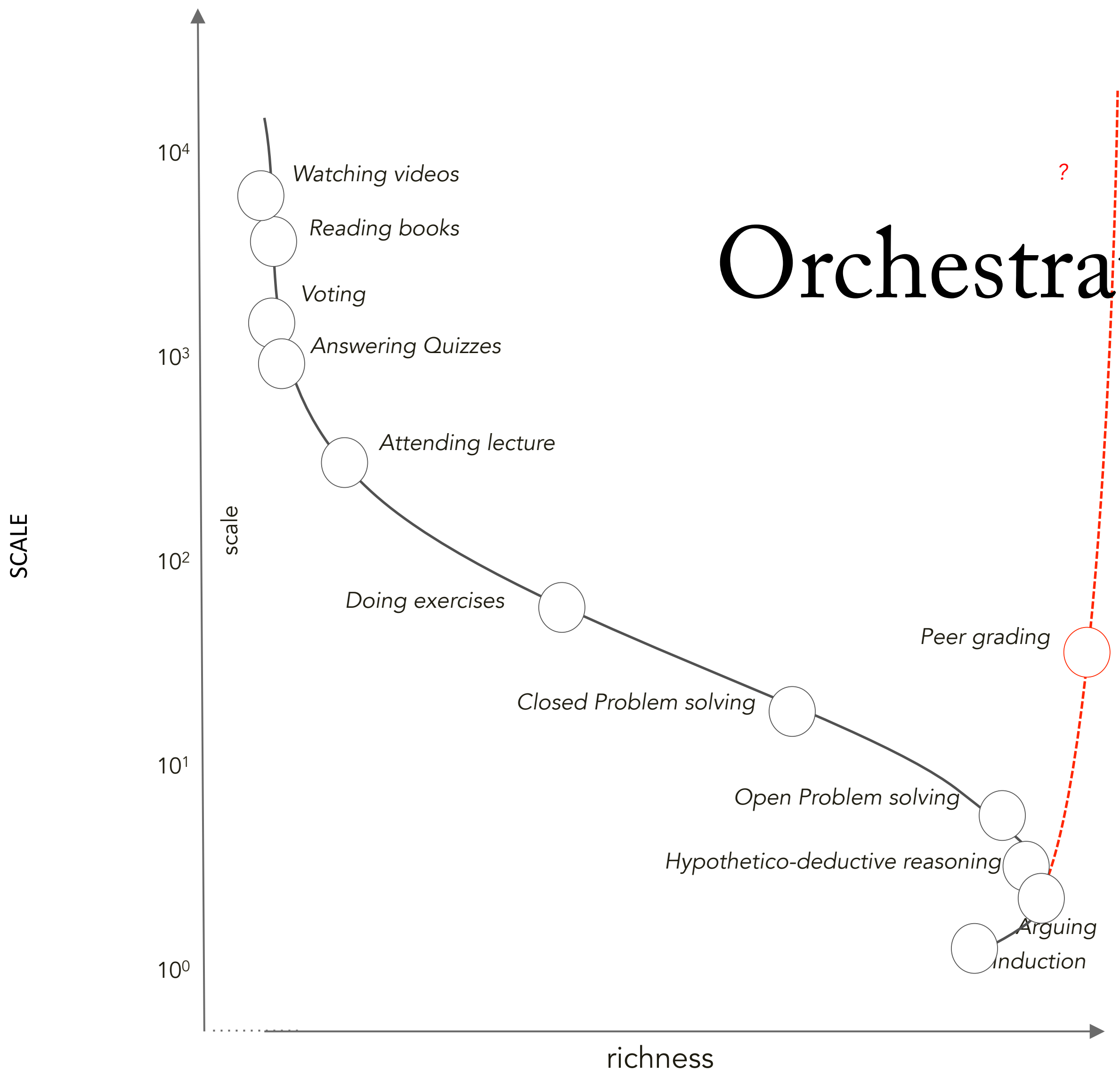
Orchestration Graphs

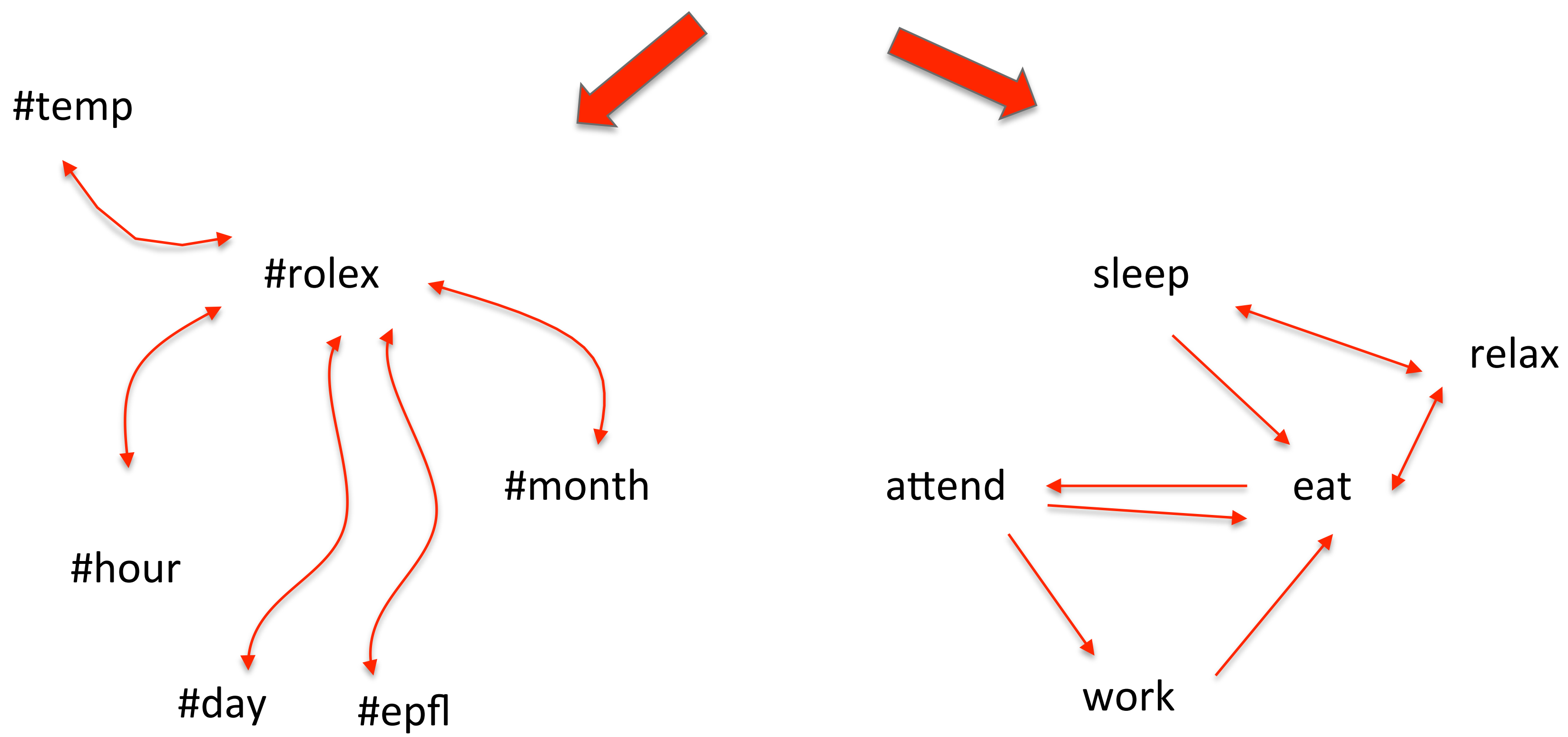


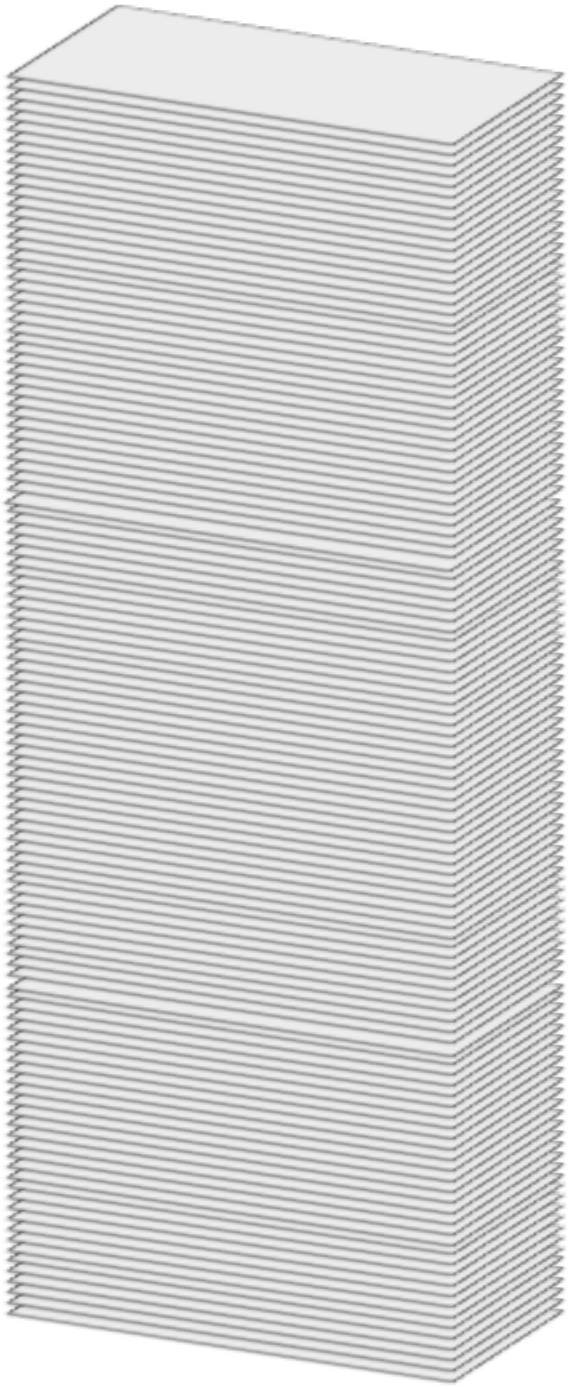
CS-411 : Digital Education & Learning Analytics

Chapter 12: Orchestration Graphs

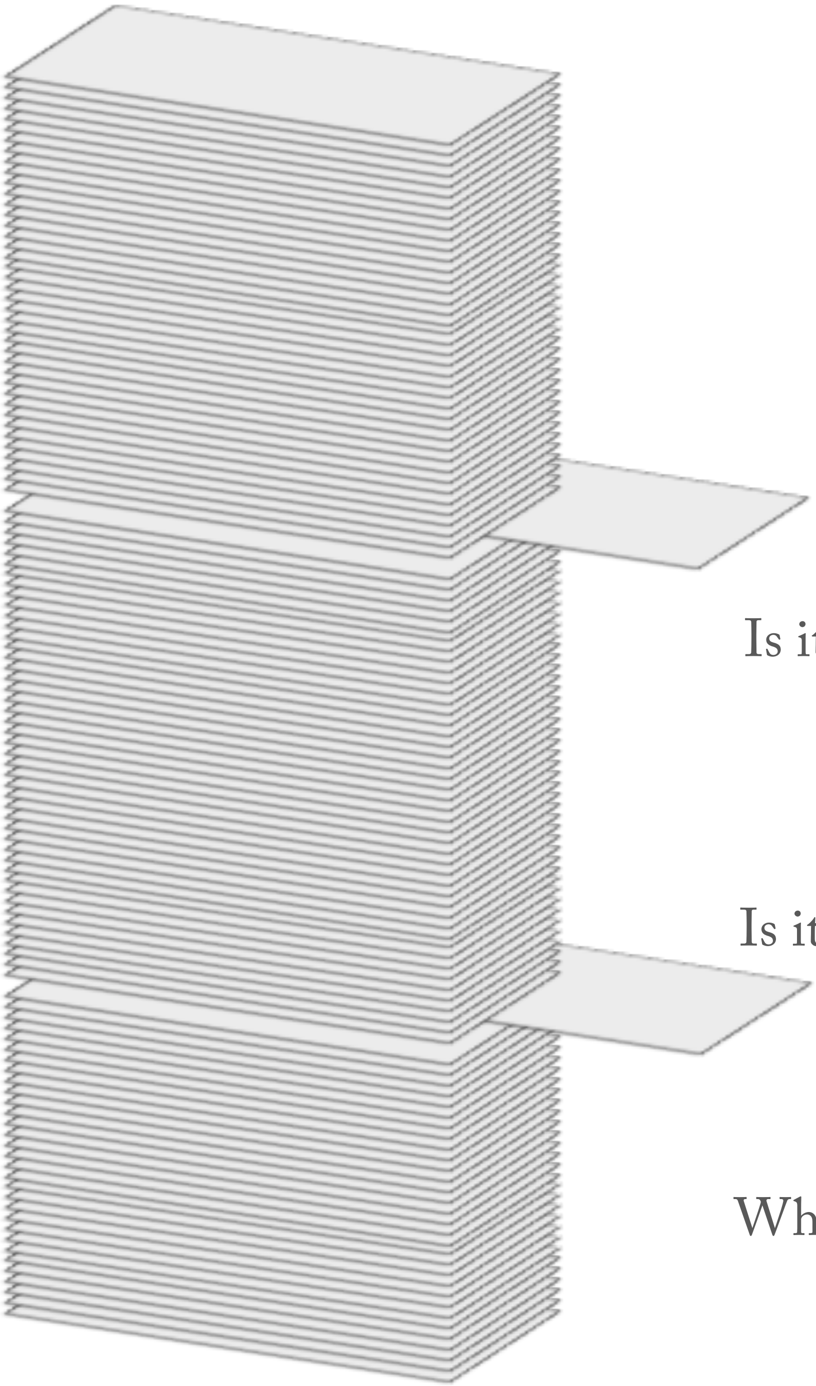
Pierre Dillenbourg and Patrick Jermann
Luis Prieto, Beat Schwendimann, Łukasz Kidziński , Nan Li, Ksitij Sharma, Himanshu Verma

Modelling rich learning scenarios





20’000 X 3 / 0.5 = 30’000 pictures

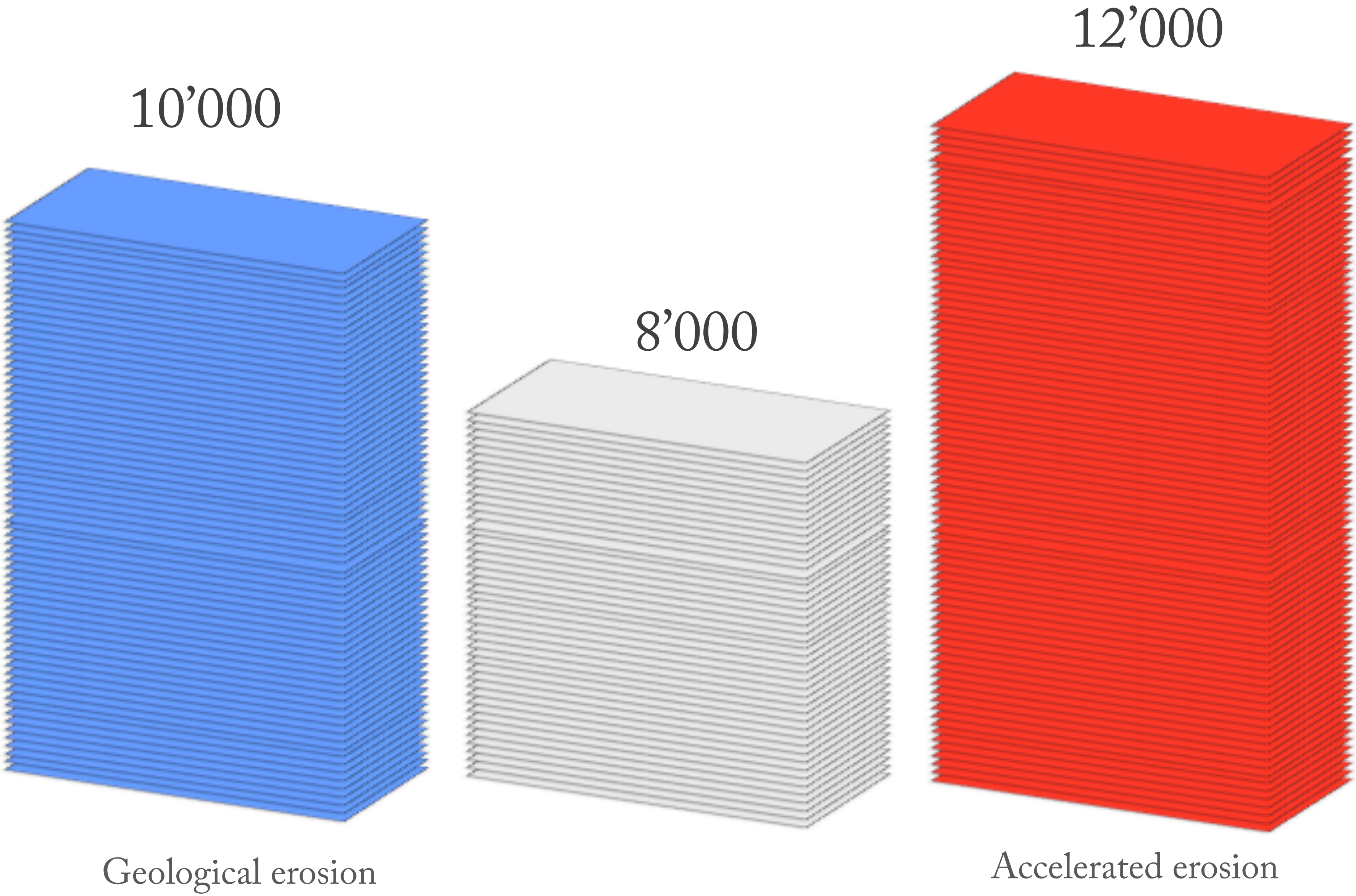


30’000 pictures

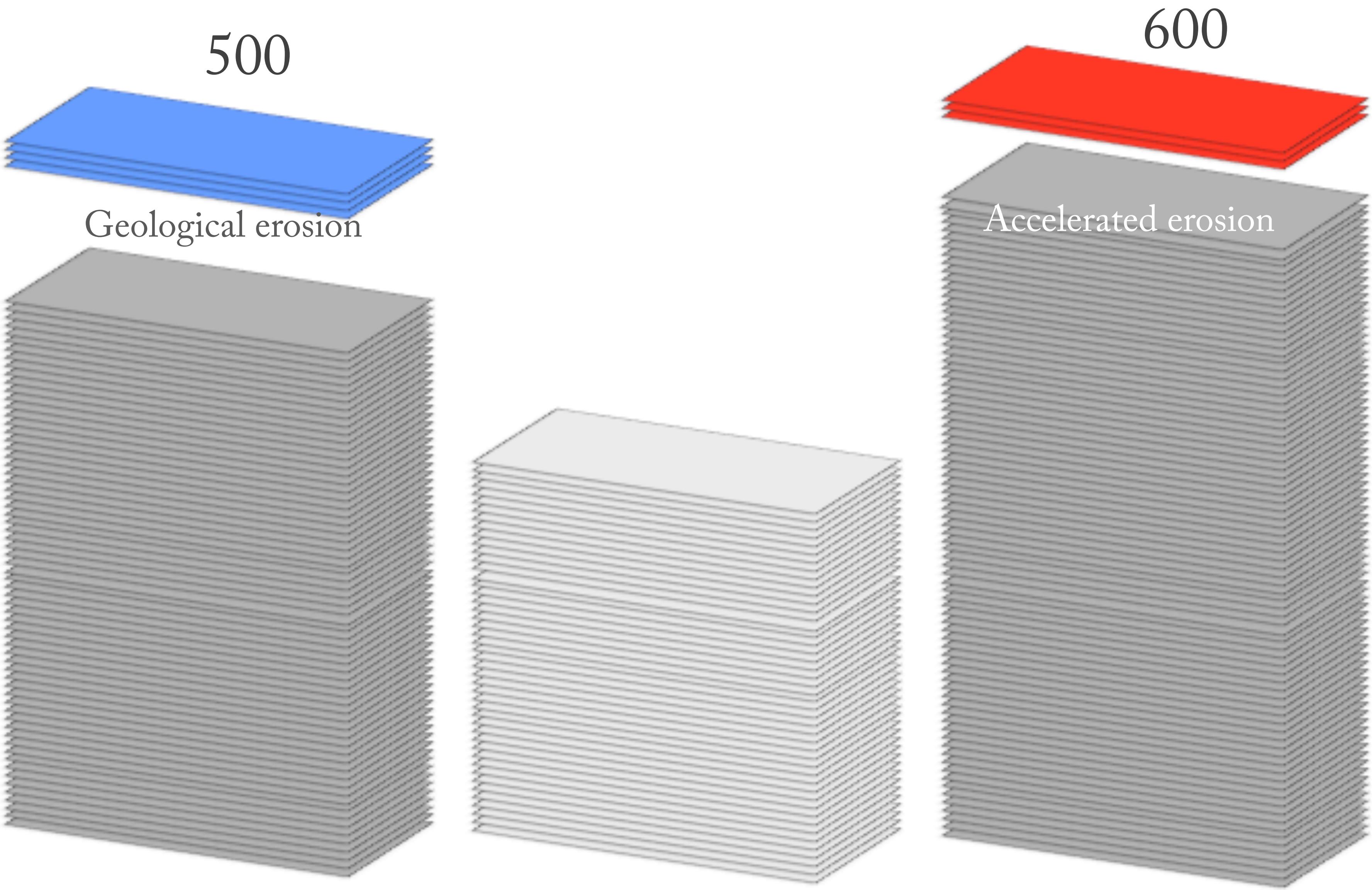
Is it geological erosion or accelerated erosion ?

Is it geological erosion or accelerated erosion ?

Which one illustrates the best erosion?


10'000
8'000
12'000
Geological erosion
Accelerated erosion

Select top 5% pictures



Such a pedagical scenario is a workflow

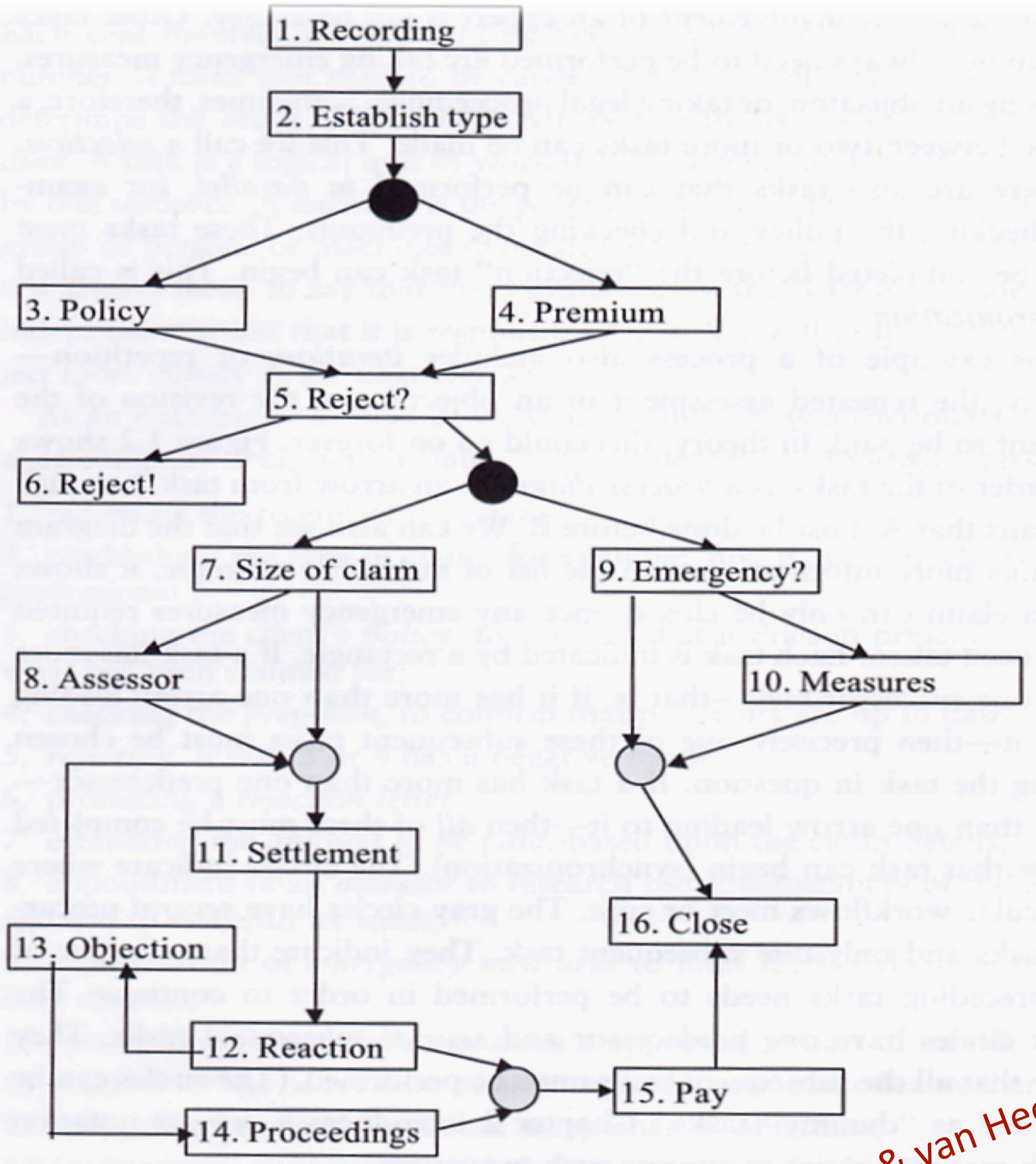
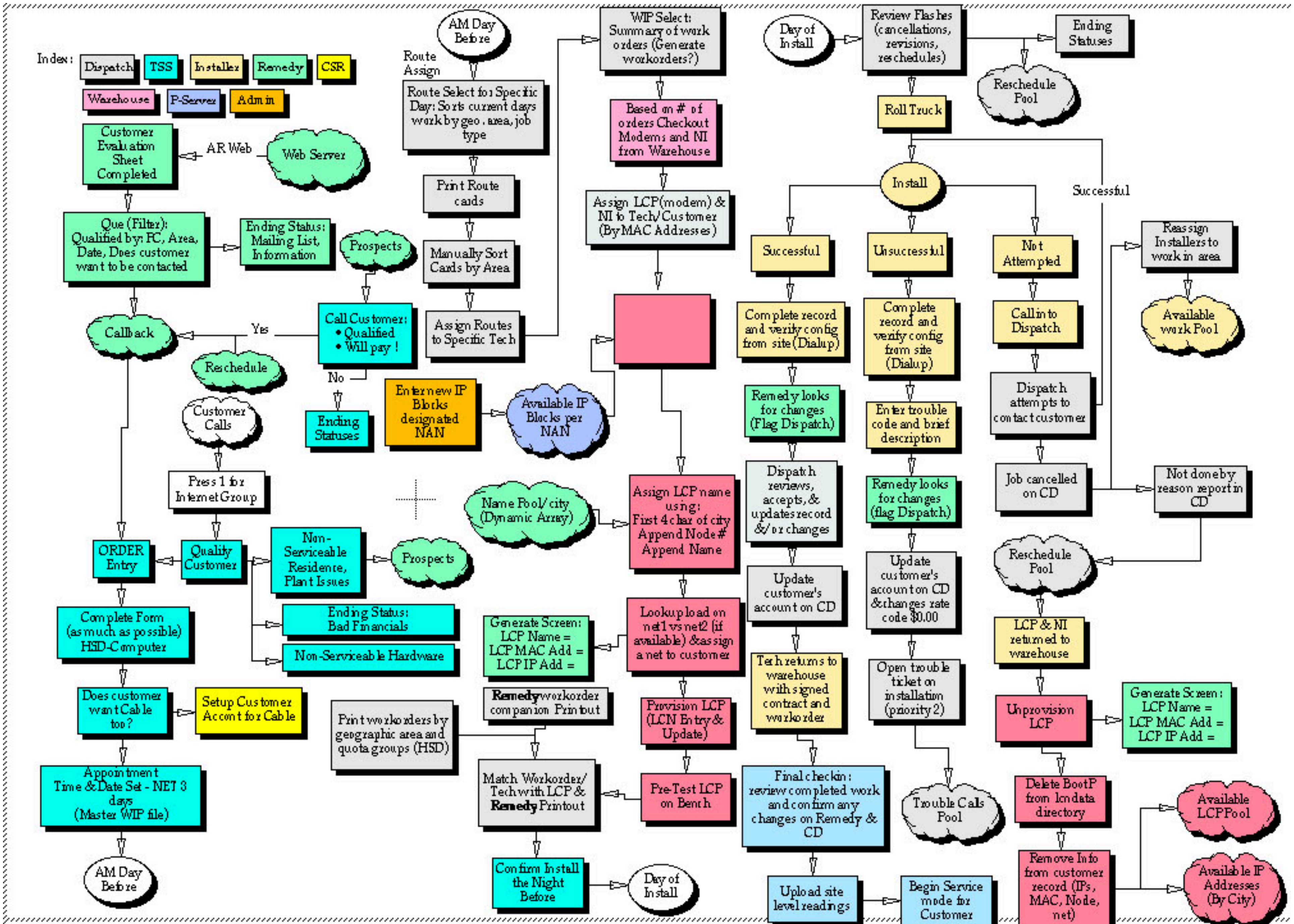


Figure 1.2
Insurance claim process

Van der Aalst & van Hee, 2002



http://www.birds-eye.net/operations_archive/hsd_installation_workflow_dia.htm

Introduction video on geology

Upload a picture

Lesson on geological versus accelerated erosion

Eliminate bad pictures

Classify pictures

Compare pictures

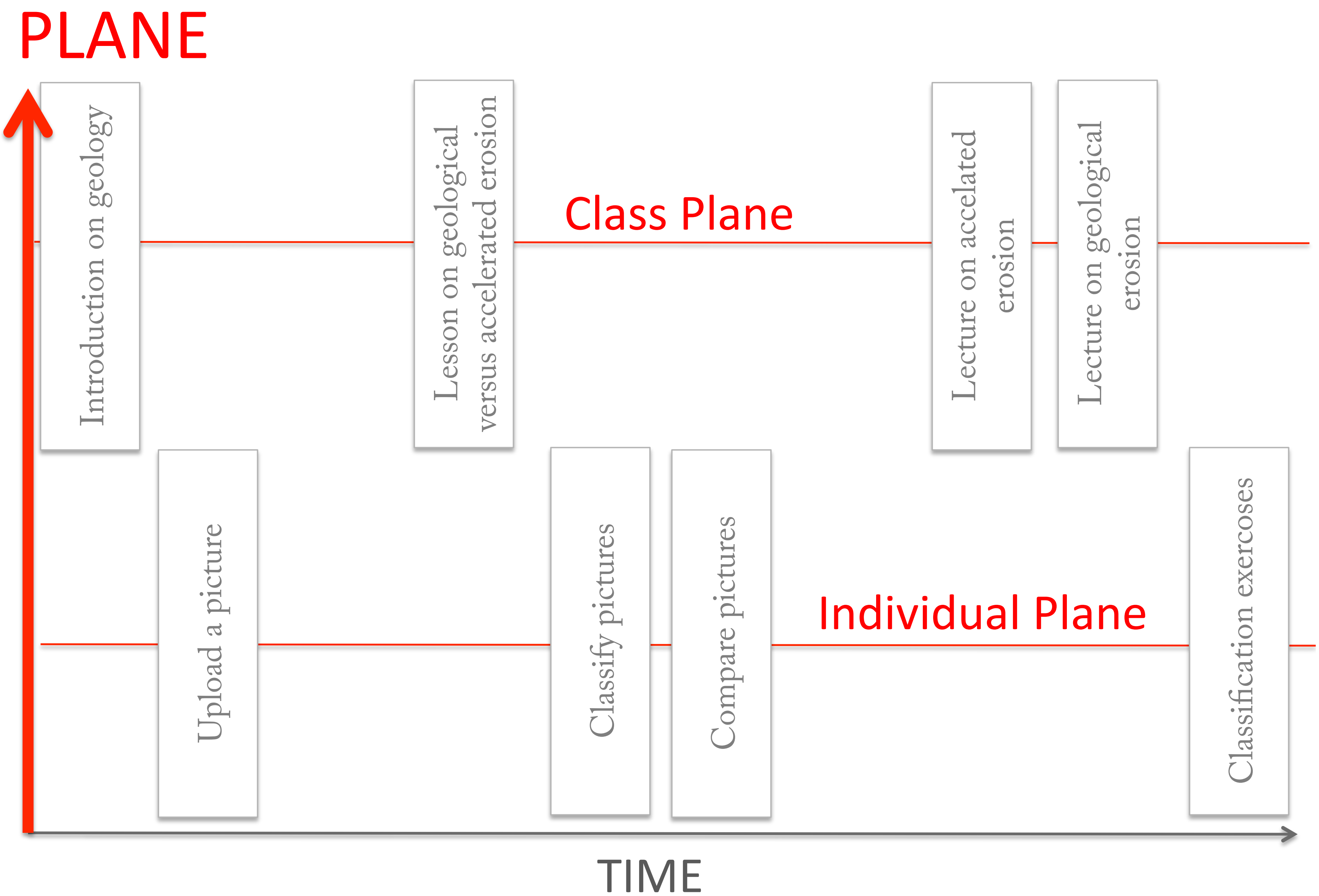
Select top pictures

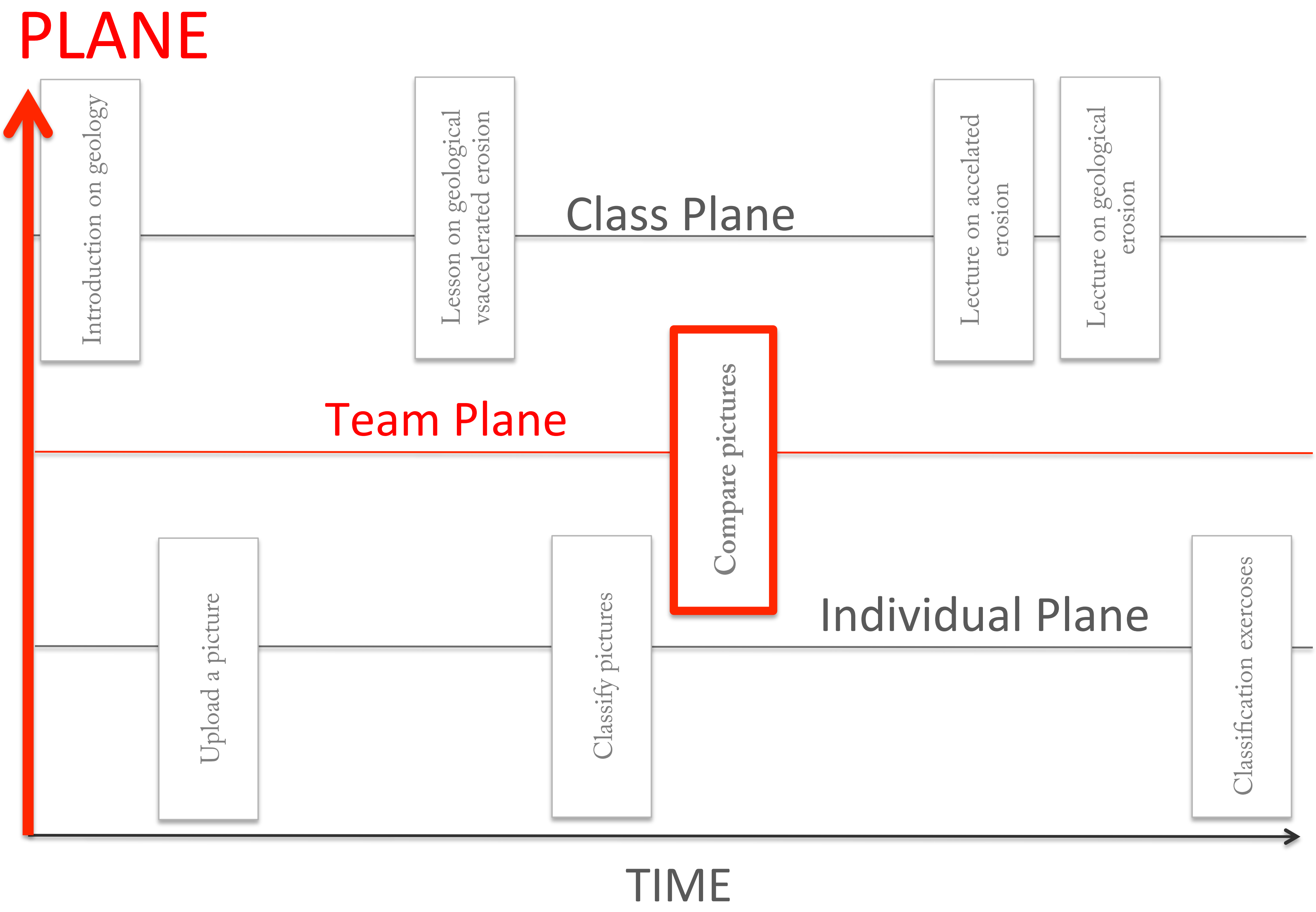
Lecture on geological erosion

Lecture on accelated erosion

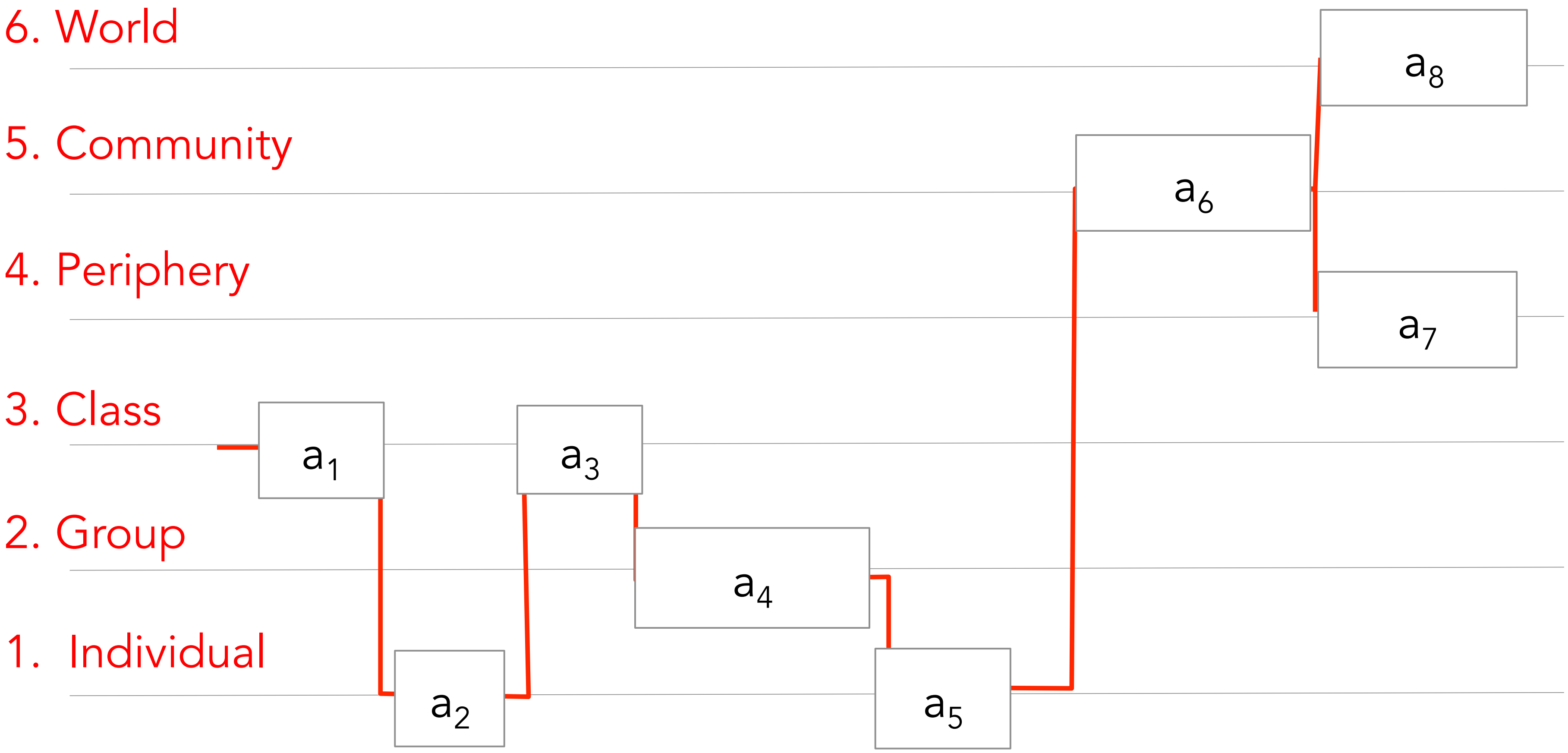
Classification exercoses


Introduction on geology
Upload a picture
Eliminate bad pictures
Lesson on geological versus accelerated erosion
Classify pictures
Compare pictures
Select top pictures
Lecture on accelated erosion
Lecture on geological erosion
Classification exercoses
TIME

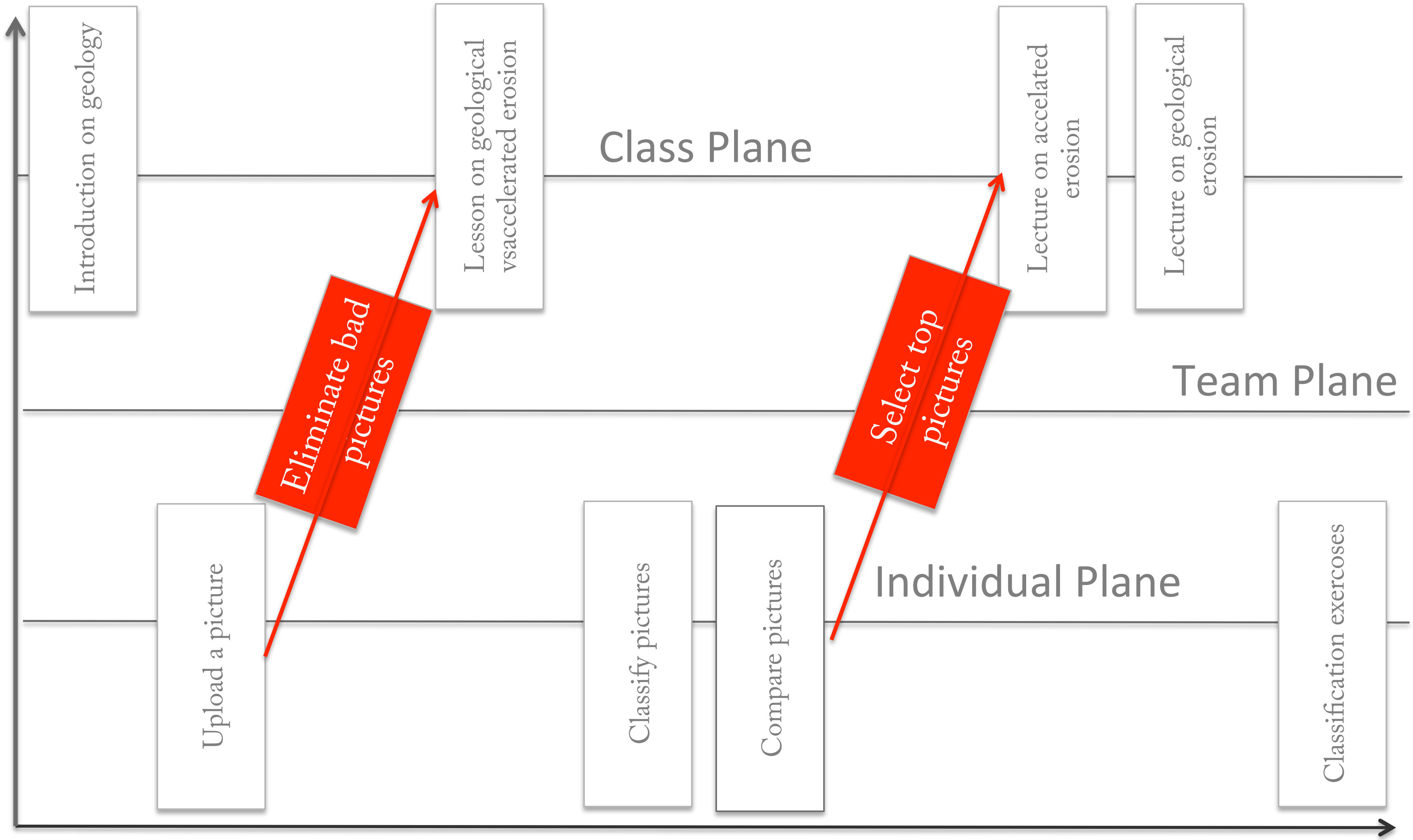

PLANE
Introduction on geology
Lesson on geological versus accelerated erosion
Class Plane
Lecture on accelated erosion
Lecture on geological erosion
Upload a picture
Classify pictures
Compare pictures
Individual Plane
Classification exercoses
TIME


PLANE
Introduction on geology
Lesson on geological vsaccelerated erosion
Class Plane
Lecture on accelated erosion
Lecture on geological erosion
Team Plane
Compare pictures
Upload a picture
Classify pictures
Individual Plane
Classification exercoses
TIME

A pedagogical scenario is modelled as a graph

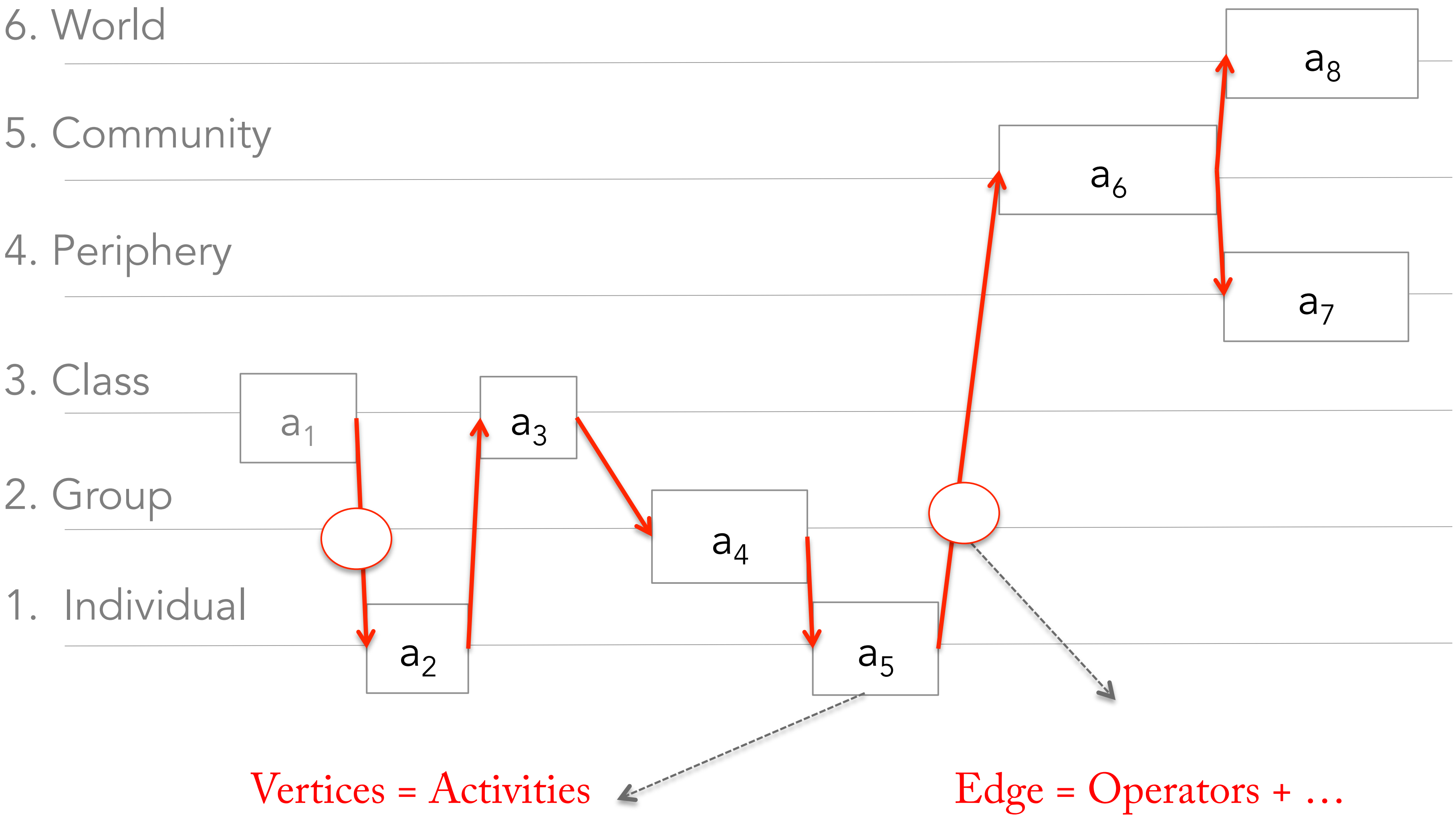


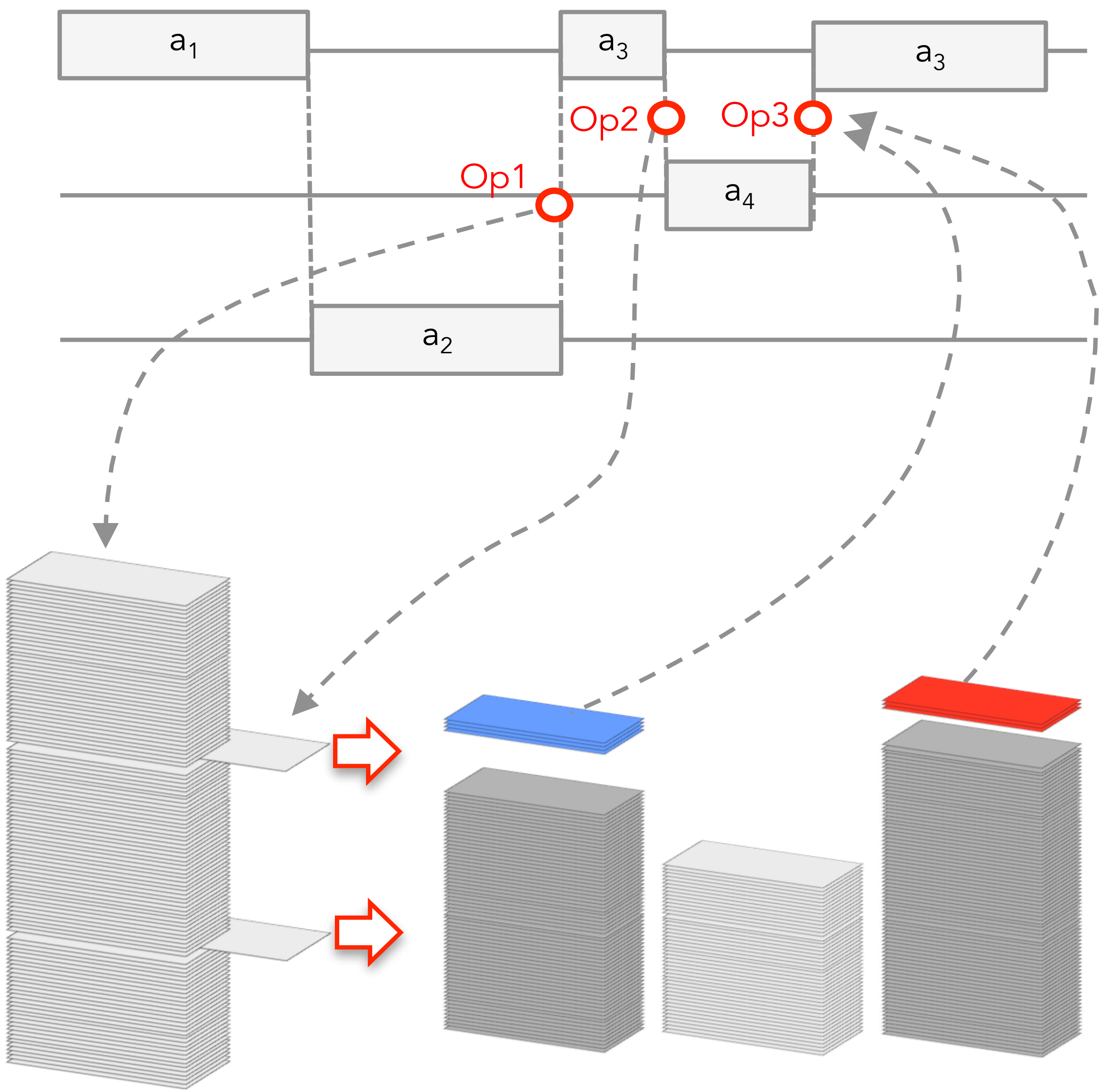
Introduction on geology
Take a picture
Eliminate bad pictures
Lesson on geological versus accelerated erosion
Classify pictures
Compare pictures
Select top pictures
Lecture on accelated erosion
Lecture on geological erosion
Classification exercoses
TIME



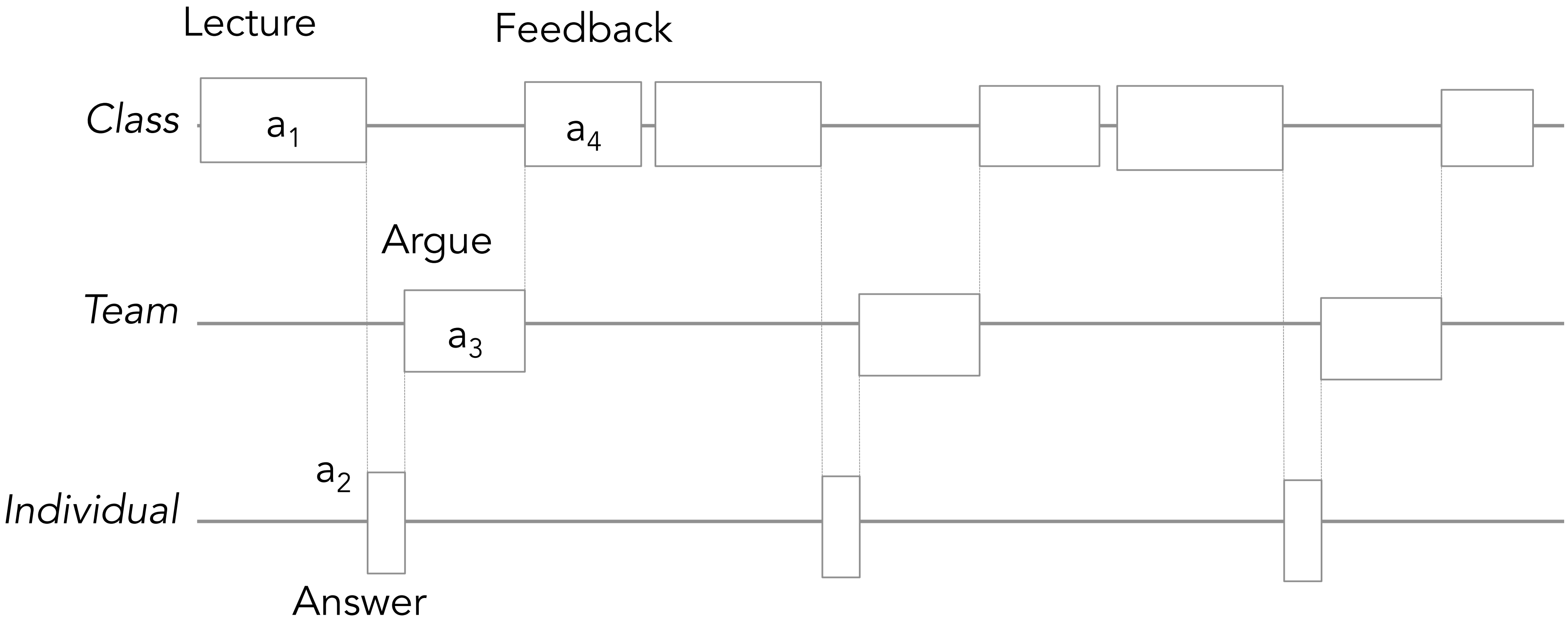
Introduction on geology
Lesson on geological vsaccelerated erosion
Class Plane
Lecture on accelated erosion
Lecture on geological erosion
Eliminate bad pictures
Select top pictures
Team Plane
Upload a picture
Classify pictures
Compare pictures
Individual Plane
Classification exercoses

An orchestration graph is a weighted directed geometric graph

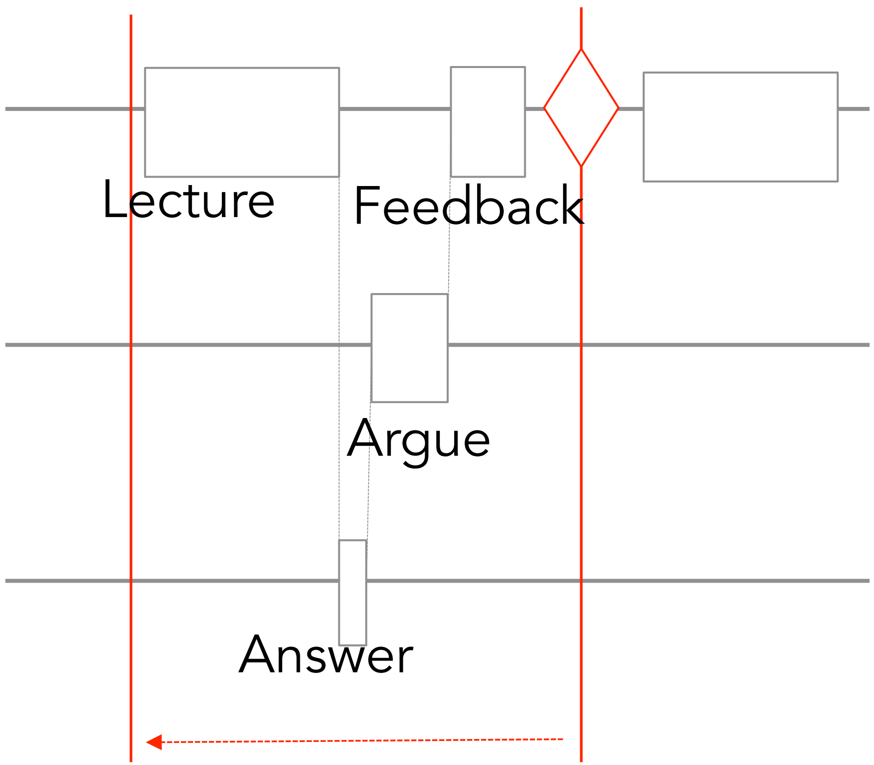




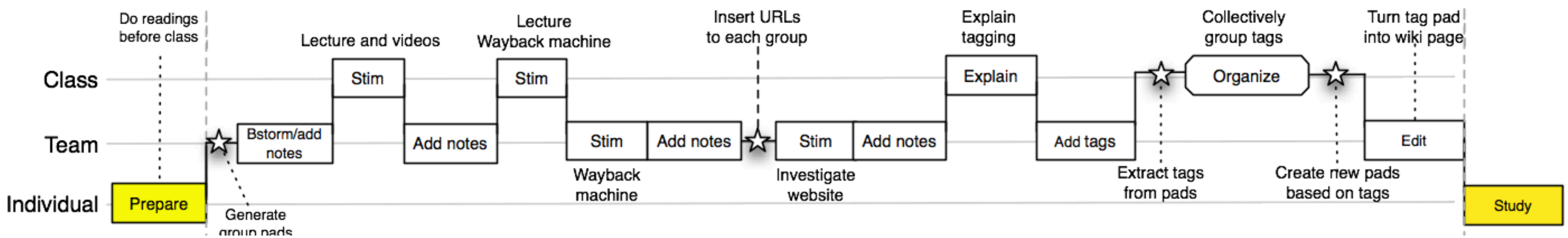
a1
a3
a3
Op2
Op3
Op1
a4
a2



Peer Instruction (E. Mazur)



Peer Instruction (E. Mazur)



Stian HAKEV

http://reganmian.net/blog/2014/10/03/a-pedagogical-script-for-idea-convergence-through-tagging-etherpad-content/

ArgueGraph

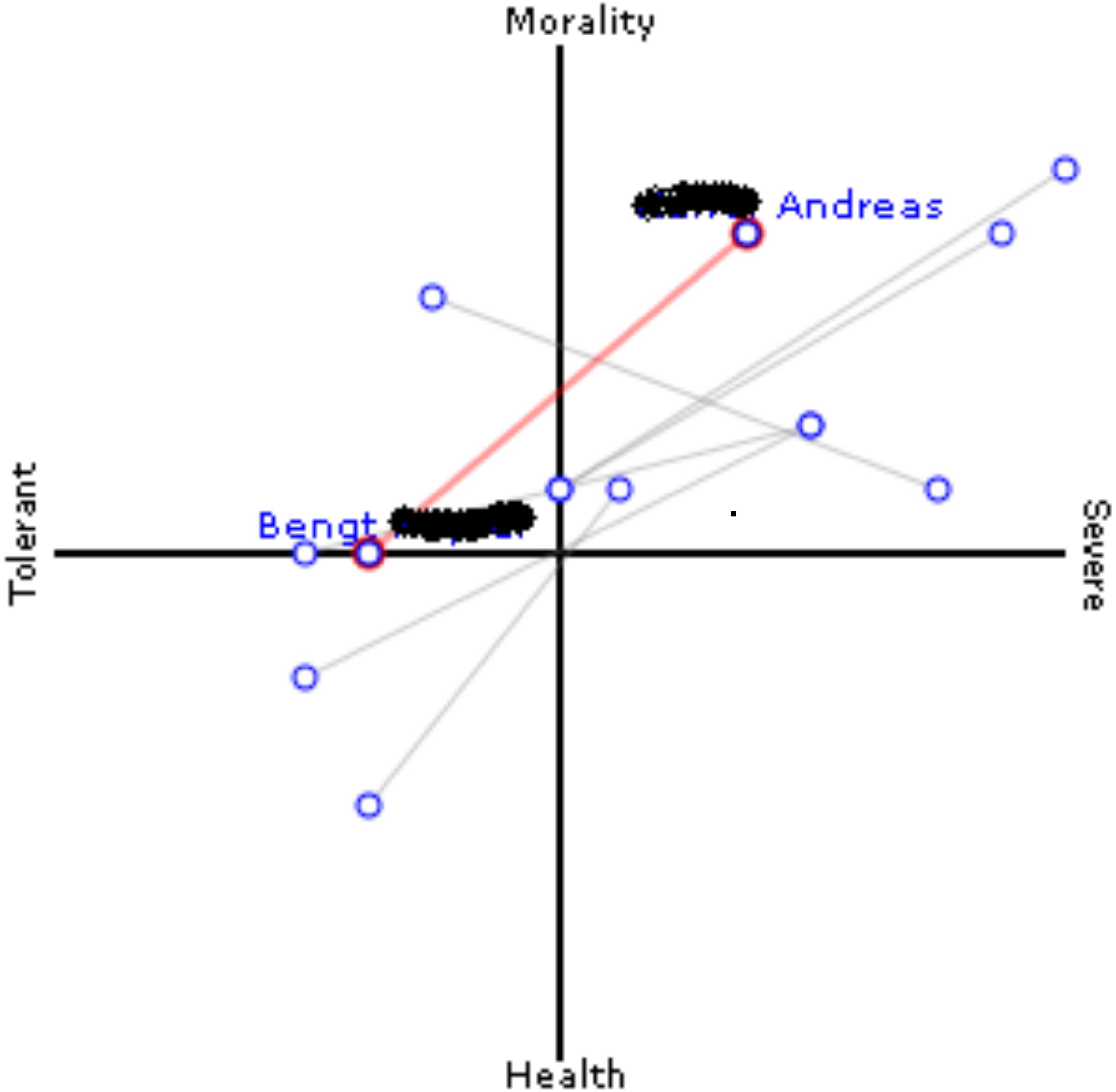
Question 1

Question: *In large city marathons, should drug testing be applied to participants that finish two hours after the winner?*

Answer:

- ○ Yes, because cheating should always be punished
- ○ Yes, because any runner taking drugs damages her health
- ○ No, because they run for themselves, not for rankings
- ◉ No, because people have also the right to smoke and to drink alcohol

Enter your arguments: I believe in individual freedom


Morality
[redacted] Andreas
Bengt [redacted]
Tolerant
Severe
Health

Question 1 :

Question: *In large city marathons, should drug testing be applied to participants that finish two hours after the winner?*

Answer:

- ○ Yes, because cheating should always be punished
- ○ Yes, because any runner taking drugs damages her health
- H ○ No, because they run for themselves, not for rankings
- B ◉ No, because people have also the right to smoke and to drink alcohol

Bengt [redacted]	Harrer [redacted]
None	For the people that are not relevant for the result lists, it's their own responsibility if they risk damage to their health. Yet, still they are cheating the other clean runners. To require a test from every amateur (while

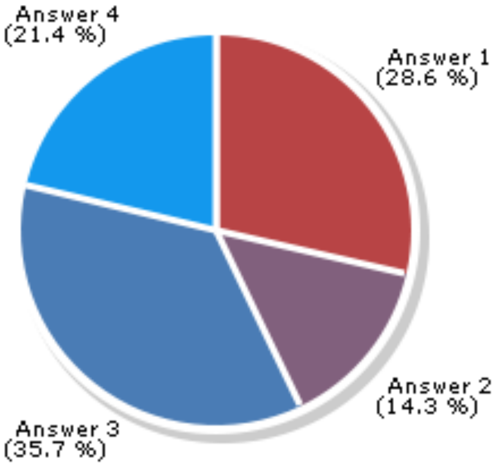
Enter your arguments:

We consider self-responsibilty an important quality for sportlers. Yet, it does not apply to participants getting prize or medals.

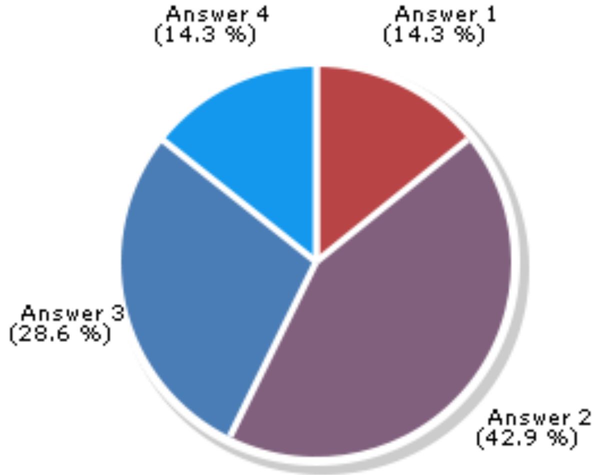
Question: In large city marathons, should drug testing be applied to participants that finish two hours after the winner?

Possible answers:
1) Yes, because cheating should always be punished
2) Yes, because any runner taking drugs damages her health
3) No, because they run for themselves, not for rankings
4) No, because people have also the right to smoke and to drink alcohol

Solo Block



Duo Block



ArgueGraph

Question 1 : *In large city marathons, should drug testing be applied to participants that finish two hours after the winner?*

Your answer and synthesis of known arguments :

Reminder

Individual :

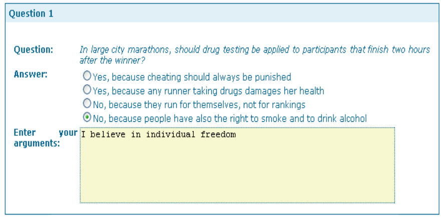
Your arguments :

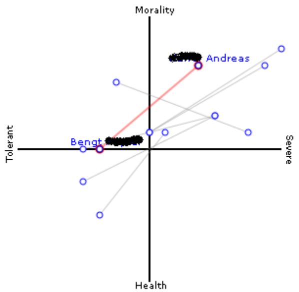
None

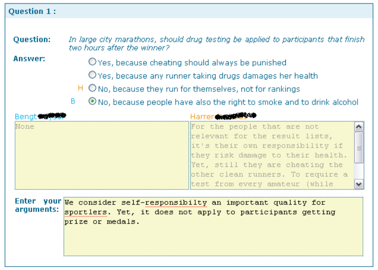
Individual arguments of students :

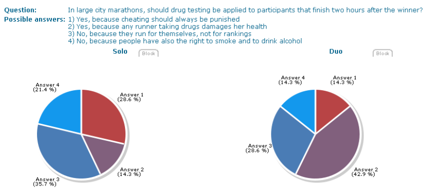
- No one would ever make the effort to run a marathon without being on drugs. *from* [redacted] *Nils*
- Someone who is two hours late this time could be the winner next time and the run before; in addition, it does not exclude drug use *from Frank* [redacted]
- For the people that are not relevant for the result lists, it's their own responsibility if they risk damage to their health. Yet, still they are cheating the other clean runners. To require a test from every amateur (while probably almost all of them are clean) would setup a system of total control and non-trust. *from* [redacted] *Andreas*
- Cheating should always be punished but in particular when it is useless. *from Pierre* [redacted]
- Even though a person runs a marathon for herself, she should be in favor of banning the use of drugs and willingly take the test *from Pantelis* [redacted]
- You should make sure that the winners do not use drugs. No need to test the loosers who are rather running for themselves. *from Armin* [redacted]

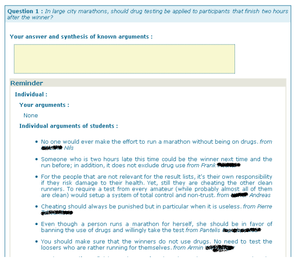
ArgueGraph











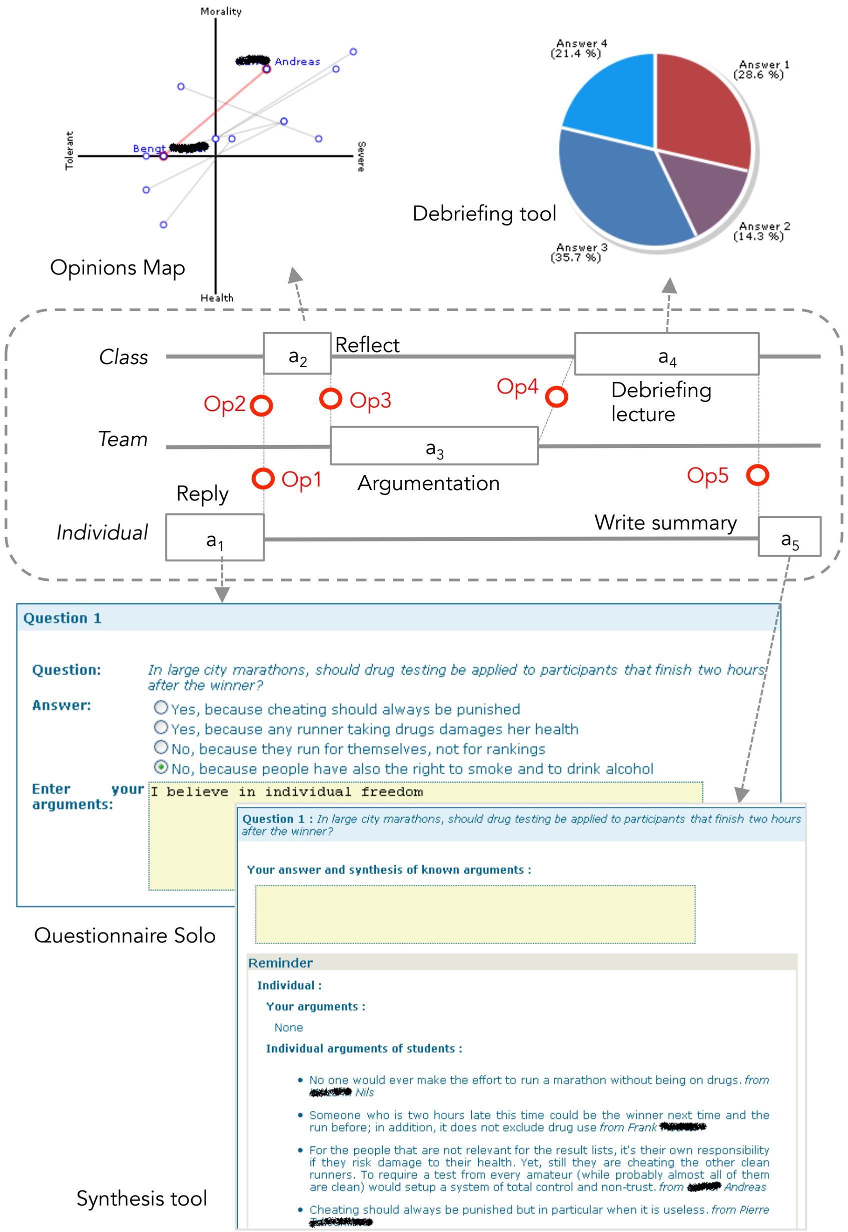
1. Each student takes a multiple-choice questionnaire produced by the teacher. The questions have no correct or wrong answer; their answers reflect theories about learning. For each choice, the students enter an argument in a free-text entry zone.

2. The system produces a graph in which students are positioned according to their answers. A horizontal and vertical score is associated to each answer of the quiz and the students' position is simply the sum of these values. Students look at the graph and discuss it informally. The system or the tutor forms pairs of students by selecting peers with the largest distance on the graph (i.e., that have most different opinions).

3. Pairs answer the same questionnaire together and again provide an argument. They can read their individual previous answer.

4. For each question, the system aggregates the answers and the arguments given individually (Phase 1) and collaboratively (Phase 3). During a face-to-face debriefing session, the teacher asks students to comment on their arguments. The set of arguments covers more or less the content of the course but is completely unstructured. The role of the teacher is to organize the students' arguments into theories, to relate them, to clarify definitions, in other words, to structure emergent knowledge

5. Each student writes a synthesis of arguments collected for a specific question. The synthesis has to be structured according



(Op1) After a_1, an operator aggregates the student answers in order to compute their horizontal and vertical position of each learner and produces the opinions map. This is an example of aggregation operator.

(Op2) Another operator uses the position of each student in order to form pairs of individuals with conflicting opinions, which is communicated to learners during a_2. This is a social operator

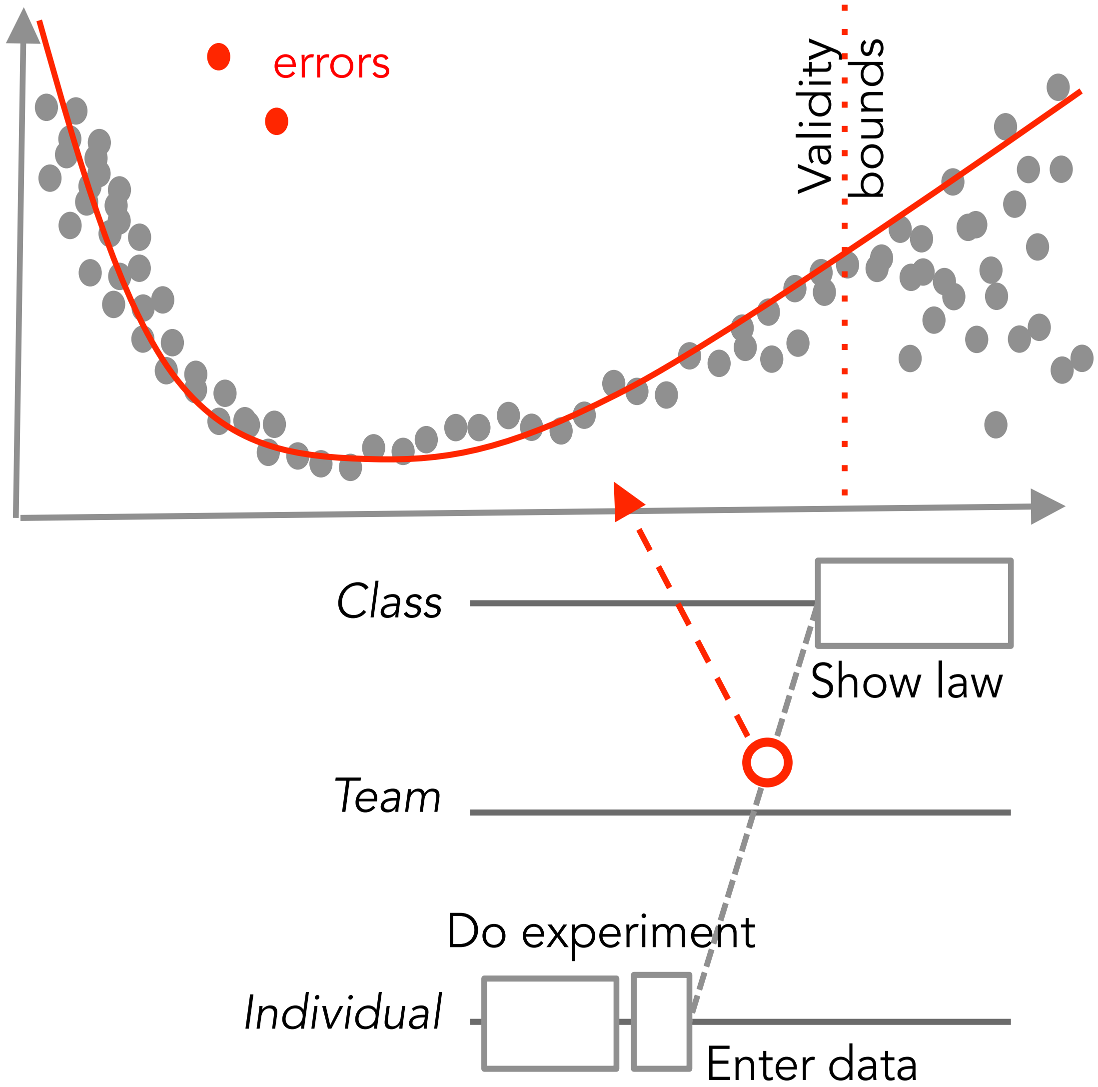
(Op3) For a_3, an operator aggregates -for each pair formed in a_2- the answers that the two peers gave individually in a_1. This is also an aggregation operator.

(Op4) For a_4, an operator counts all answers and justifications per question, for each individual and each team. This aggregation operator produces several pie charts and tables that the teacher uses during the debriefing lecture.

(Op5) For a_5, an operator produces a list of all data collected per question, which the student will use to write their summary.

Library of Graph Operators

Aggregation	Distribution	Social	BackOffice
(A) Listing	(D) Broadcasting	(S) Group formation	(B) Grading
(A) Classifying	(D) User selection	(S) Class Split	(B) Feedback
(A) Sorting	(D) Sampling	(S) Role assignment	(B) Anti-plagiarism
(A) Synthesizing	(D) Splitting	(S) Role rotation	(B) Rendering
(A) Visualizing	(D) Conflicting	(S) Group rotation	(B) Translating
	(D) Adapting	(S) Drop out management	(B) Summarizing
		(S) Anonymisation	(B) Converting
			(B) Updating


errors
Validity bounds
Class
Show law
Team
Do experiment
Individual
Enter data

analytics

$$G = (V, E) \text{ where } E = V \times V$$

$$V = \{a_i\} \mid a_i: t^s, t^e, \pi, \text{object}, \text{product}, \{c\}, \text{traces}, \{\text{metadata}\}$$

$$E = \{ e_{ij}\} \mid e_{ij}: (a_i, a_j, \{\text{operators}\}, \{\text{controls}\}, \text{label}, \text{weight}, \text{elasticity})$$

Workflow

Aggregation	Distribution	Social	BackOffice
(A) Listing	(D) Broadcasting	(S) Group formation	(B) Grading
(A) Classifying	(D) User selection	(S) Class Split	(B) Feedback
(A) Sorting	(D) Sampling	(S) Role assignment	(B) Anti-plagiarism
(A) Synthesizing	(D) Splitting	(S) Role rotation	(B) Rendering
(A) Visualizing	(D) Conflicting	(S) Group rotation	(B) Translating
	(D) Adapting	(S) Drop out management	(B) Summarizing
		(S) Anonymisation	(B) Converting
			(B) Updating

Pedagogical idea

Preparation	Set	Translation	Generalization
(P) Pre-requisite	(S+) Aggregation	(T) Proceduralisation	(G+) Induction
(P) ZPD	(S+) Expansion	(T) Elicitation	(G+) Deduction
(P) Adv. organizer	(S-) Decomposition	(T) Alternate	(G+) Extraction
(P) Motivation	(S-) Selection	(T) Re-Frame	(G+) Synthesis
(P) Anticipation	(S=) Juxtaposition	(T) Reverse	(G=) Analogy
(P) Logistics	(S=) Contrast	(T) Repair	(G=) Transfer
(P) Data Collection	(S=) Identity	(T) Teach	(G-) Restriction

Stochastic model

Library of Edge Labels

Why is a_i a condition for a_j ?

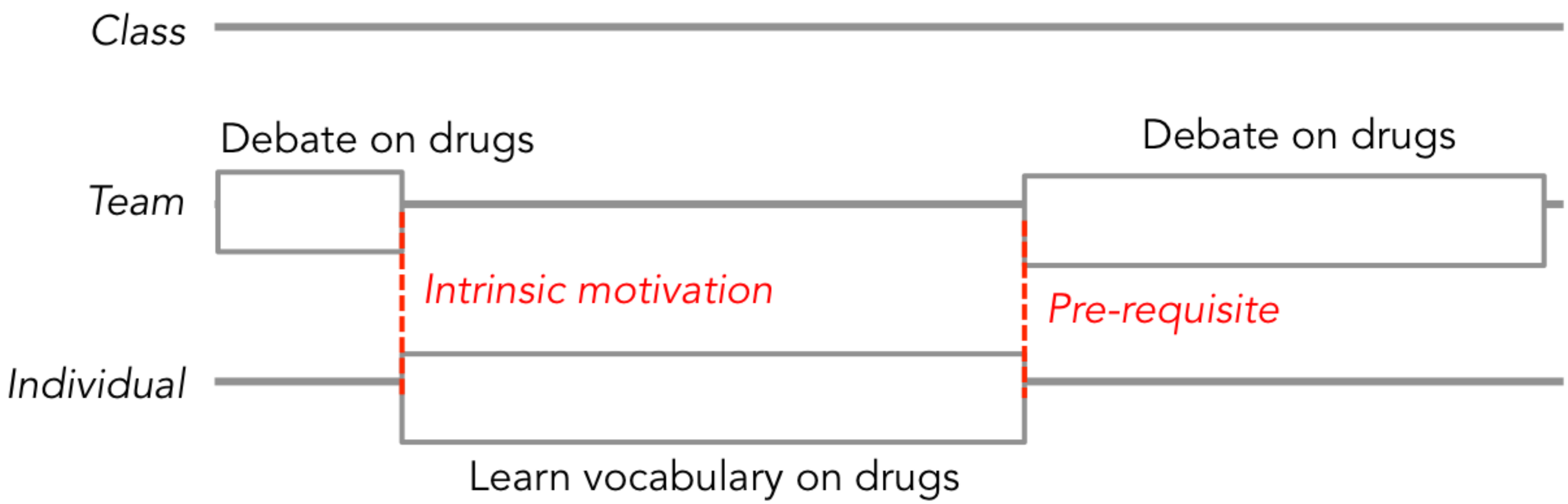
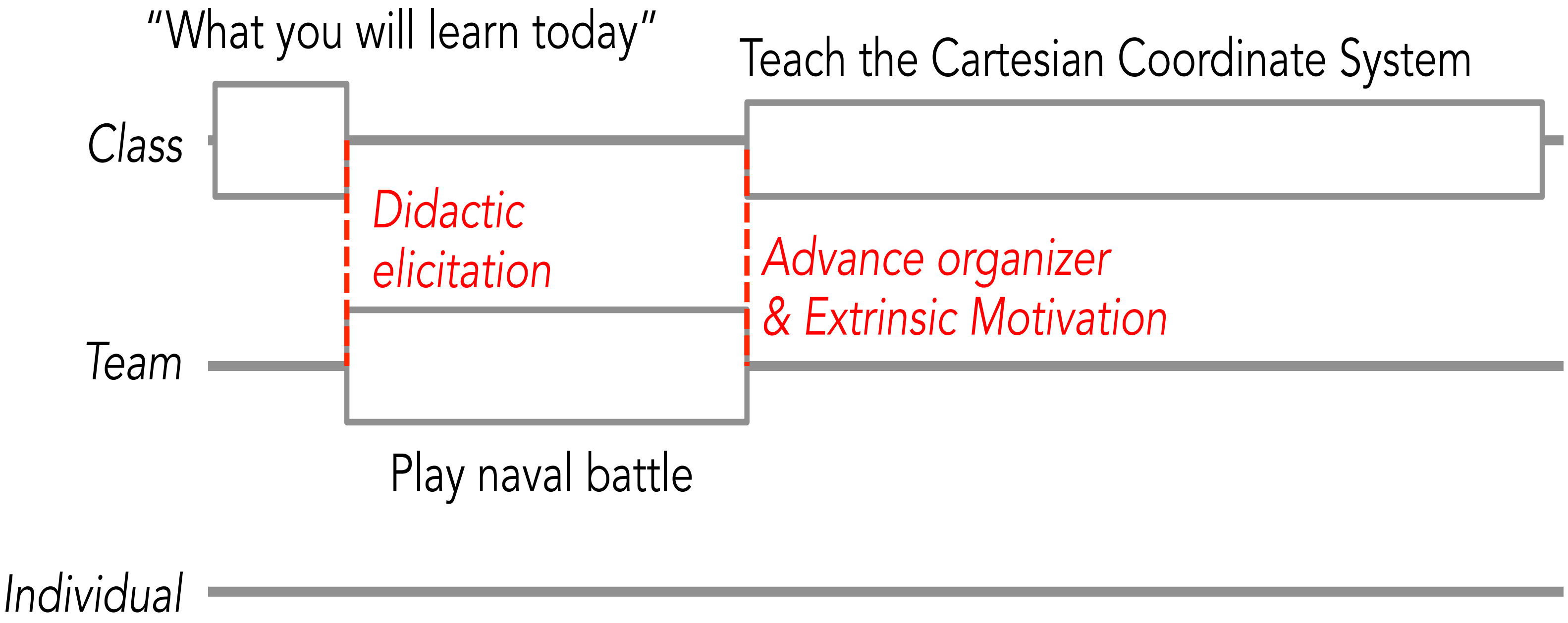
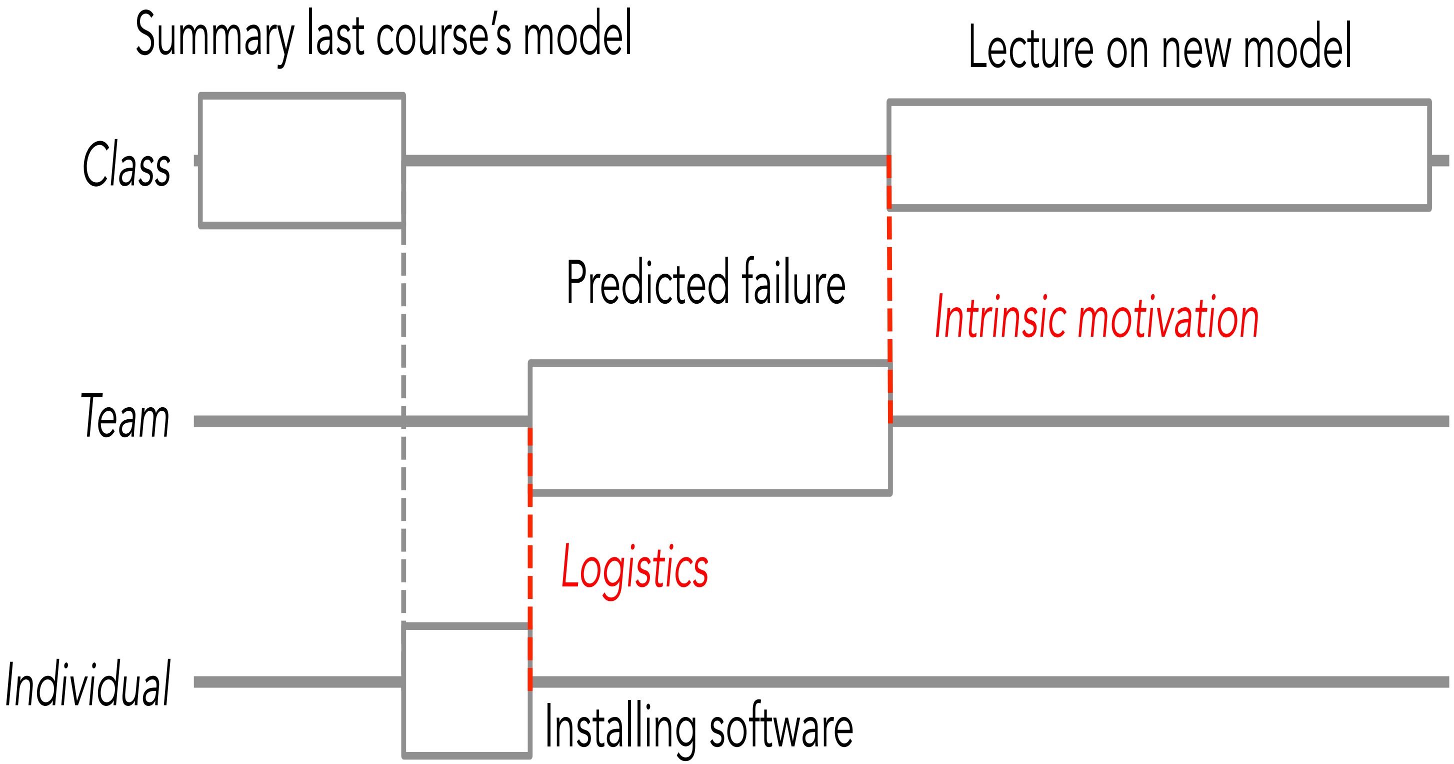


Figure 9.1. Edge labels in a "German as foreign language" graph. The graph includes a group debate on a topic, e.g. drugs. This generates some frustration among learners due to their lack of vocabulary. This frustration hypothetically creates motivation to learn some vocabulary. This activity is a pre-requisite for the debate that will follow.



"What you will learn today"
Teach the Cartesian Coordinate System
Class
Didactic elicitation
Advance organizer & Extrinsic Motivation
Team
Play naval battle
Individual


Summary last course's model
Lecture on new model
Class
Predicted failure
Intrinsic motivation
Team
Logistics
Individual
Installing software

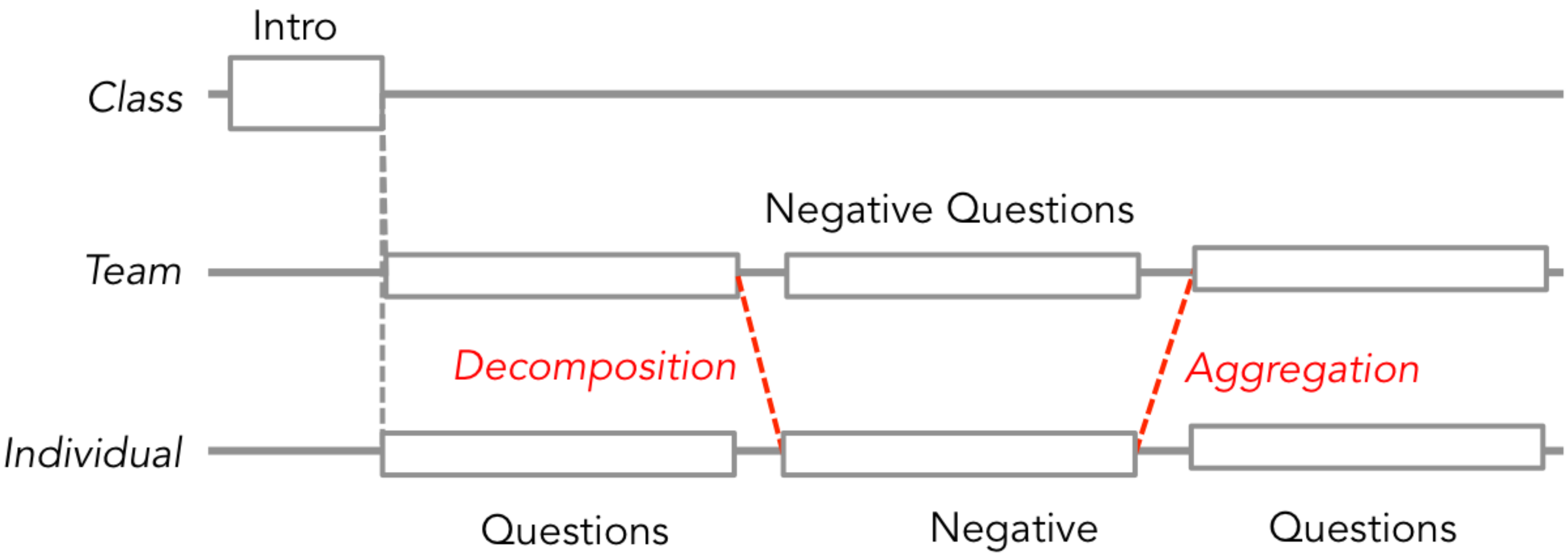


Figure 10.1. After an introduction, the teacher splits the class into two sub-classes, those who have already studied how to form questions and negative sentences in English and those who did not. The novices do individual exercises on each skill, first questions and then negative sentences and finally these two skills are aggregated during pair dialogue exercises that include negative questions. The more experienced sub-class starts directly with the pair dialogue exercises, but the students who encounter difficulties are then redirected towards individual exercises on each skill.

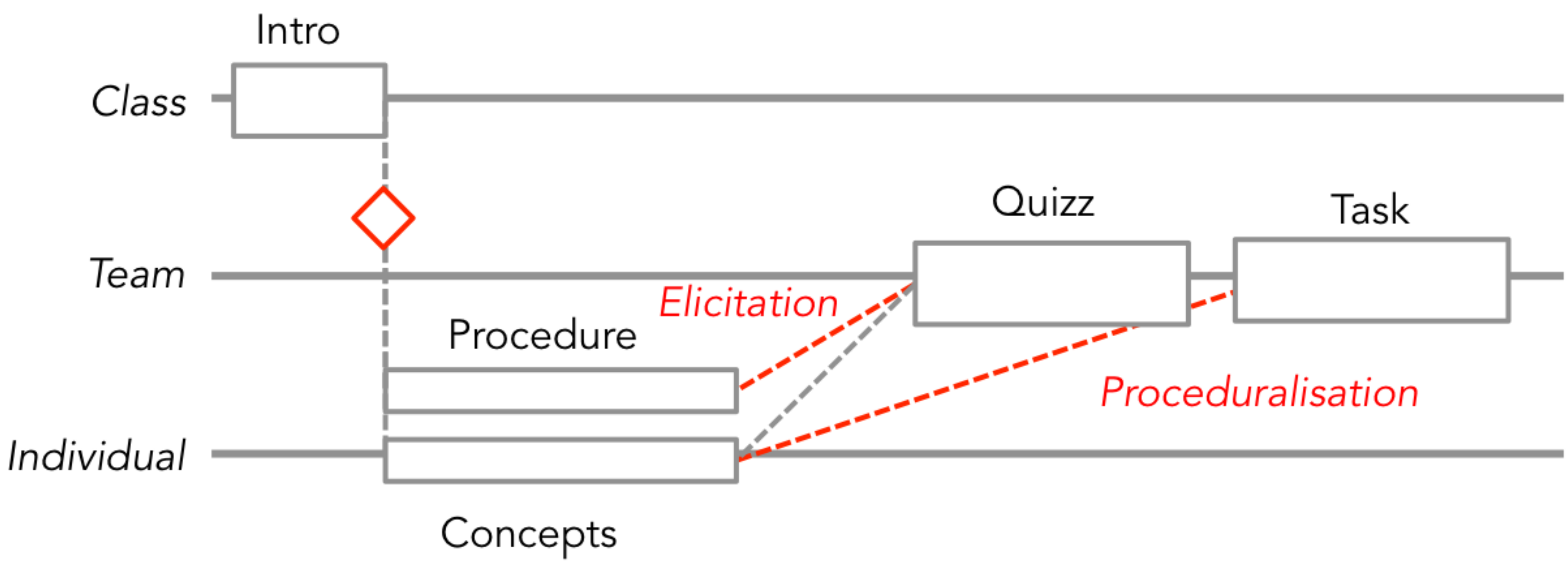
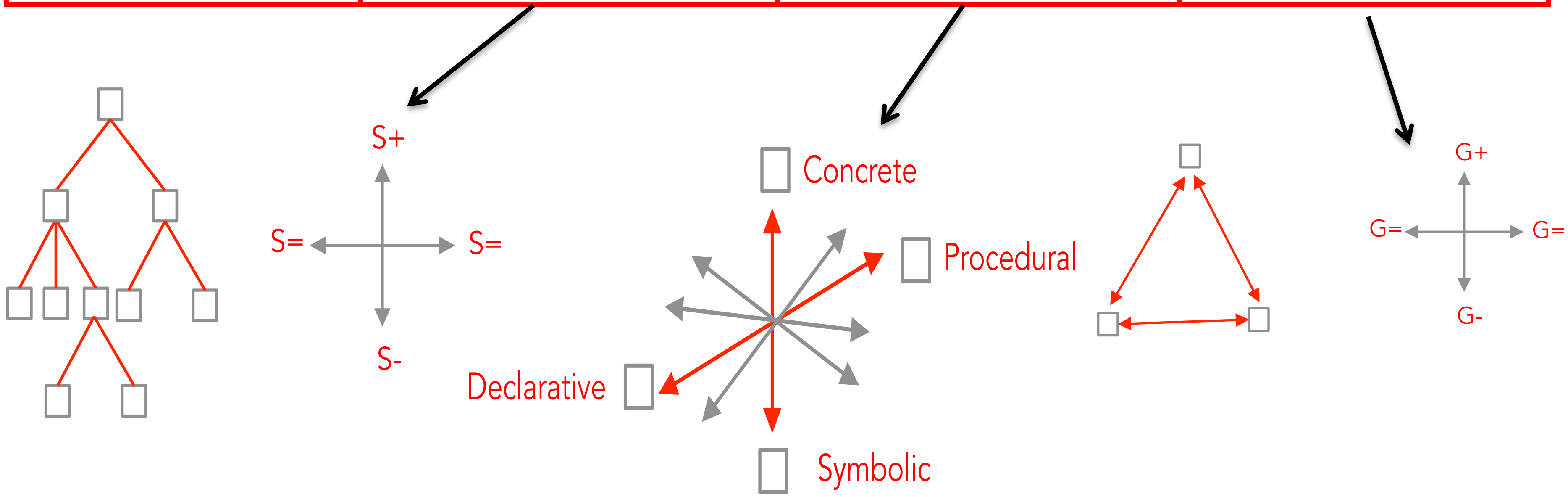
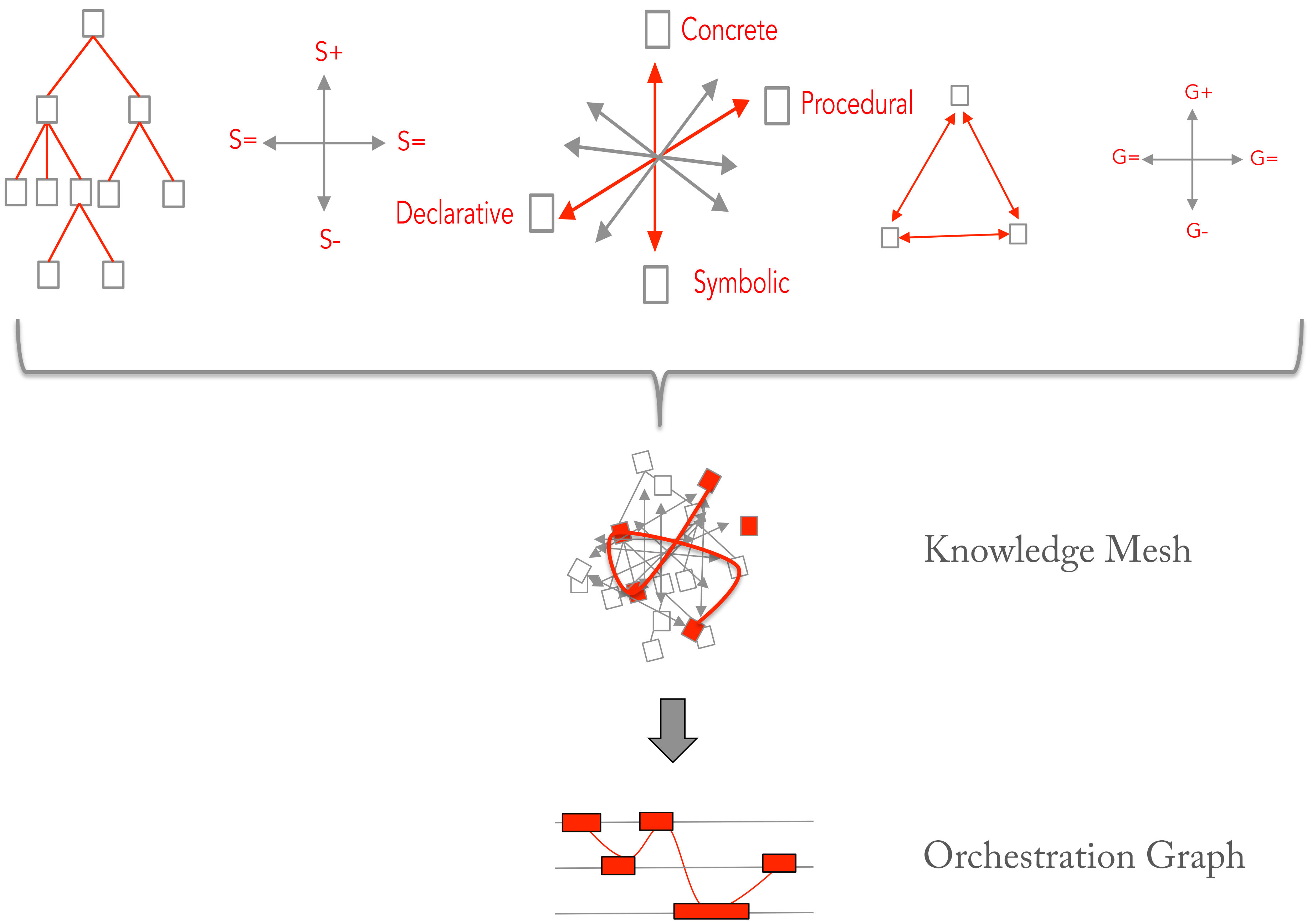


Figure 11.1. After an introductory video, the participants to this MOOC "introduction to statistics" are split into 2 sub-classes for individual activities. In the first subclass, students acquires procedural knowledge; how to compute manually the standard deviation for a set of 20 data points. In the second sub-class, students acquire declarative knowledge: the concepts of dispersion, heterogeneity and variance, illustrated graphical representations. Then, every student from a subclass is paired with a student from the other sub-class and they have to collaborative do first a quiz that measures declarative knowledge and then a task that requires procedural knowledge. To be able to collaborate with their peer, those who acquired declarative knowledge individually have to proceduralize it with the help of their peer and those who acquired procedural knowledge individually have to elicit it (next edge label).

Library of Edge Labels

Preparation	Set	Translation	Generalization
(P) Pre-requisite	(S+) Aggregation	(T) Proceduralisation	(G+) Induction
(P) ZPD	(S+) Expansion	(T) Elicitation	(G+) Deduction
(P) Adv. organizer	(S-) Decomposition	(T) Alternate	(G+) Extraction
(P) Motivation	(S-) Selection	(T) Re-Frame	(G+) Synthesis
(P) Anticipation	(S=) Juxtaposition	(T) Reverse	(G=) Analogy
(P) Logistics	(S=) Contrast	(T) Repair	(G=) Transfer
(P) Data Collection	(S=) Identity	(T) Teach	(G-) Restriction



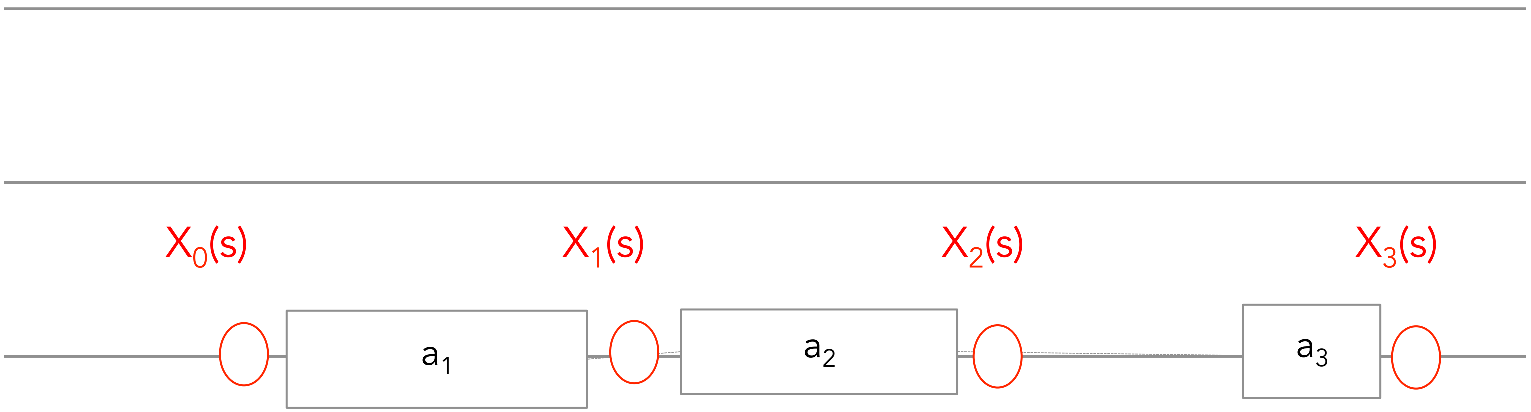

S+
S=
S=
S-
Concrete
Procedural
Declarative
Symbolic
G+
G=
G=
G-
Knowledge Mesh
Orchestration Graph

$G = (V, E)$ where $E = V \times V$

$V = \{a_i\} \mid a_i: t^s, t^e, \pi, \text{object}, \text{product}, \{c\}, \text{traces}, \{\text{metadata}\}$

$E = \{ e_{ij}\} \mid e_{ij}: (a_i, a_j, \{\text{operators}\}, \{\text{controls}\}, \text{label}, \text{weight}, \text{elasticity})$

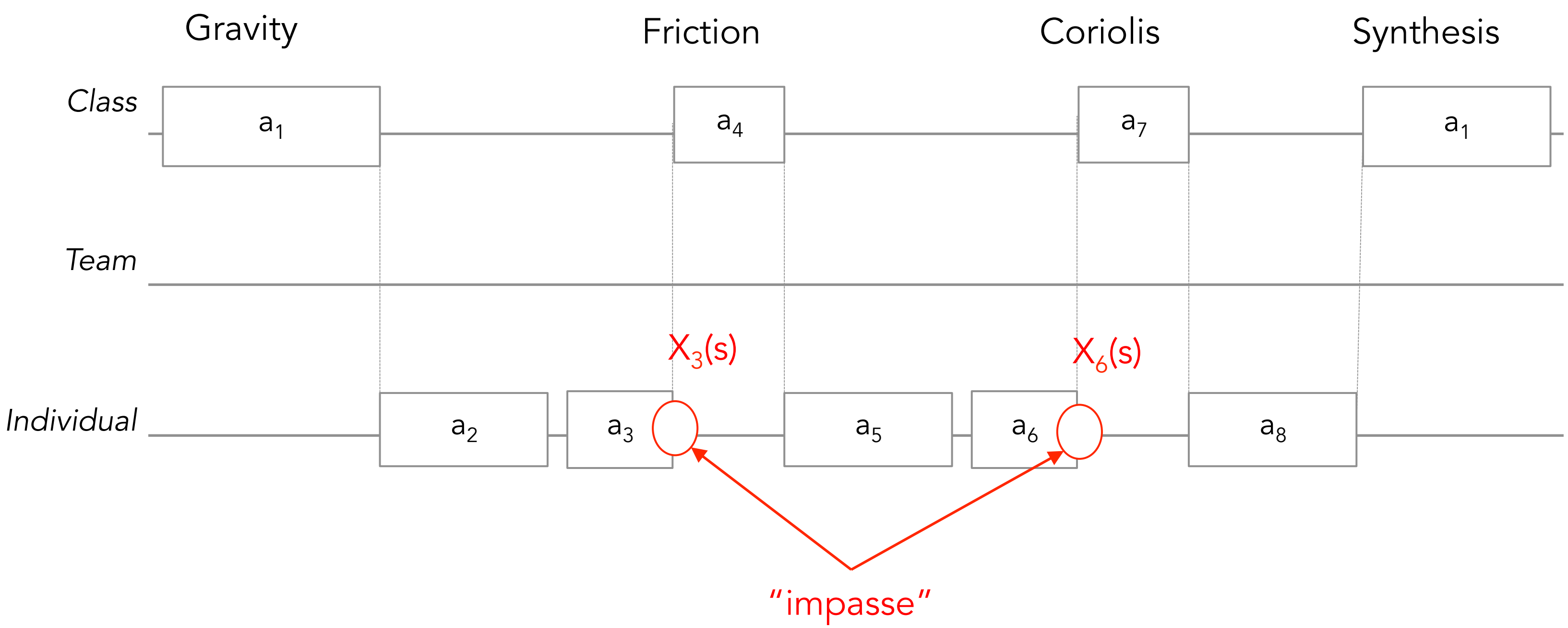
Orchestration



$$X_0(s) \longrightarrow X_1(s) \longrightarrow X_2(s) \longrightarrow X_3(s)$$

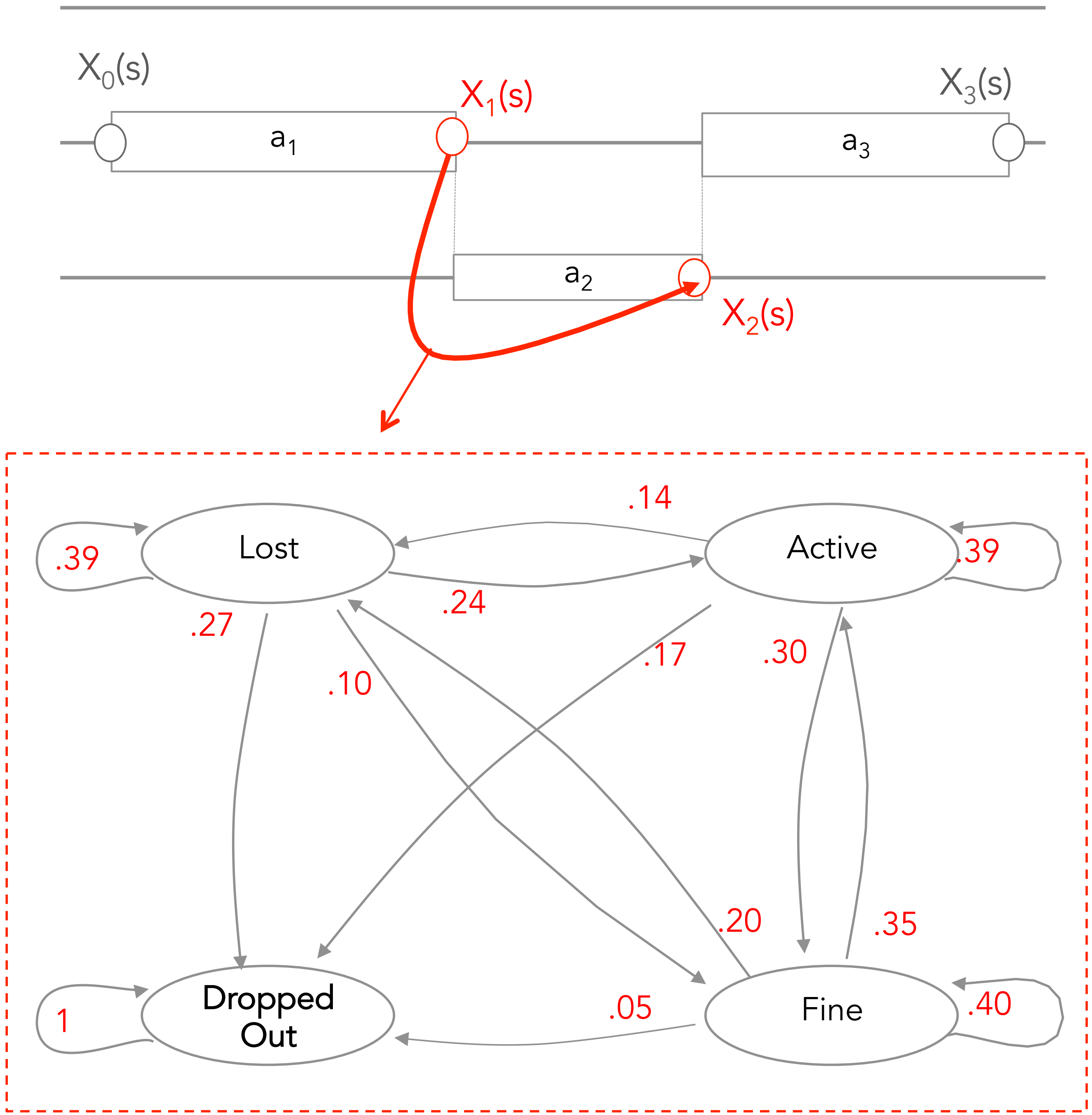
$$x_i\,(s) \in X_i(S) = \{\text{fine, active, lost, drop}\}$$

State "fine": the learner is performing well
State "active": the learner is working but does not seem to succeed well
State "lost": the learner does not understand at all or did not complete the activities
State "drop": the learned has dropped out (e.g. no login since N days)


Gravity
Friction
Coriolis
Synthesis
Class
Team
Individual
a1
a4
a7
a1
a2
a3
a5
a6
a8
X3(s)
X6(s)
"impasse"

Library of States

		Plane of Activity		
		π_1	π_2	π_3
Plane of Modeling	Individual Model (π_1)	**X_i (s)**	**X_i (s_1)**	**X_i (s_1)**
		Active / Passive	Social loafing	With-me
		On-Leave / Drop-Out / Late-Comer	Free-rider	Central
		Disoriented	Leader	Isolated
		Linear rigidity	On/Off Role	Bridge
		Impasse		
		Trapped		
		Over/Under generalization		
		Deep/surface		
		Gaming		
	Group Model (π_2)		**X_i (s1,s2,s3,…)**	**X_i (s1,s2,s3,…)**
			Under/Over Sized	Cluster
			Cognitive/Emotional Conflict	
			Misunderstanding	
			Groupthink	
			Distributed	
	Class Model (π_3)			**X_i (S)**
				Good/Bad Spirit
				Slow
				Split



The weight of edges

State Transition Matrix

$M^{ij}(S)$	$X_2(s)$				
$X_1(s)$	Lost	Active	Fine	Drop	Total
Lost	39%	24%	10%	27%	100%
Active	14%	39%	30%	17%	100%
Fine	20%	35%	40%	5%	100%
Drop	0%	0%	0%	100%	100%

State Transition Matriy Entropy

$$H(X) = -\sum_i P(x_i)\log_b P(x_i)$$

M1	Lost	Active	Fine	**H**
Lost	0.98	0.01	0.01	0.16
Active	0.01	0.98	0.01	0.16
Fine	0.01	0.01	0.98	0.16

M2	Lost	Active	Fine	**H**
Lost	0.01	0.01	0.98	0.16
Active	0.01	0.01	0.98	0.16
Fine	0.01	0.01	0.98	0.16

M3	Lost	Active	Fine	**H**
Lost	0.34	0.33	0.33	1.58
Active	0.34	0.33	0.33	1.58
Fine	0.34	0.33	0.33	1.58

M4	Lost	Active	Fine	**H**
Lost	0.5	0.3	0.2	1.49
Active	0.1	0.4	0.5	1.36
Fine	0.1	0.1	0.8	0.92

M5	Lost	Active	Fine	Great	**H**	**H0**
Lost	0.25	0.25	0.25	0.25	2.00	1.00
Active	0.25	0.25	0.25	0.25	2.00	1.00
Fine	0.25	0.25	0.25	0.25	2.00	1.00
Great	0.25	0.25	0.25	0.25	2.00	1.00
					H'(M5)	**1.00**

State Transition Matriy Utopy

M6	Lost	Active	Fine	H	H0
Lost	0.01	0.24	0.75	0.87	0.55
Active	0.01	0.24	0.75	0.87	0.55
Fine	0.01	0.24	0.75	0.87	0.55
				ω(M5)	0.45

M7	Lost	Active	Fine	H	H0
Lost	0.75	0.24	0.01	0.87	0.55
Active	0.75	0.24	0.01	0.87	0.55
Fine	0.75	0.24	0.01	0.87	0.55
				ω(M6)	0.45

State Transition Matriy Utopy

M8

0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2
			U(M)	**0**

M11

1	0	0	0	0
1	0	0	0	0
1	0	0	0	0
1	0	0	0	0
1	0	0	0	0
			U(M)	**-1**

M9

1	0	0	0	0
0	1	0	0	0
0	0	1	0	0
0	0	0	1	0
0	0	0	0	1
			U(M)	**0**

M12

0.2	0.2	0.2	0.2	0.2
0.1	0.1	0.2	0.3	0.3
0	0	0.2	0.3	0.5
0	0.1	0.2	0.2	0.4
0	0	0	0.2	0.8
			U(M)	**0.47**

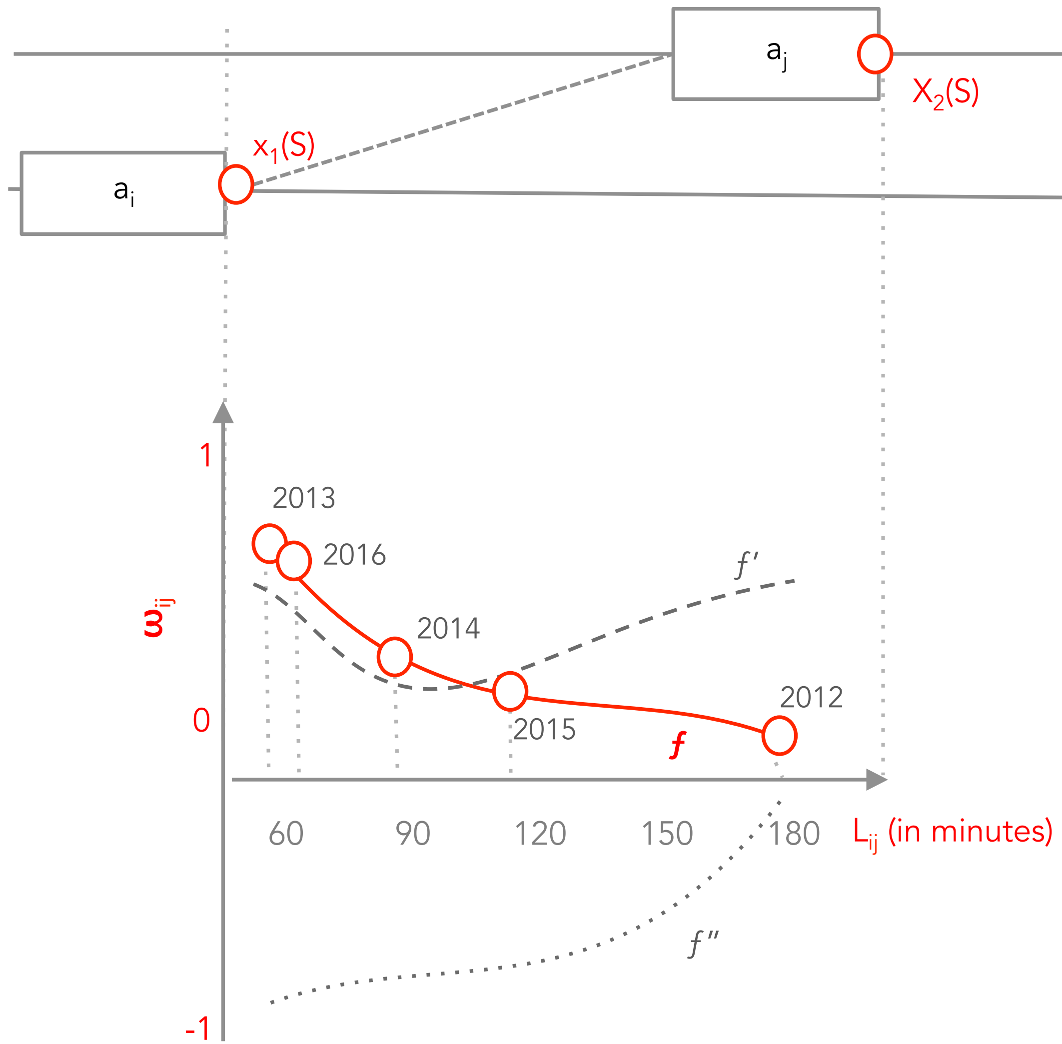
M10

0	0	0	0	1
0	0	0	0	1
0	0	0	0	1
0	0	0	0	1
0	0	0	0	1
			U(M)	**1**

M13

0.5	0.1	0.2	0.1	0.1
0.2	0.2	0.2	0.2	0.2
0.7	0.2	0.1	0	0
0.2	0.2	0.2	0.2	0.2
0.8	0.2	0	0	0
			U(M)	**-0.42**

The elastucuy of edges



How to build transition matrices ?

Association. If the learner associates frequently items x and y, such as "nitrate" and 'NO_3^-' during a_i, this increases the probability that, when presented with x during a_j, the learner will be able to cite y.

Reinforcement. This is a special case of association. If the learner behavior $b_i(s)$ is triggered by stimuli x and then followed systematically and immediately by a positive feedback during a_i, the probability increases that, if the stimuli x is presented during a_j, the learner will produce behavior $b_i(s)$.

Compilation. If the learner applies a procedural skill c many times during a_i, and if a_i and a_j are very similar to each other, the learner will probably apply c faster and with a lower cognitive load during a_j.

Chunking. If the learner applies c_1 and c_2 sequentially during a_i, the combined skill c_{12} will generate a lower cognitive load during a_j than the sum of the cognitive load triggered by c_1 and c_2.

Reflection. If, during a_i, the learner hesitates between possible answers that differ with respect to element x, an immediate feedback during a_i will inhibit the elicitation of x during a_j.

Argumentation. If two learners argue on x during a_i and if y is an element used in the argument y➔x, the probability increases that these learners may apply y➔x in a_j.

Explanation. If, during a_i, a learner elaborates a new explanation with a chain of elements [x➔y➔z], and a_i and a_j are very similar to each other, then the probability increases that the learner will be able to use x➔y or y➔z while performing a_j.

Induction. If, during a_i, a learner compares positive {e+} and negative {e-} instances of a concept K and if {f} is the set of features that are common to {e+} and simultaneously absent from {e-}, then the probability increases that the learner includes {f} in the definition of K after a_j.

Mutual regulation. If a student is able to regulate the problem solving process of his teammate during a_i, and if a_i and a_j require similar problem solving strategies, the probability increases that he will be able to regulate his own problem solving process during a_j.

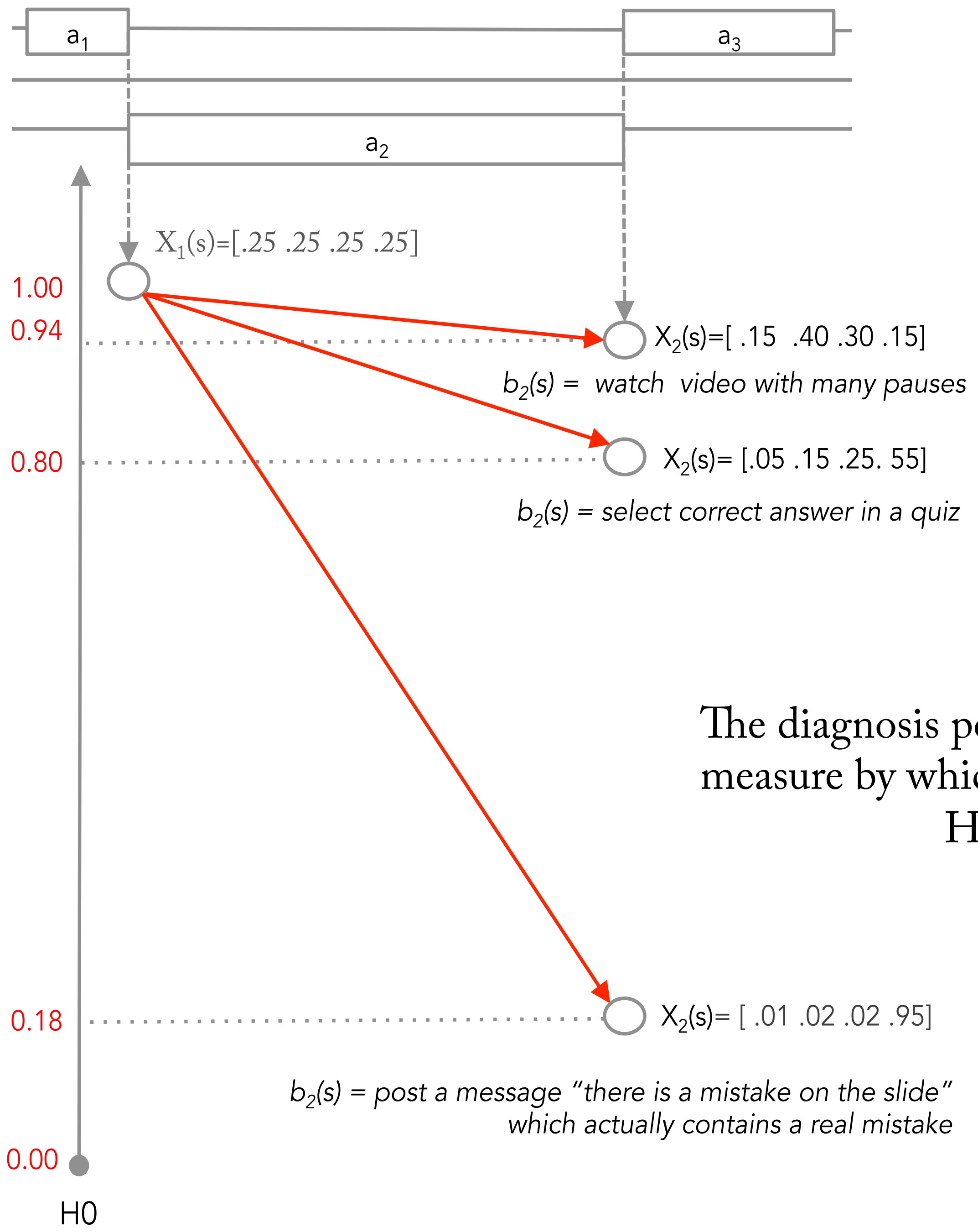
Internalization If, during a_i, a student s_1 participates into a meaningful dialogue with a more advanced student s_2 within the zone of proximal development of s_1, the probability increases that s_1 replays this dialogue during individual reasoning for a_j, i.e. as monologue.

How to build transition matrices ?

Learning Analytics

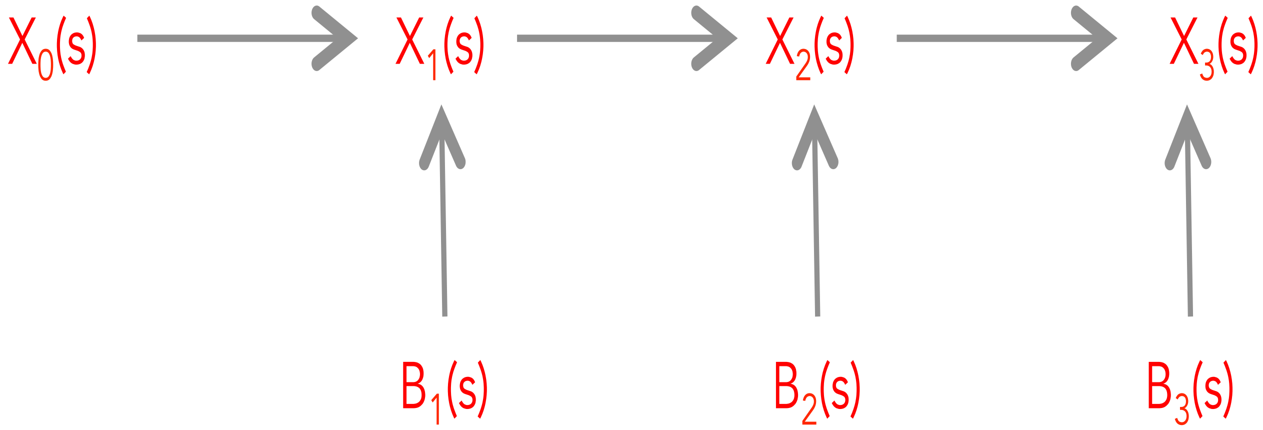
Diagnosis Entropy

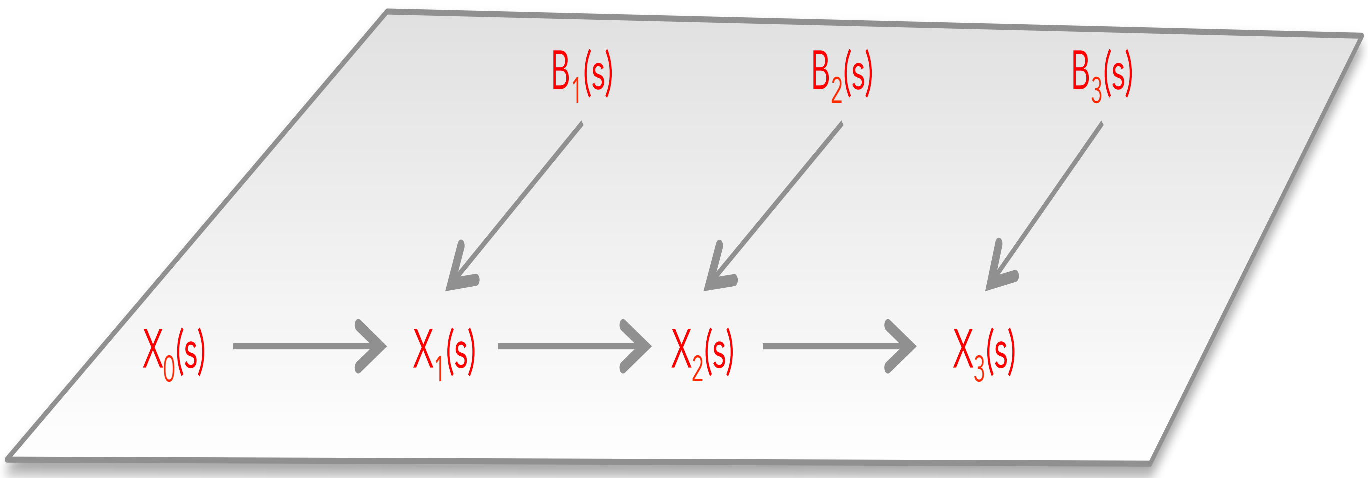
$X_i(S)=\{\text{lost, active, fine, brilliant}\}$

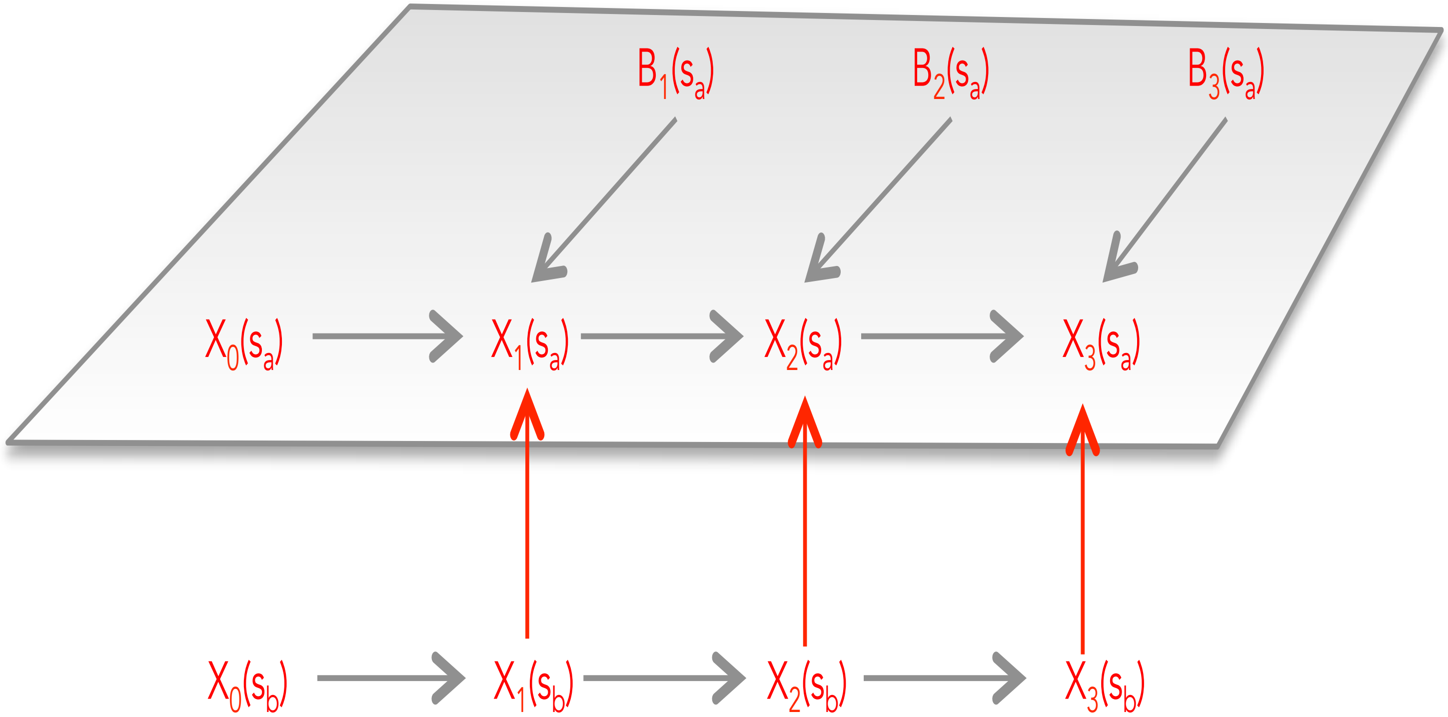


The diagnosis power of an activity a_i is the measure by which it reduces entropy:

$$H(X_i(s)) - H(X_{i-1}(s)).$$

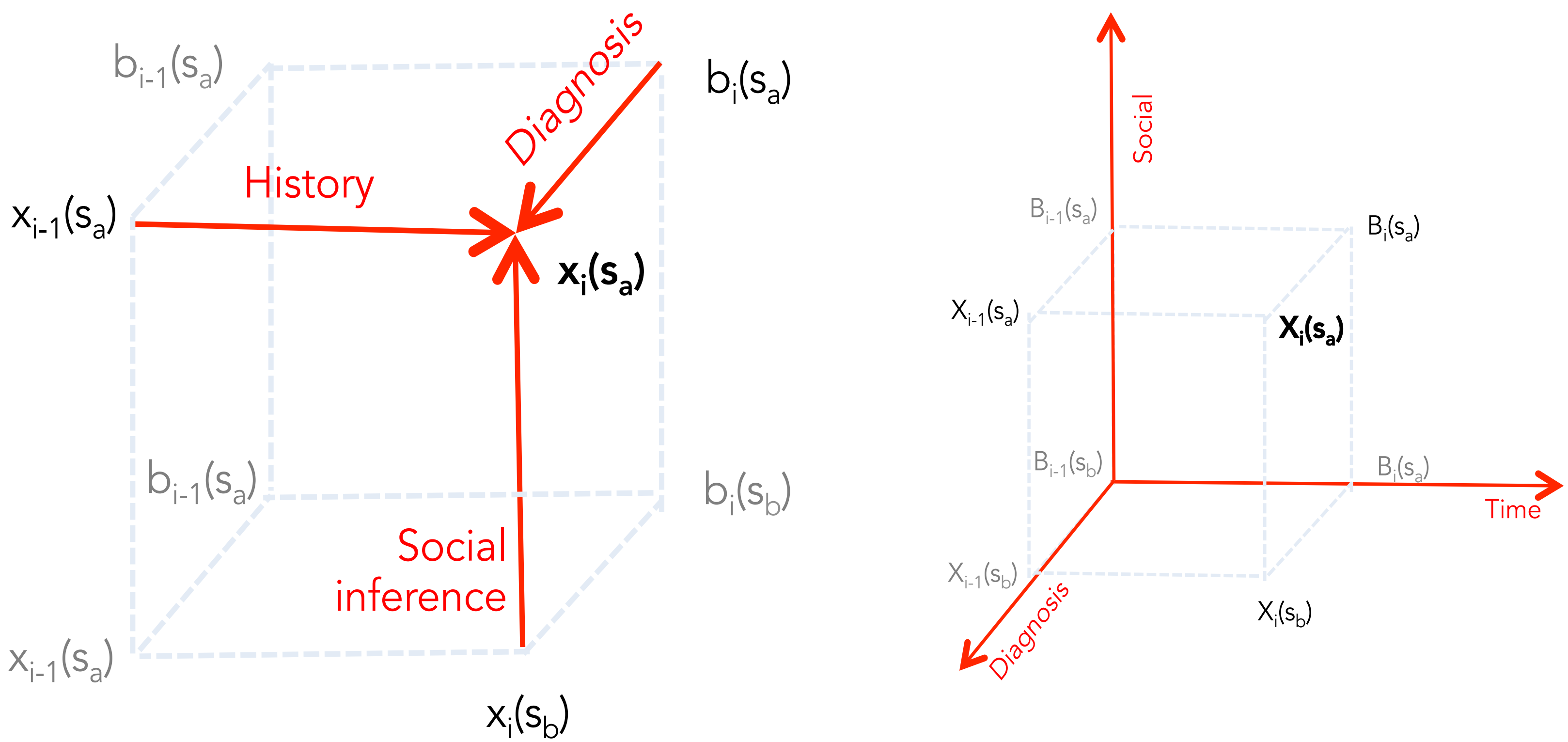

$X_0(s)$
$X_1(s)$
$X_2(s)$
$X_3(s)$
$B_1(s)$
$B_2(s)$
$B_3(s)$

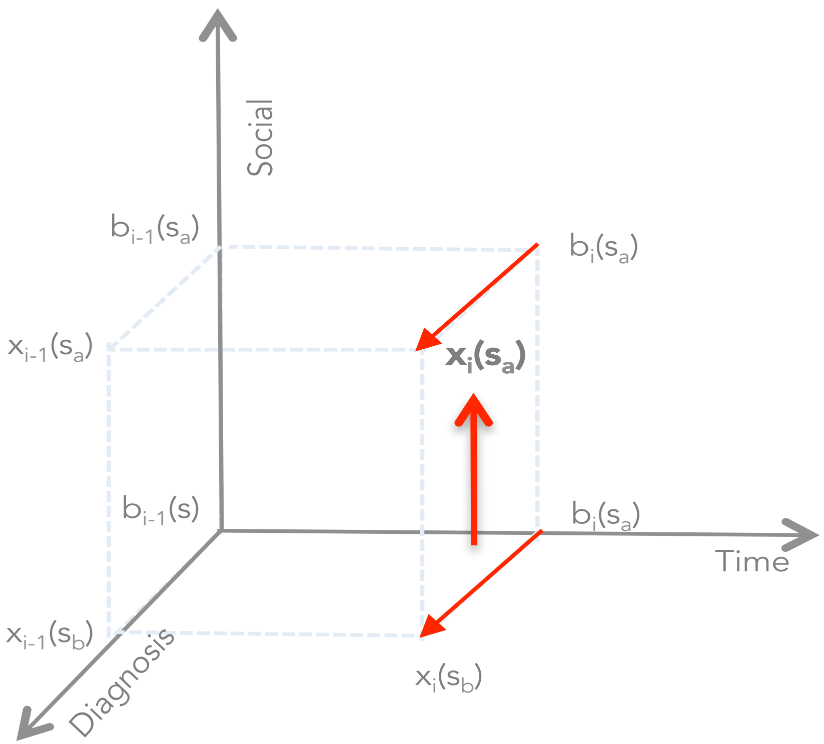

$B_1(s)$
$B_2(s)$
$B_3(s)$
$X_0(s)$
$X_1(s)$
$X_2(s)$
$X_3(s)$

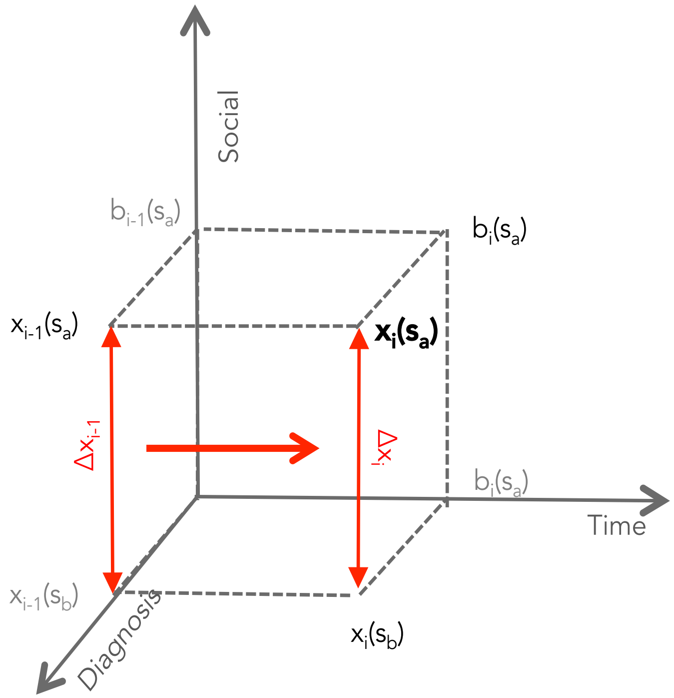


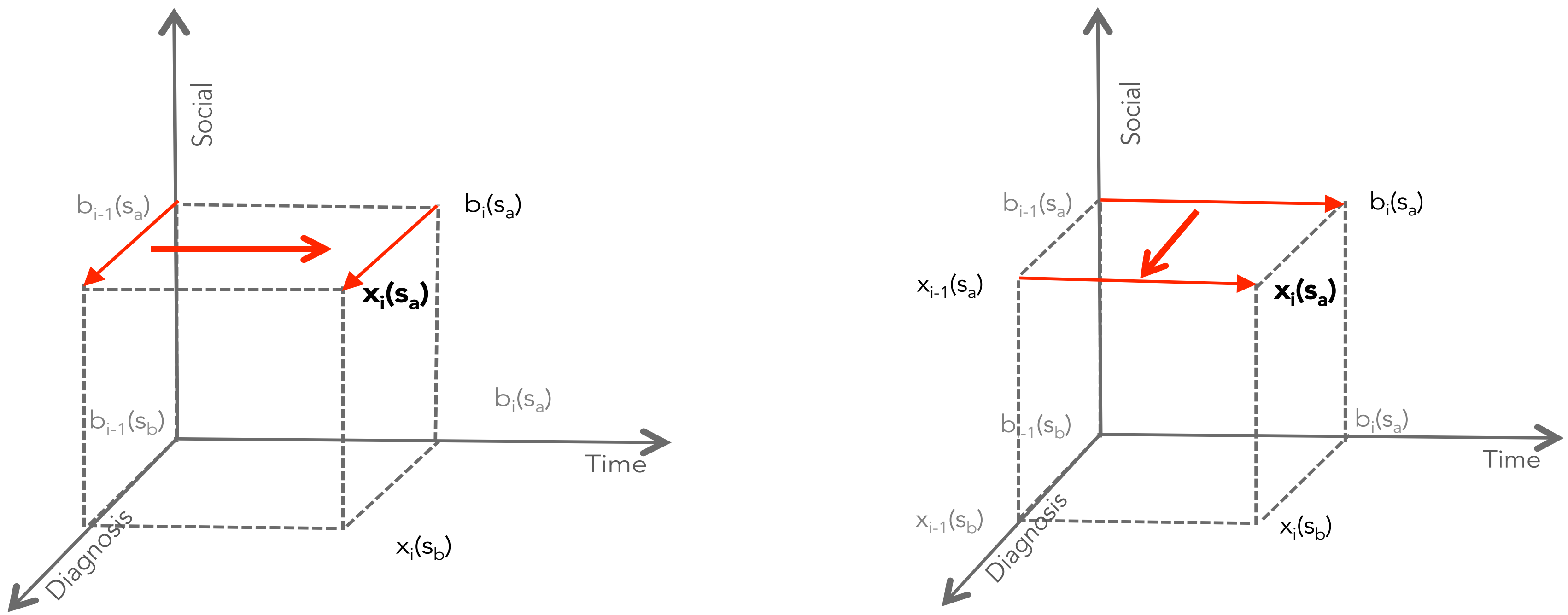
B1(sa)
B2(sa)
B3(sa)
X0(sa)
X1(sa)
X2(sa)
X3(sa)
X0(sb)
X1(sb)
X2(sb)
X3(sb)

The learning analytics cube

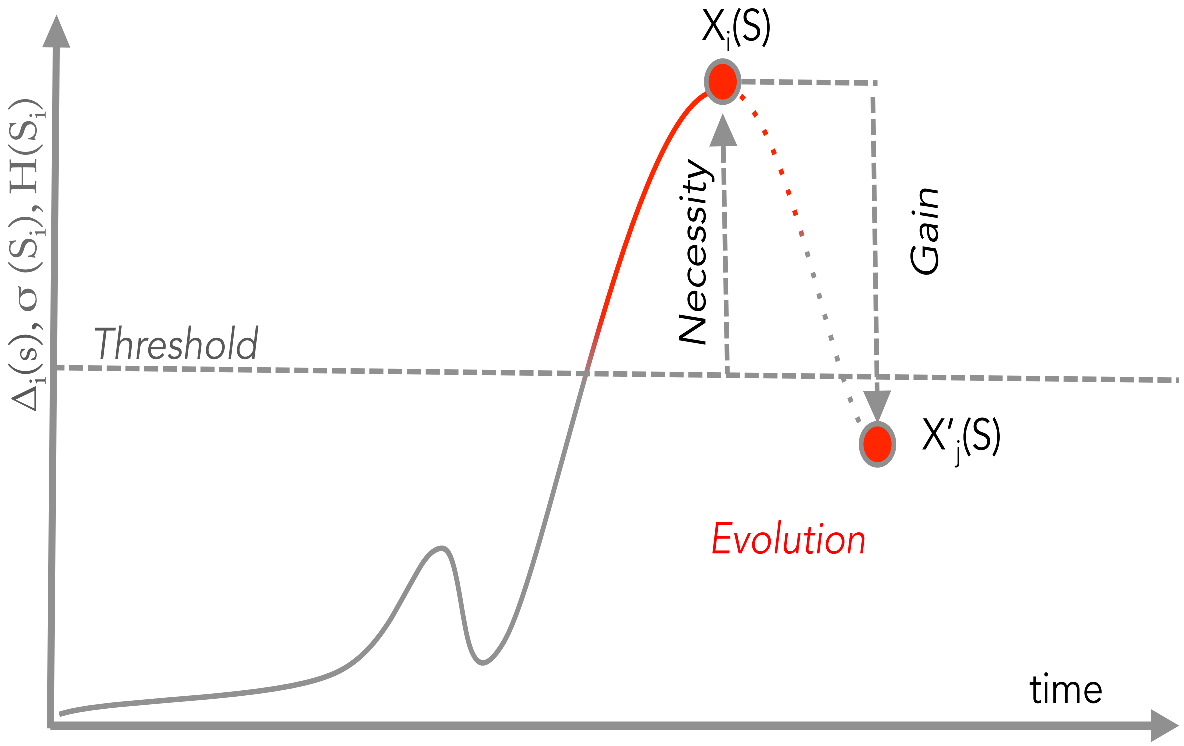



Social
$b_{i-1}(s_a)$
$b_i(s_a)$
$x_{i-1}(s_a)$
$x_i(s_a)$
$b_{i-1}(s)$
$b_i(s_a)$
Time
$x_{i-1}(s_b)$
Diagnosis
$x_i(s_b)$

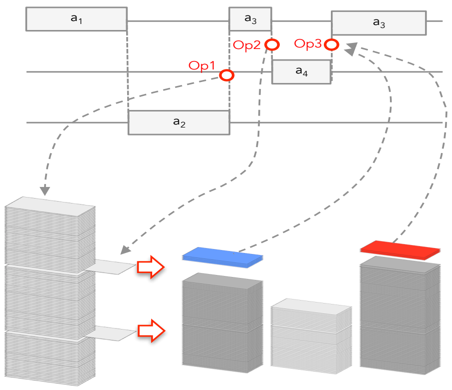

Social
$b_{i-1}(s_a)$
$b_i(s_a)$
$x_{i-1}(s_a)$
$x_i(s_a)$
Δx_{i-1}
Δx_i
$b_i(s_a)$
Time
$x_{i-1}(s_b)$
Diagnosis
$x_i(s_b)$


Social
$b_{i-1}(s_a)$
$b_i(s_a)$
$x_i(s_a)$
$b_{i-1}(s_b)$
$b_i(s_a)$
Time
Diagnosis
$x_i(s_b)$
Social
$b_{i-1}(s_a)$
$b_i(s_a)$
$x_{i-1}(s_a)$
$x_i(s_a)$
$b_{i-1}(s_b)$
$b_i(s_a)$
Time
$x_{i-1}(s_b)$
Diagnosis
$x_i(s_b)$

Orchestration



$$p\,(\text{modification}\,(G)) = \frac{\text{necessity}\,(\text{modification}\,(G)) * \text{benefit}\,(\text{modification}\,(G))}{\text{cost}\,(\text{modification}\,(G)))}$$



So what ?

1. « Design for analytics »
2. Pedagogy inside technology
3. A model is a simplication
4. Not only of learning technologies