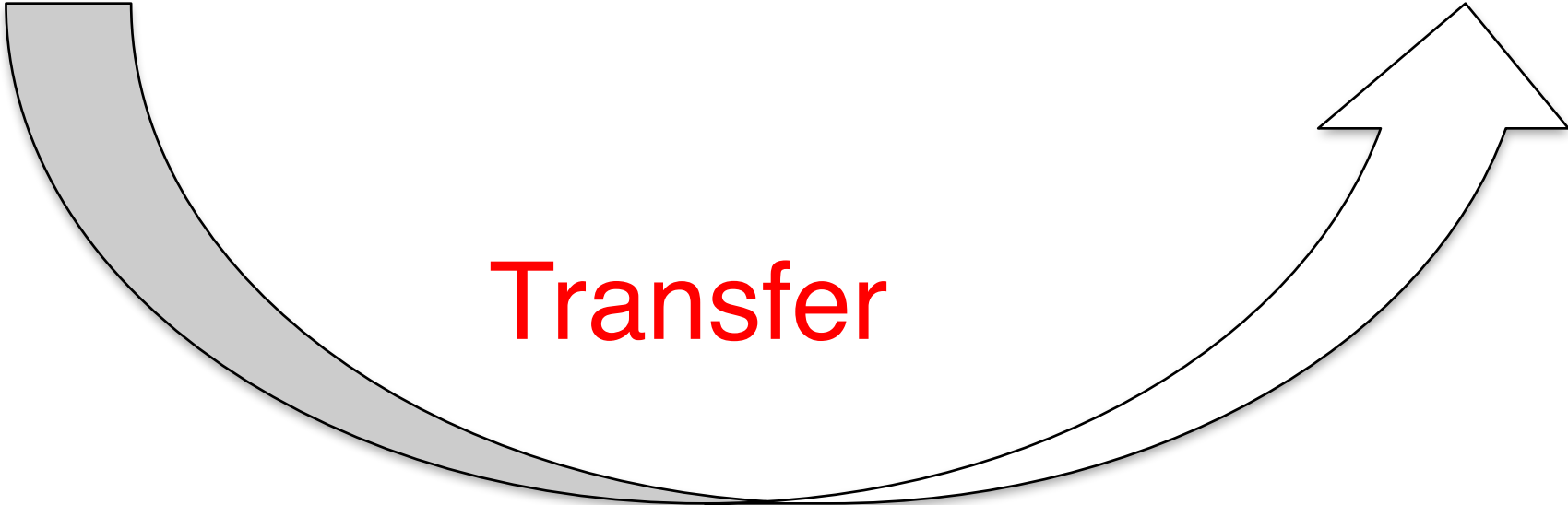
$$5 \times < 27$$

a_i

A chocolate bar costs 5 CHF.
How many bars can you buy for 27 CHF

a_i

A man walks 1 km in 5 min.
How many km can he walk in 27 min



Transfer

Why is an activity a_i useful for an activity a_{i+1} ?

1. a_i is prerequisite to a_{i+1}
2. a_i pre-activates cognitive schema for a_{i+1}
3. a_{i+1} varies the representations used in a_1
4. a_i brings motivation for a_{i+1}
5. a_{i+1} practices the transfer of skills acquired in a_1
- 6.

Why is an activity a_i useful for an activity a_{i+1} ?

1. a_i is prerequisite to a_{i+1}
2. a_i pre-activates cognitive schema for a_{i+1}
3. a_{i+1} varies the representations used in a_1
4. a_i brings motivation for a_{i+1}
5. a_{i+1} practices the transfer of skills acquired in a_1
6. a_{j+1} summarizes in $\{a_1, \dots, a_j\}$
7. a_{i+2} contrasts examples used in a_1 and a_2

How do people learn ?

☒ by exploration, trial and error

✓ **by incremental mastery**

- by verbal elaboration