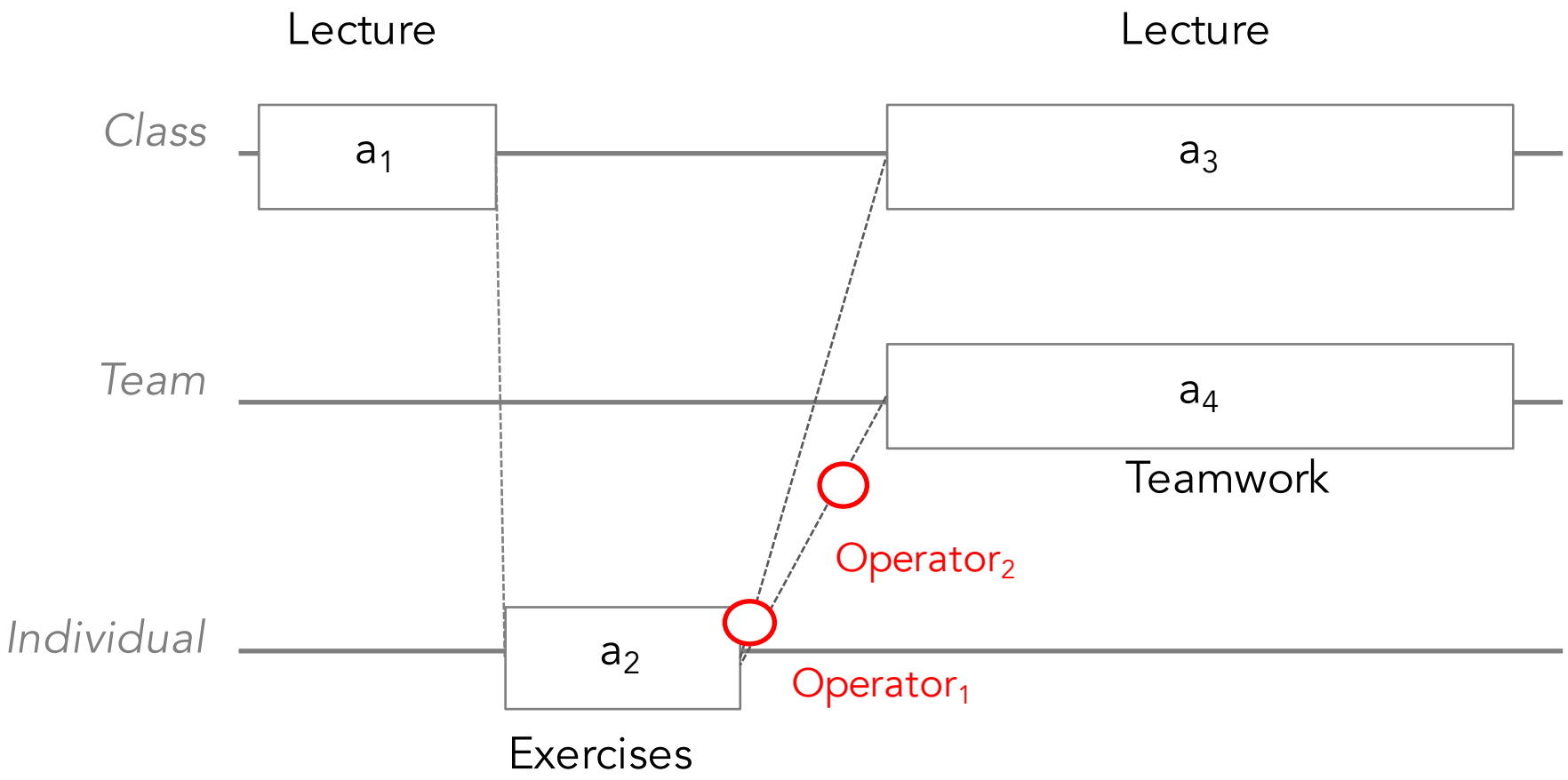
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

CS-411 : Digital Education & Learning Analytics

# Chapter 2:

# Orchestration Graphs

Pierre Dillenbourg, Patrick Jermann, Thanasis Hadzilakos & Stian Haklev



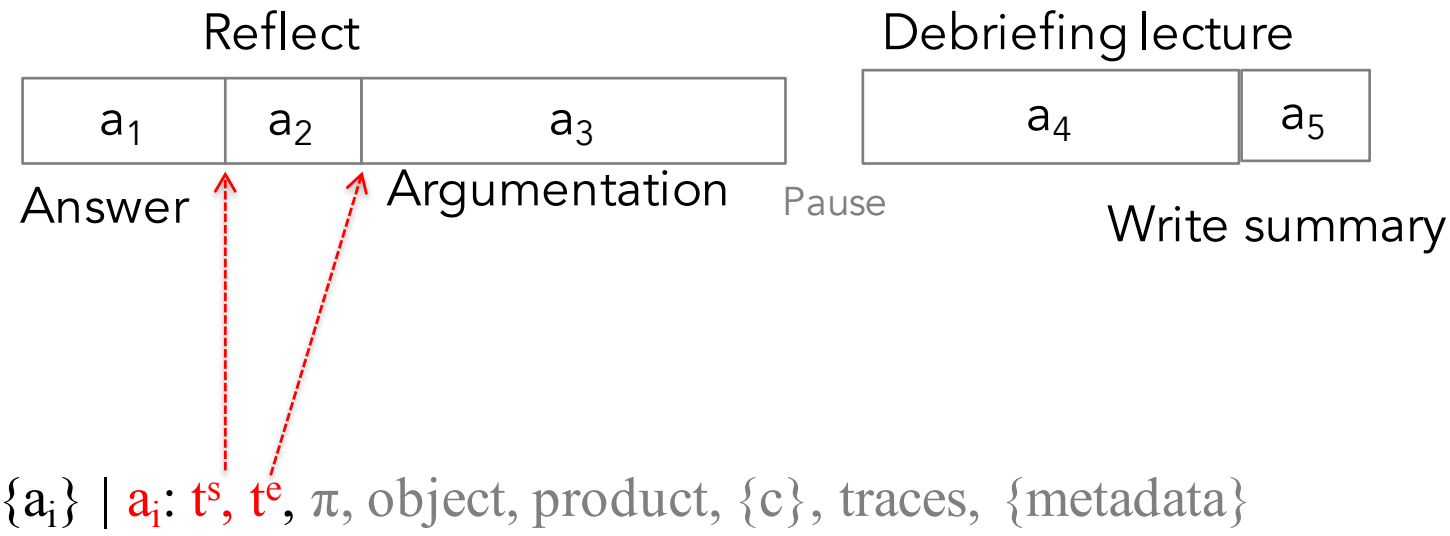

Pedagogical scenario.

The teacher begins by giving a 20-minute lecture, followed by a 20-minute problem solving task on computers, where the automatic grader accepts several correct solutions.

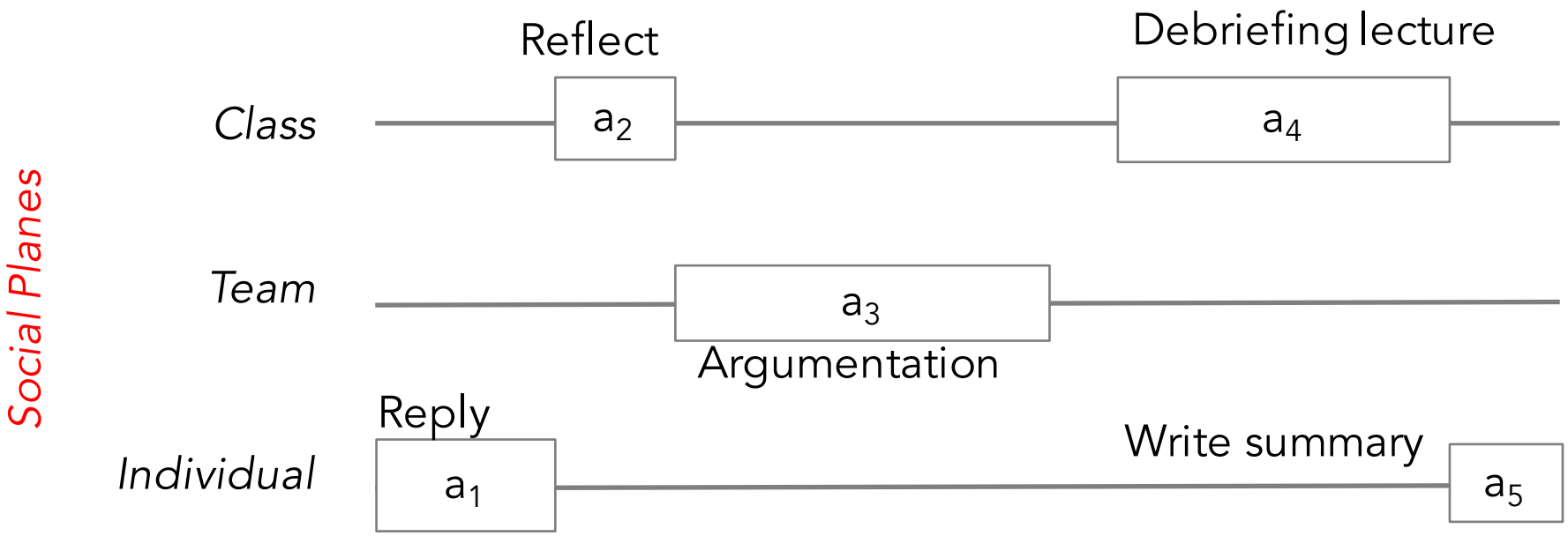
After a pause, those who did not find any solution follow a longer lecture.

The other learners are divided into groups formed with individuals who elaborated different correct solutions. They are asked to rank their solutions from the most suitable to the least.

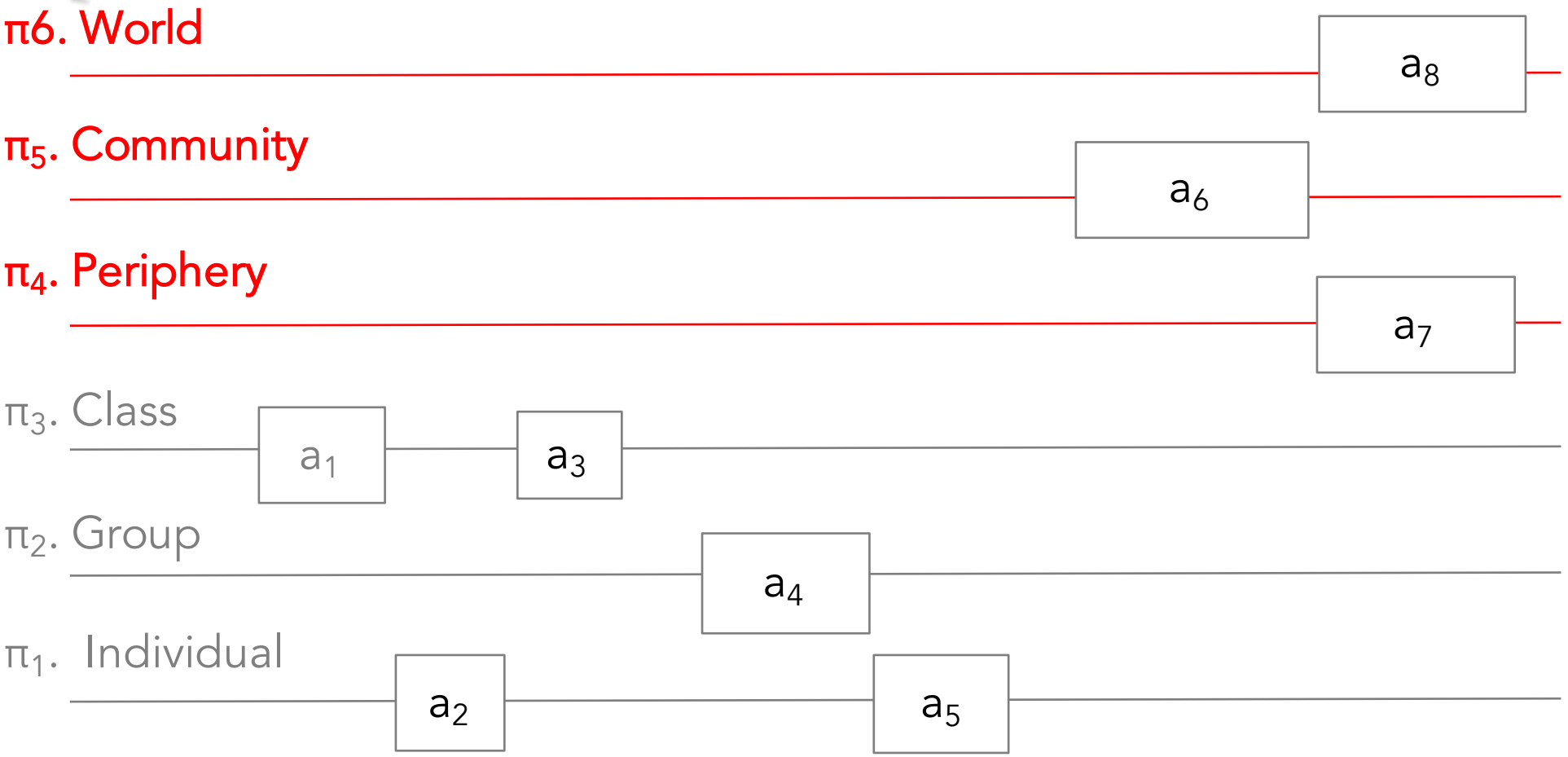
A script is a sequence of activities…



An integrated learning scenario is a sequence of activities located at different social planes



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



# Social planes

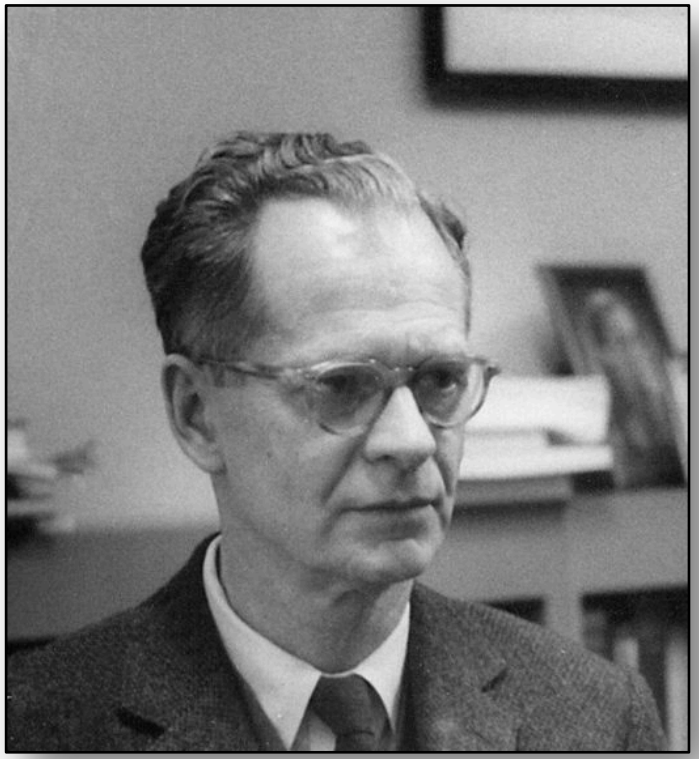
- Individual plane (intra-psychological plance): students work on a task by themselves
- Group plane (inter-psychological plane): students work in teams. They are assigned a joint task to achieve.
- Class plane (social plane): the activity involves all the students in the class.The concept of class is used in a broad sense (e.g. MOOC participants)
- Periphery plane: activities involve actors who do not belong to the class, but have a stable educational relationship with it: the director, other teachers, other classes, parents, …. They typically have a log-in.
- Community plane: activities engage temporary actors from the community, such as a museum guide, a butcher, an expert in astronomy… The "community" around a class is the set of people who have occasional interactions with the class.
- World plan: activities include disseminating information via the Internet, radio, publications, exhibitions, feedback on online objects (e.g., "likes" or forum postings), etc.

*This arbitrary segmentation corresponds to widespread educational practices*

# Remarks

- A plane does not describe the individual cognitive processes, but the social structure of activities (e.g. individual reasoning at π3)
- A plane does not necessarily correspond to a physical space or to a virtual space (but it sometime does)
- The notion of plane does not correspond to the notion of scale: 1,000 students may do exercises individually ($\pi_1$), while 10 students may listen a lecture ($\pi_3$).

An integrated learning scenario : education is not a religion, a designer does not need to choose or belong to a theory, but simply select the most relevant learning activity for the learning objectives



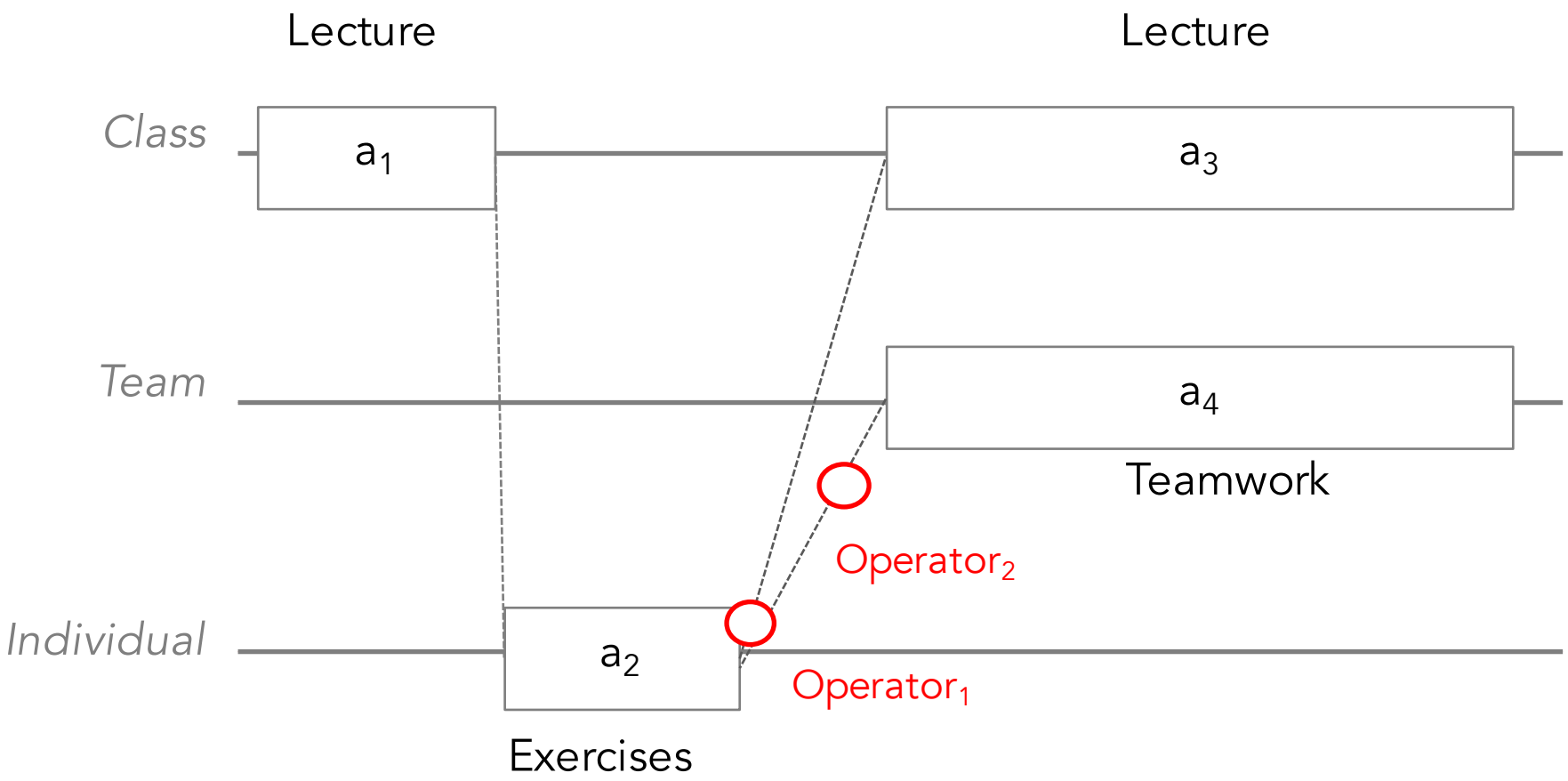
Skinner (Chapter 4)

Piaget (Chapter 5)

Vygotsky (Chapter 6)

"integrated" in the pedagogical meaning : the activities make a consistent pedagogical whole

"integrated" in the technical meaning : the data produced by an activity are reused by other activities ; they are connect by operators



An orchestration graph is defined by a set of Vertices and a set of Edges that connect vertices

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

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

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

# A sequence of operators constitute a workflow

« A workflow consists of an orchestrated and repeatable pattern of business activity enabled by the systematic organization of resources into processes that transform materials, provide services, or process information. It can be depicted as a sequence of operations, declared as work of a person or group, an organization of staff, or one or more simple or complex mechanisms ». (Wkipedia)

Workflows have been designed for automating bureaucratic processes such as processing insurance claims.

(Last week, it was operated manually.)

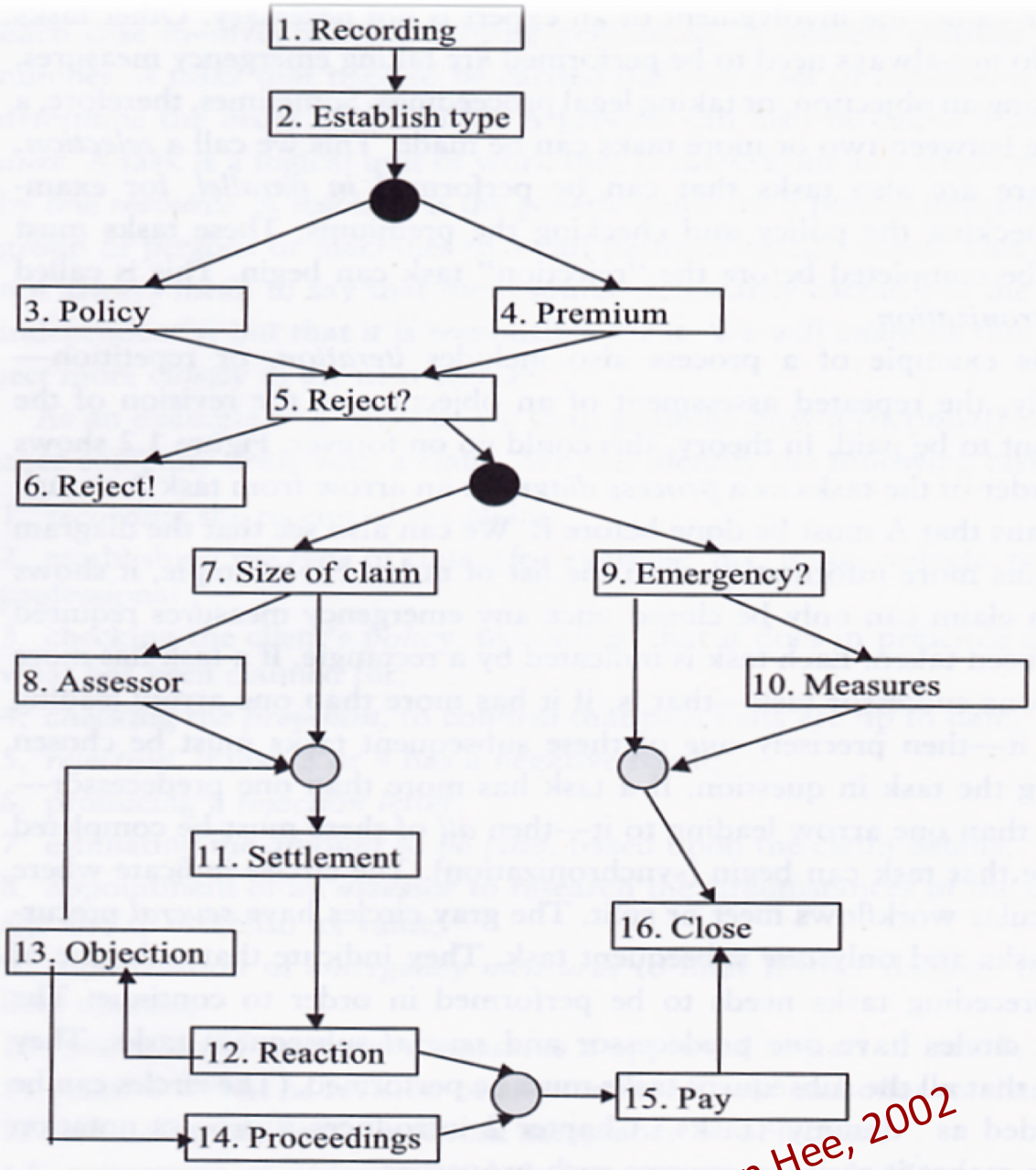
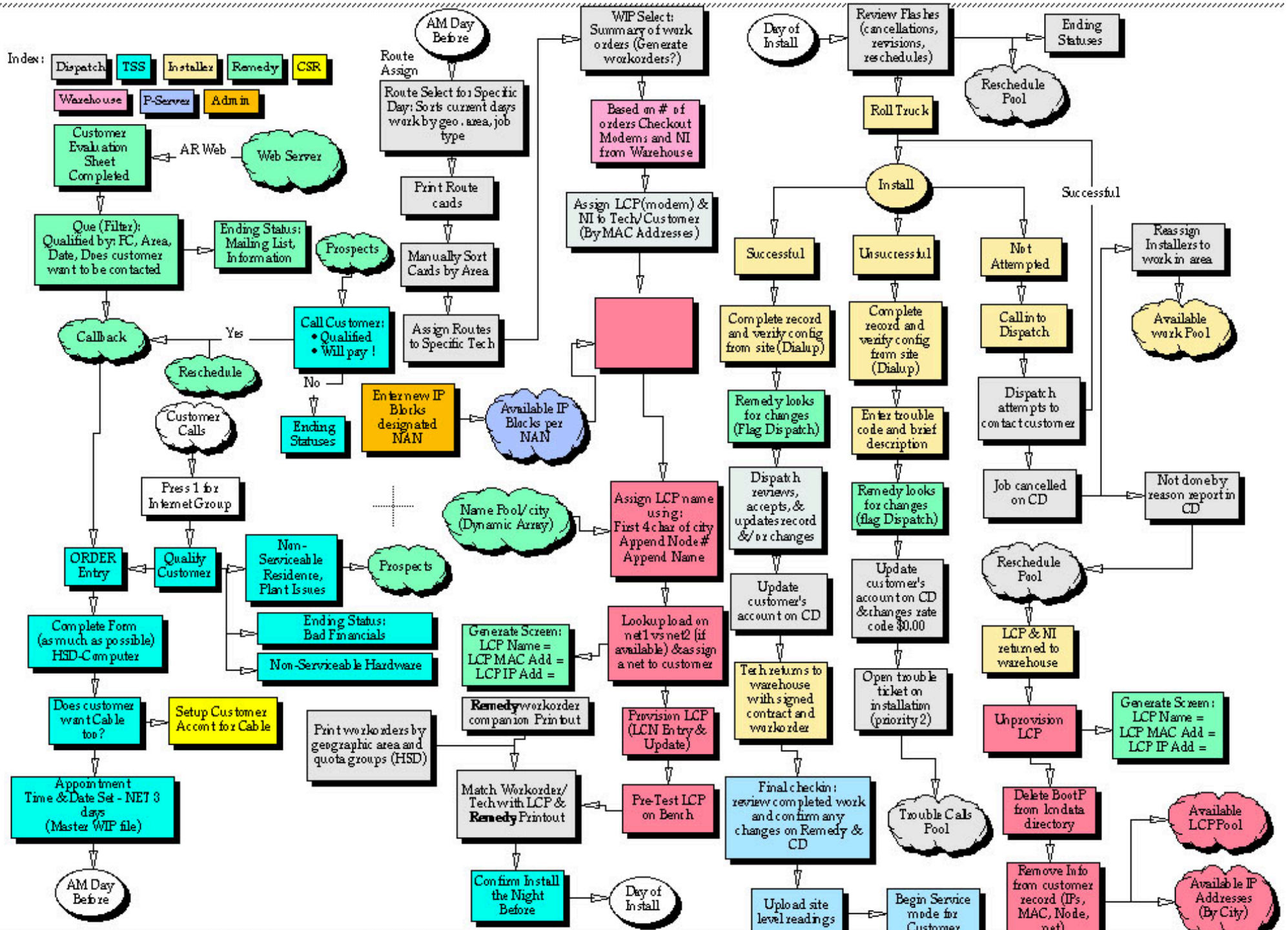


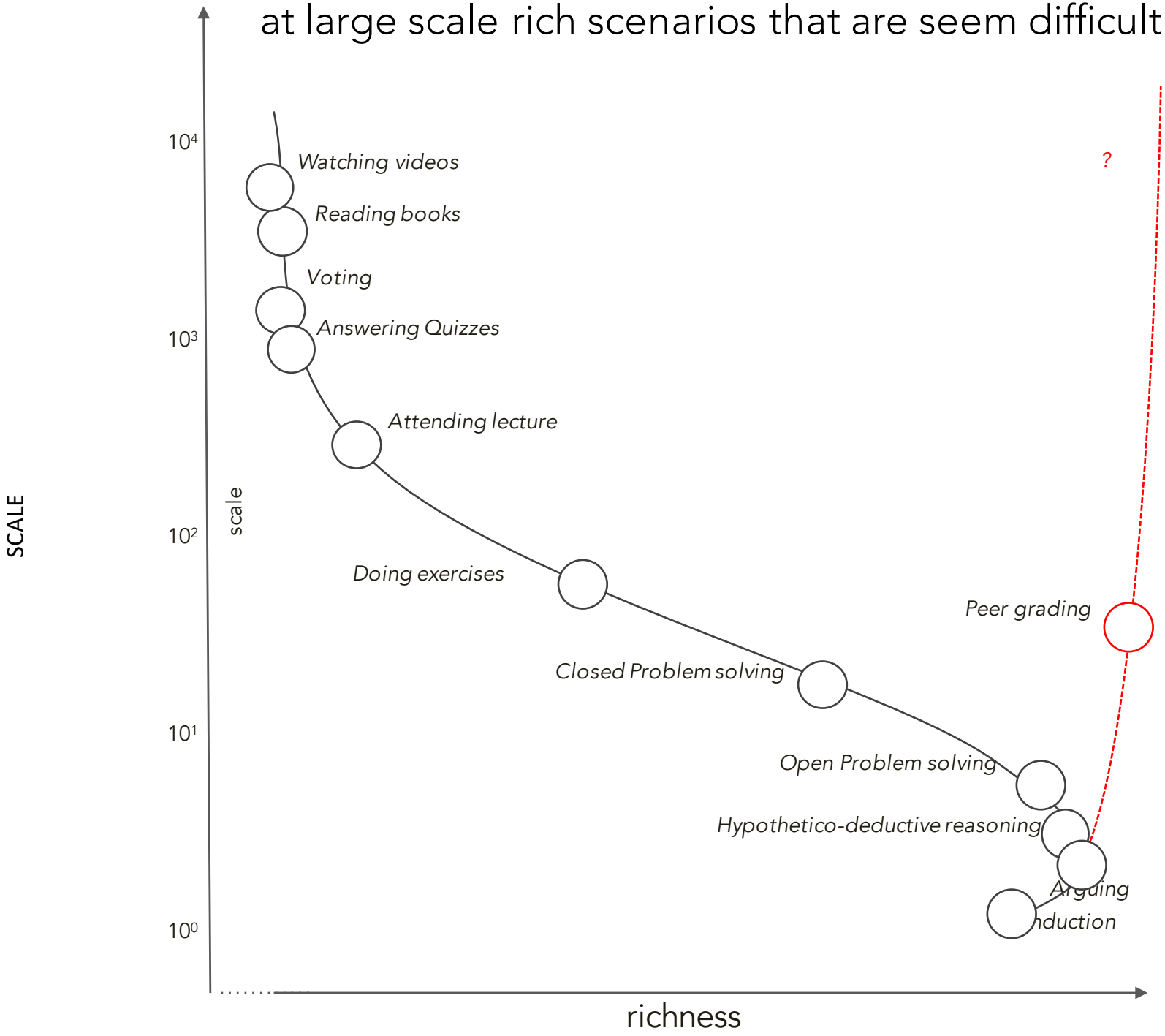

**Figure 1.2**
Insurance claim process

Van der Aalst & van Hee, 2002




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

The goal of this formalizing pedagogical scenarios is to bring at large scale rich scenarios that are seem difficult to be scaled



# Let's try this scenario for a geology MOOC…

## ($A_1$) Introductory lecture on erosion


https://www.youtube.com/watch?v=B3iDcDGqFG8

# Let's try this scenario for a geology MOOC…

## ($A_2$) Please upload 3 pictures of erosions

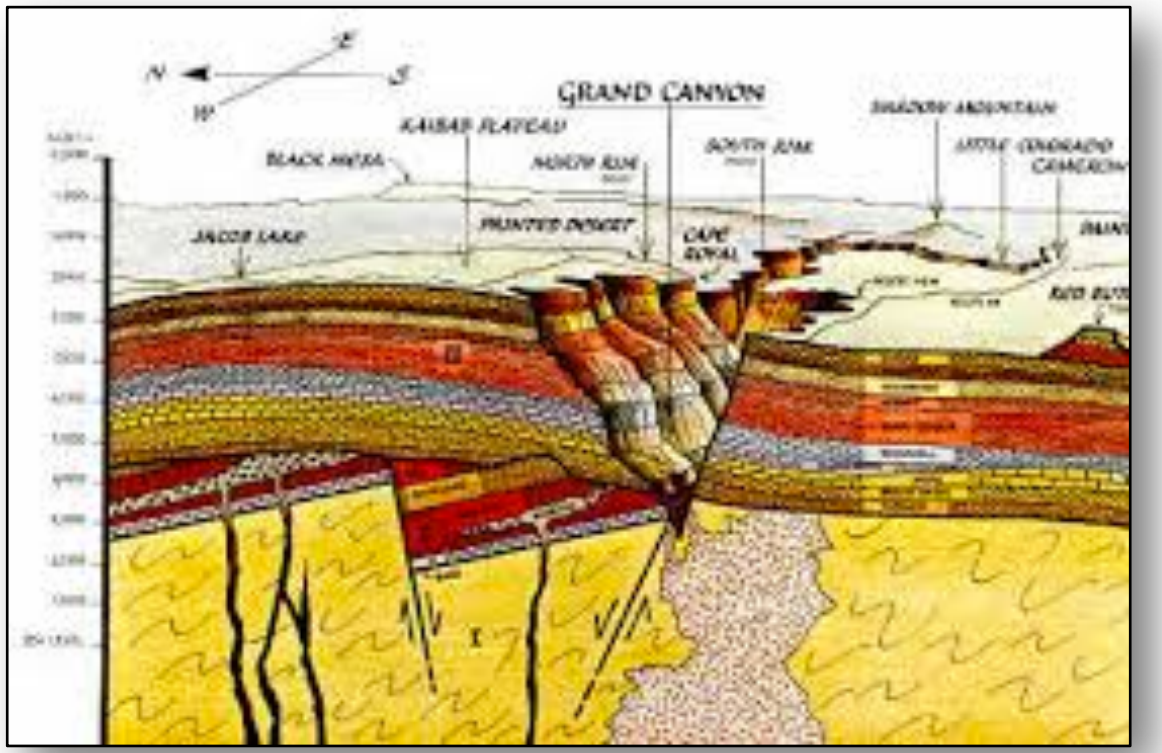
http://www.yorkccd.org/erosion-and-sediment-control/

http://www.maine.gov/dep/land/erosion/

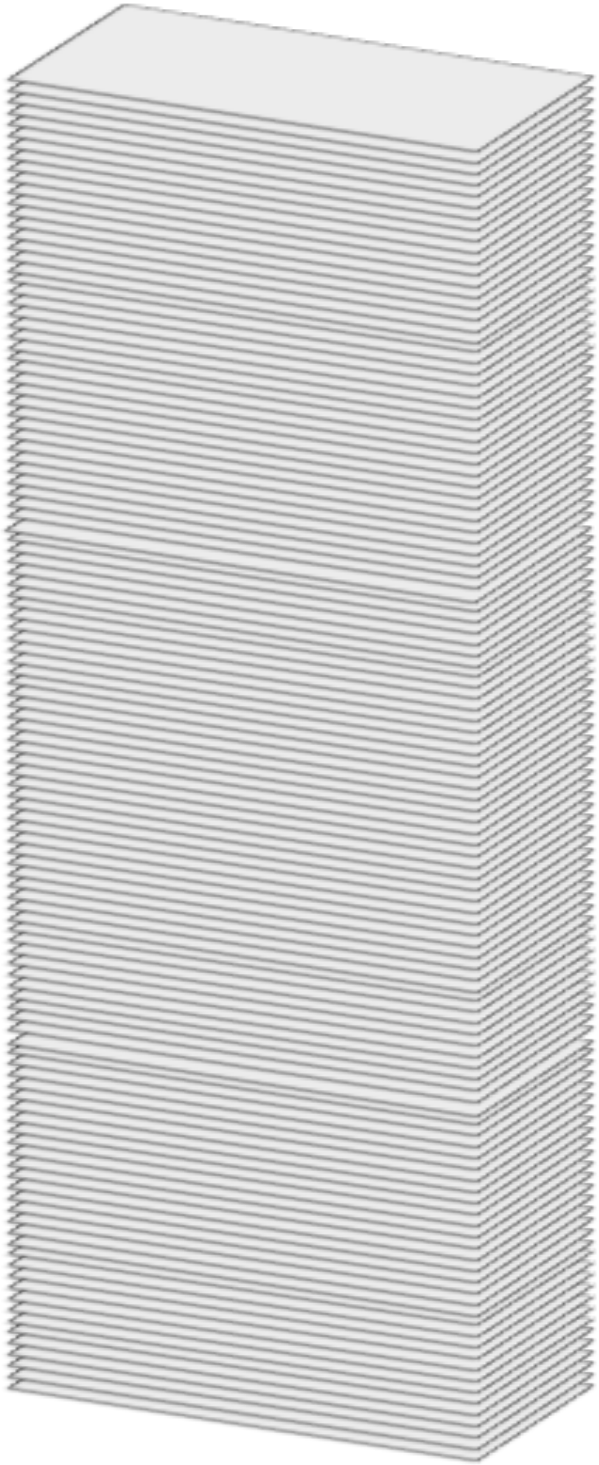
http://passel.unl.edu/pages/informationmodule.php?idinformationmodule=1086025423&topicorder=18&maxto=7

# Let's try this scenario for a geology MOOC…

($A_3$) Lecture on types of erosion



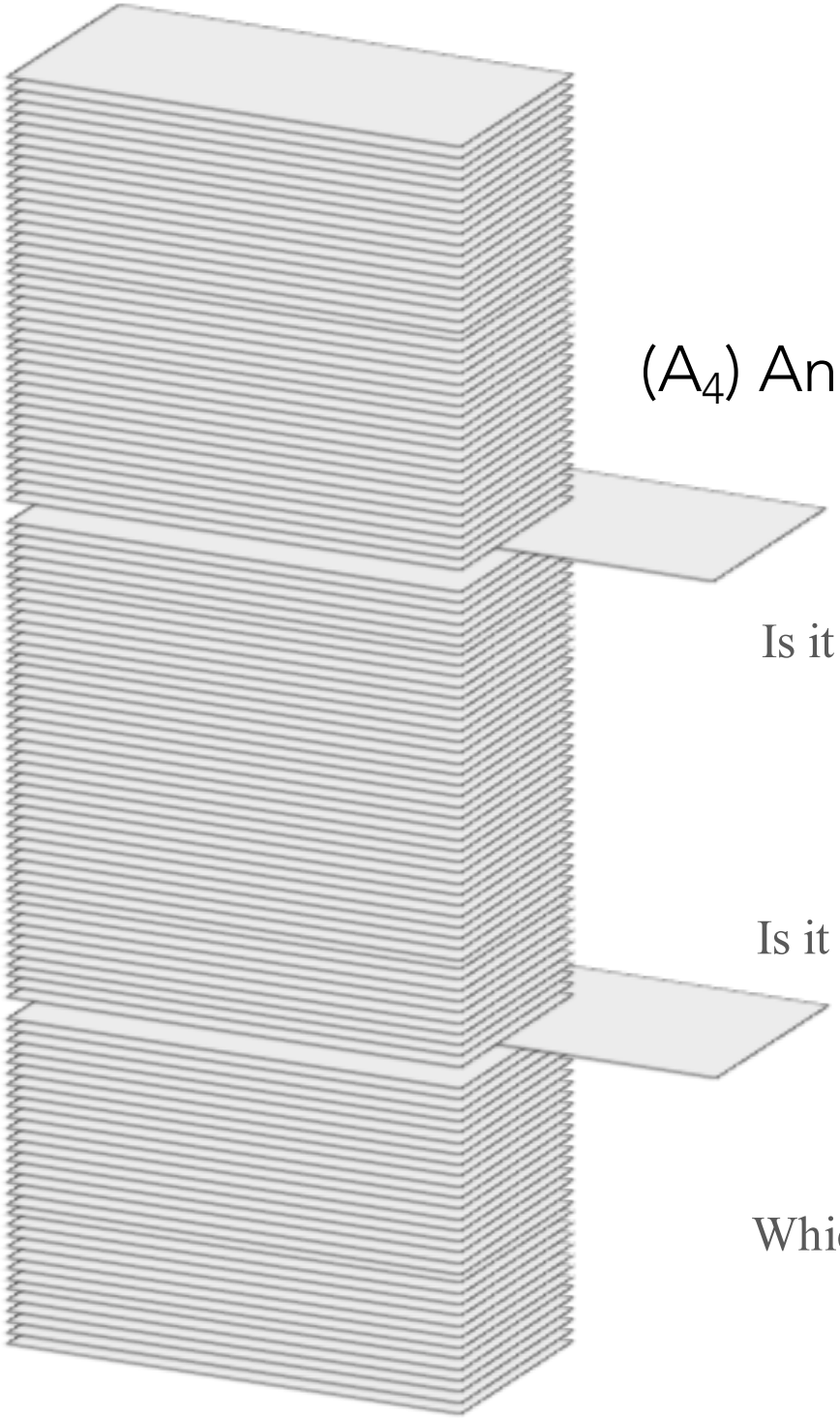

http://www.detectingdesign.com/geologiccolumn.html



# Workflow ?

20’000 students
X 3 pictures
/ 2 (Filter automatically very bad pictures)

= 30’000 pictures



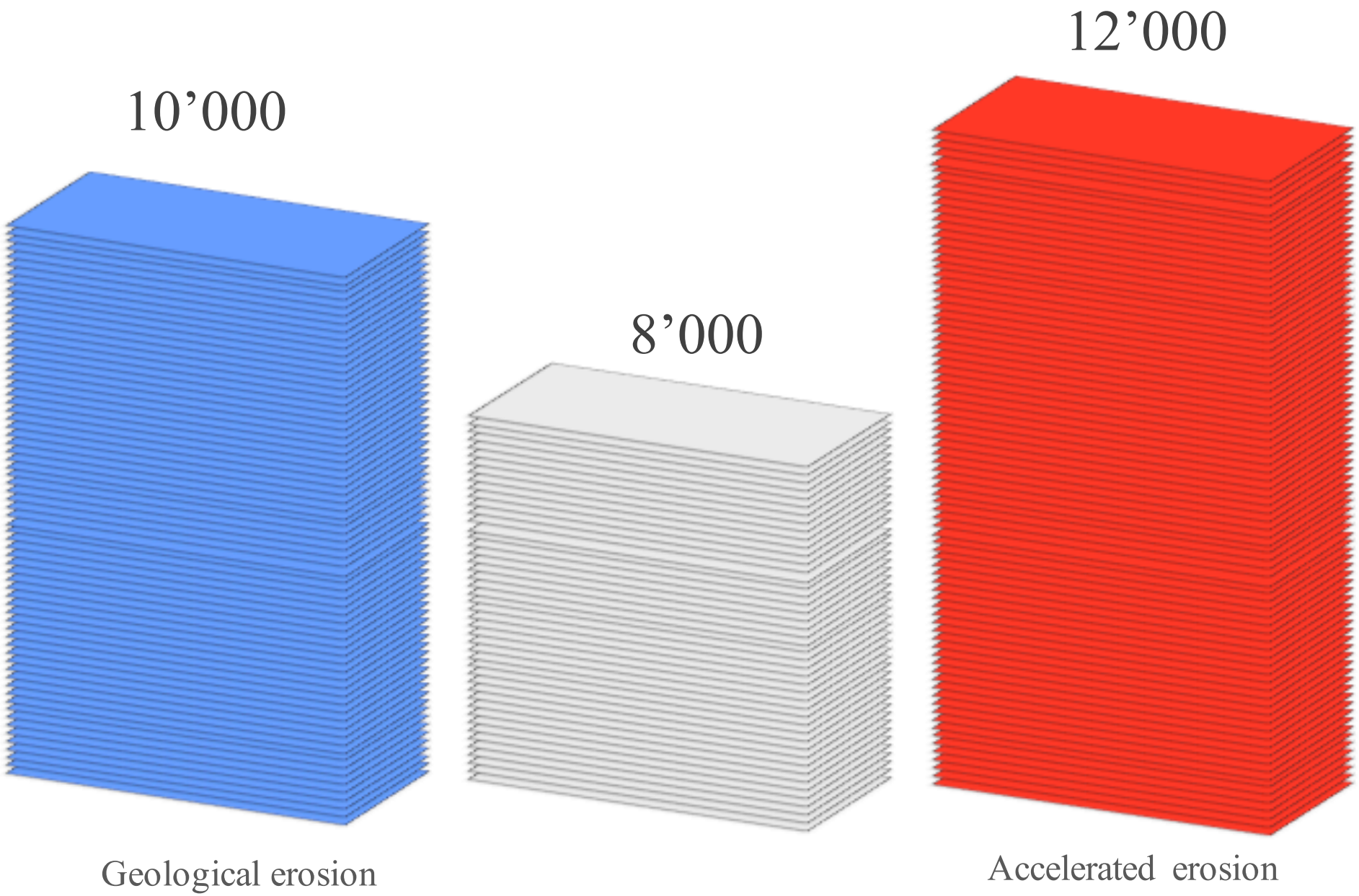
# Workflow ?

($A_4$) Answer 3 questions (teams of 2)

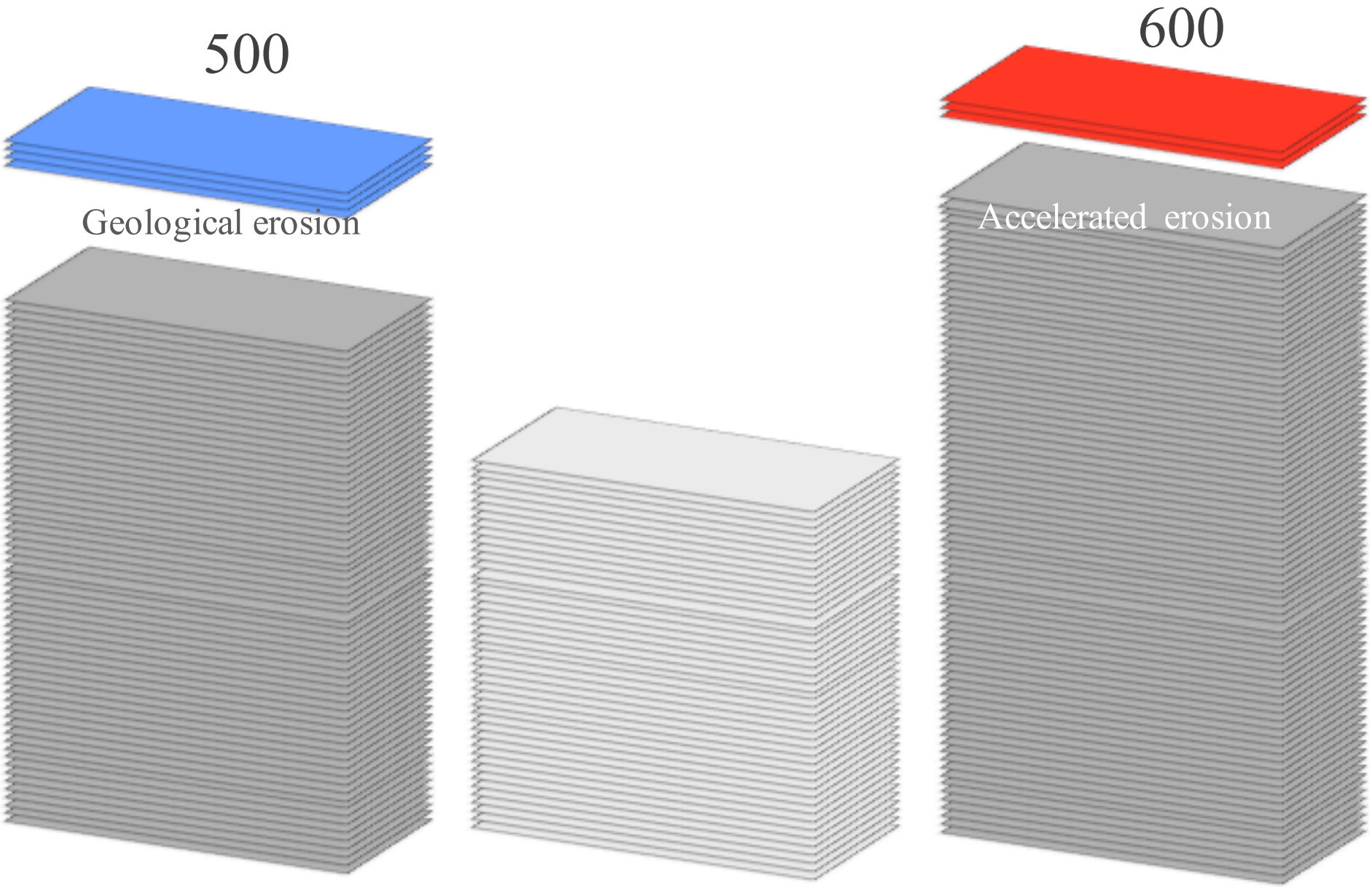
Is it geological erosion or accelerated erosion ?

Is it geological erosion or accelerated erosion ?

Which one illustrates the best erosion?

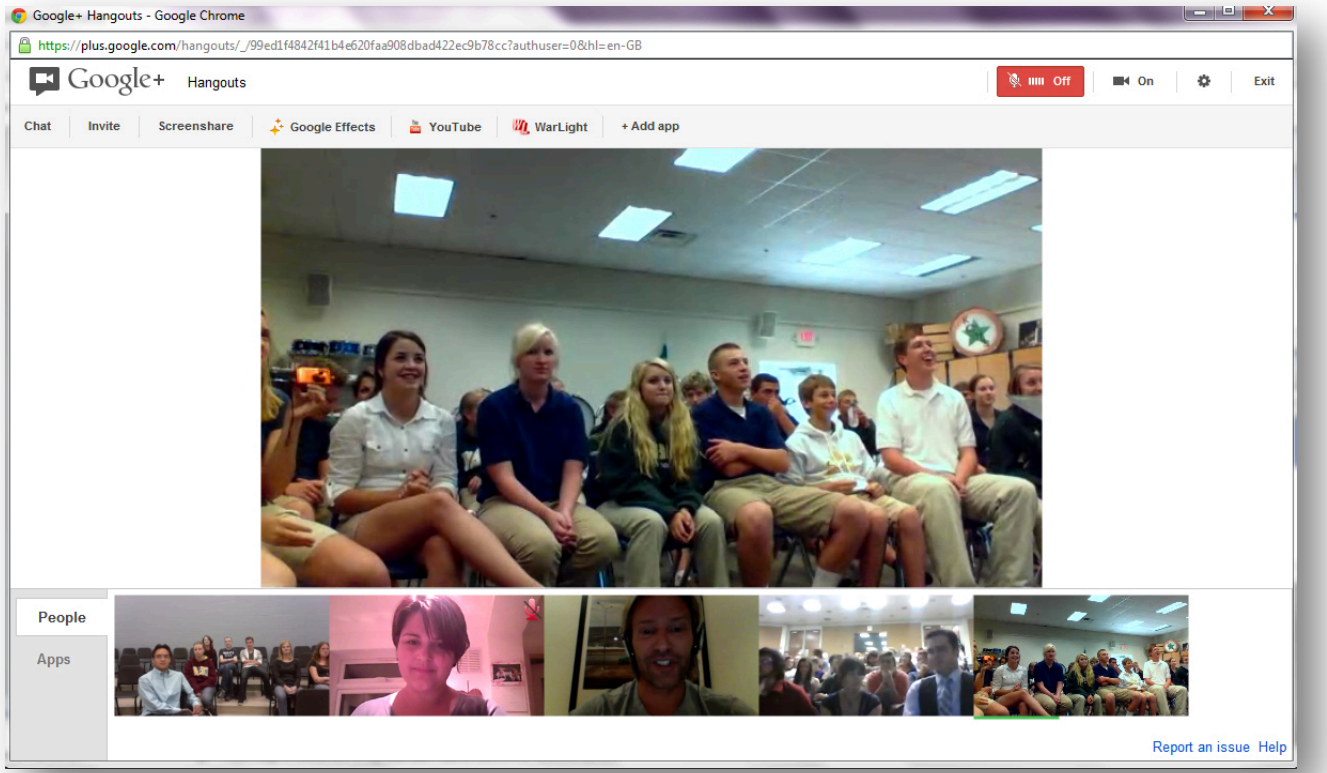

10’000
8’000
12’000
Geological erosion
Accelerated erosion

# Select top 5% pictures



# Let's try this scenario for a geology MOOC…

## ($A_5$) Debriefing lecture by HangOut on different types of erosion




http://bnnovation.com/tag/google-hangouts/

Draw the orchestration graph, with the workflow

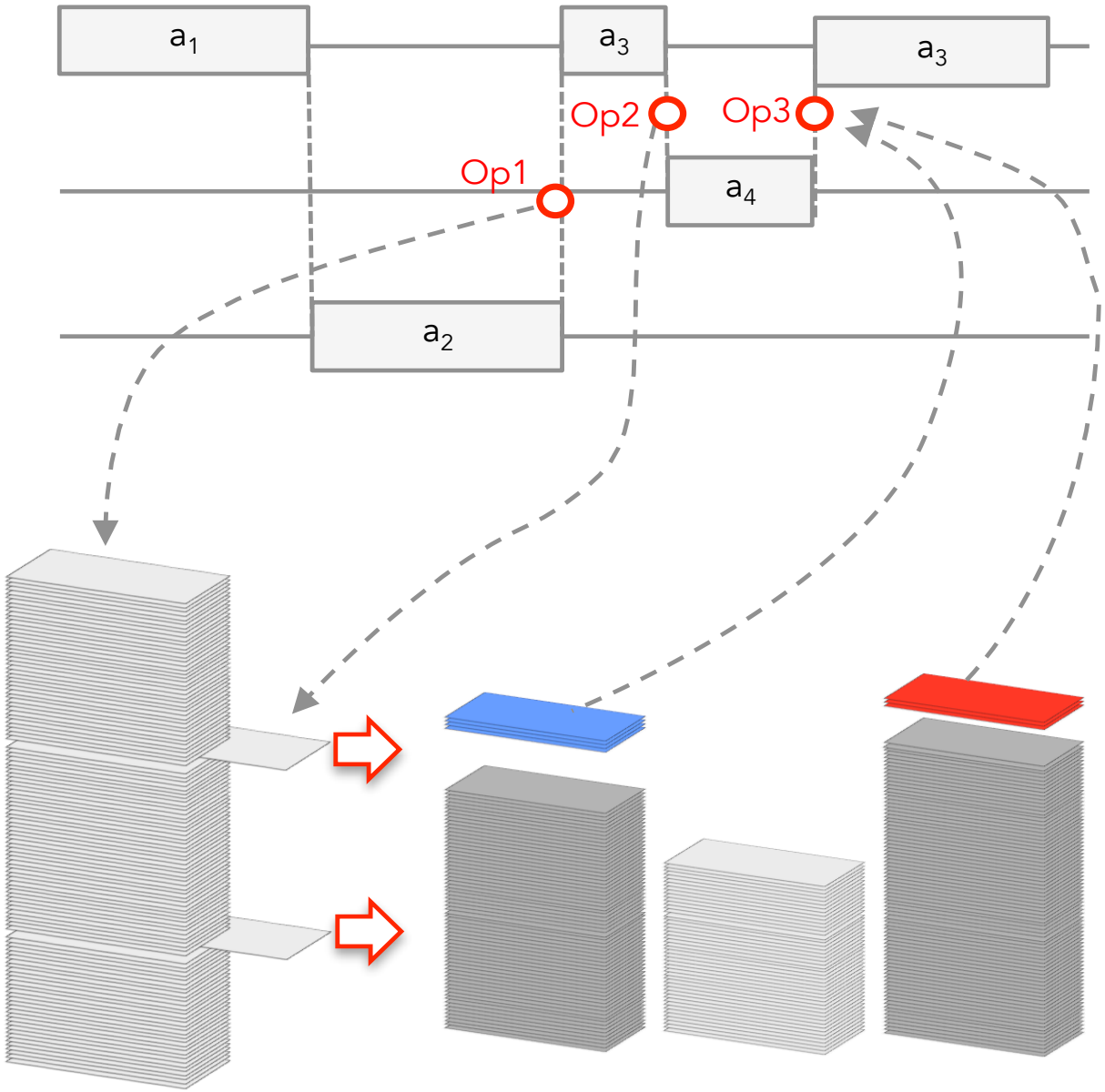
($A_1$) Introductory lecture on erosion

($A_2$) Please upload 3 pictures of erosions

($A_3$) Lecture on types of erosion

($A_4$) Answer 3 questions (teams of 2)

($A_5$) Debriefing lecture by HangOut


a1
a3
a3
Op2
Op3
Op1
a4
a2

# Library of Graph Operators

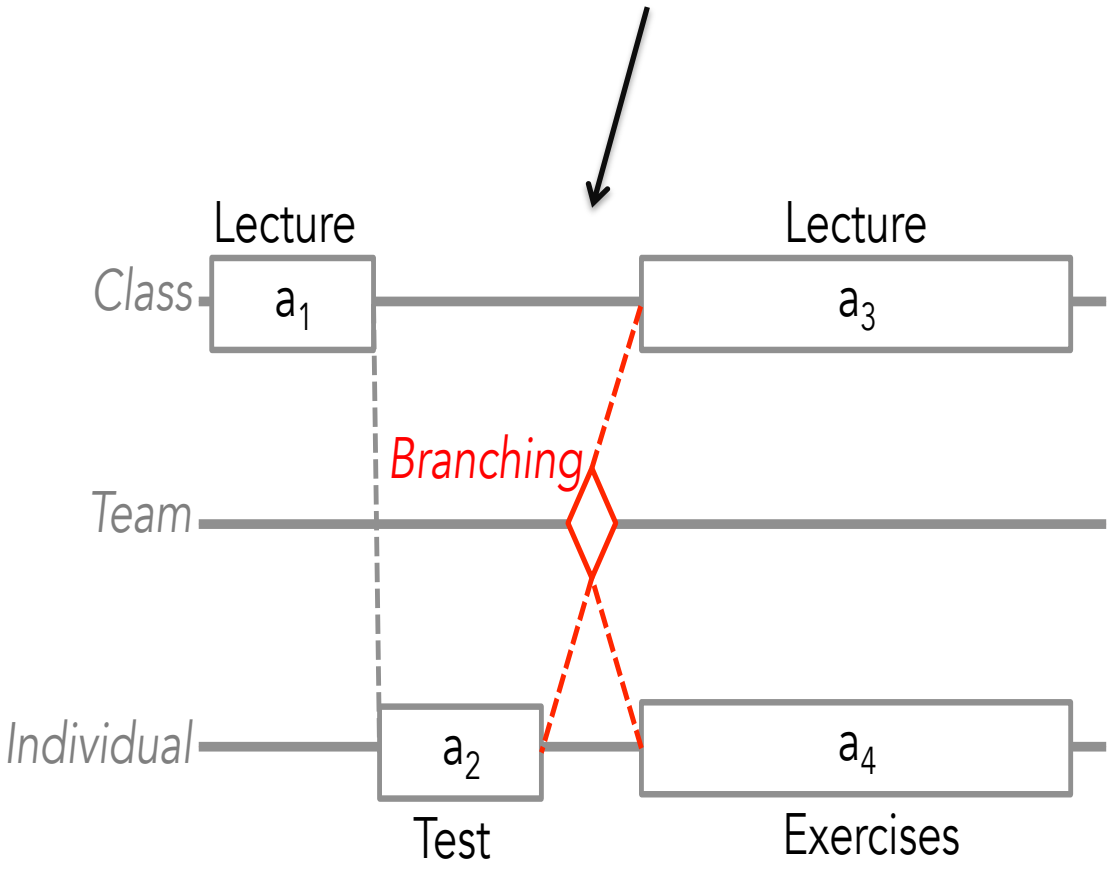
| Aggregation | Distribution | Social | BackOffice |
|---|---|---|---|
| (A) Listing | (D) Broadcasting | (S) Group formation | (B) Grading |
| (A) Classifying | (D) User selection | (S) Class Split | (B) Feedback |
| (A) Sorting | (D) Sampling | (S) Role assignment | (B) Anti-plagiarism |
| (A) Synthesizing | (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 |

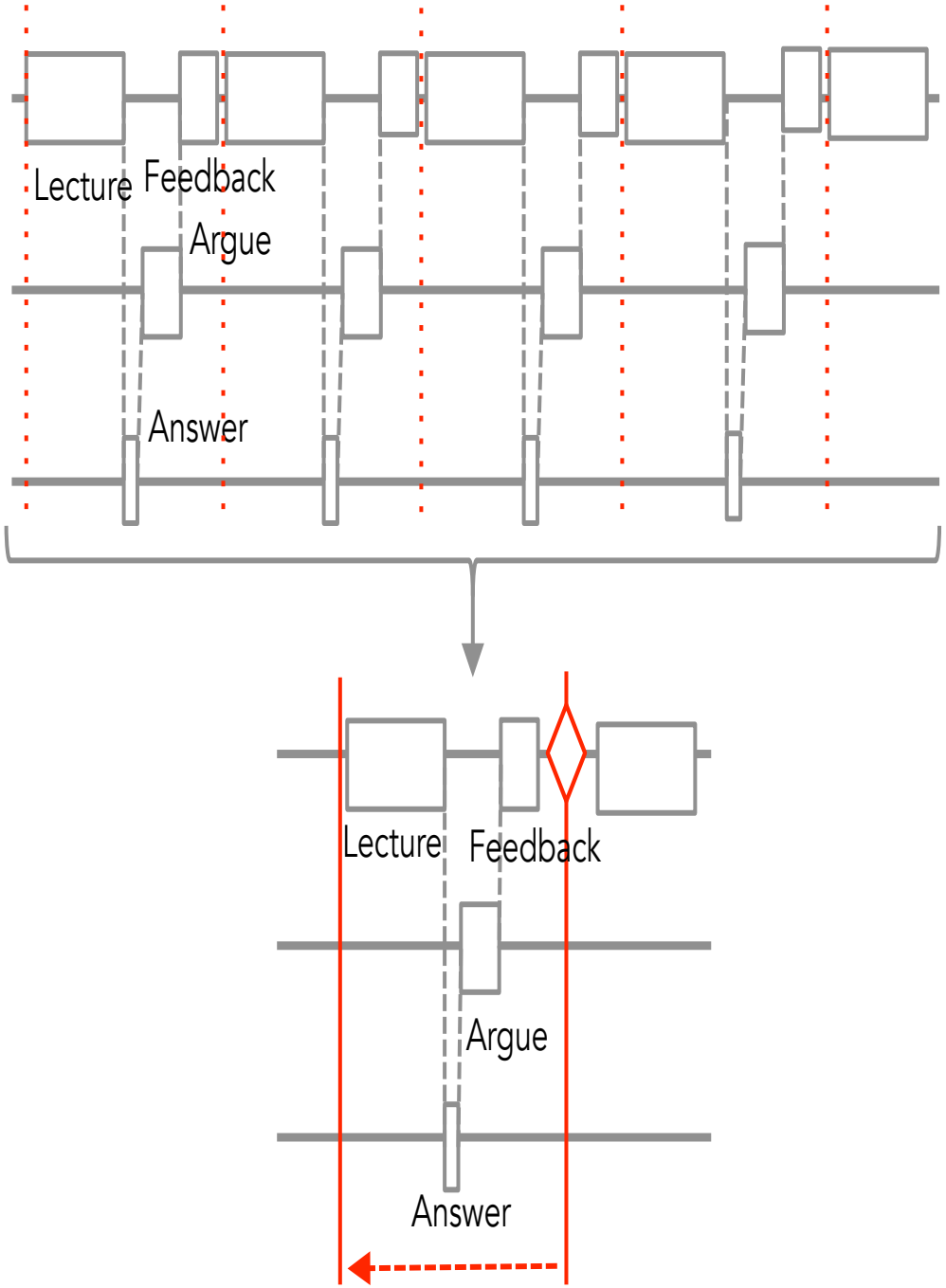
G= (V, E) where  E= V X V

V = {$a_i$} | $a_i$: $t^s$, $t^e$, π, object, product, {c}, traces, {metadata}

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

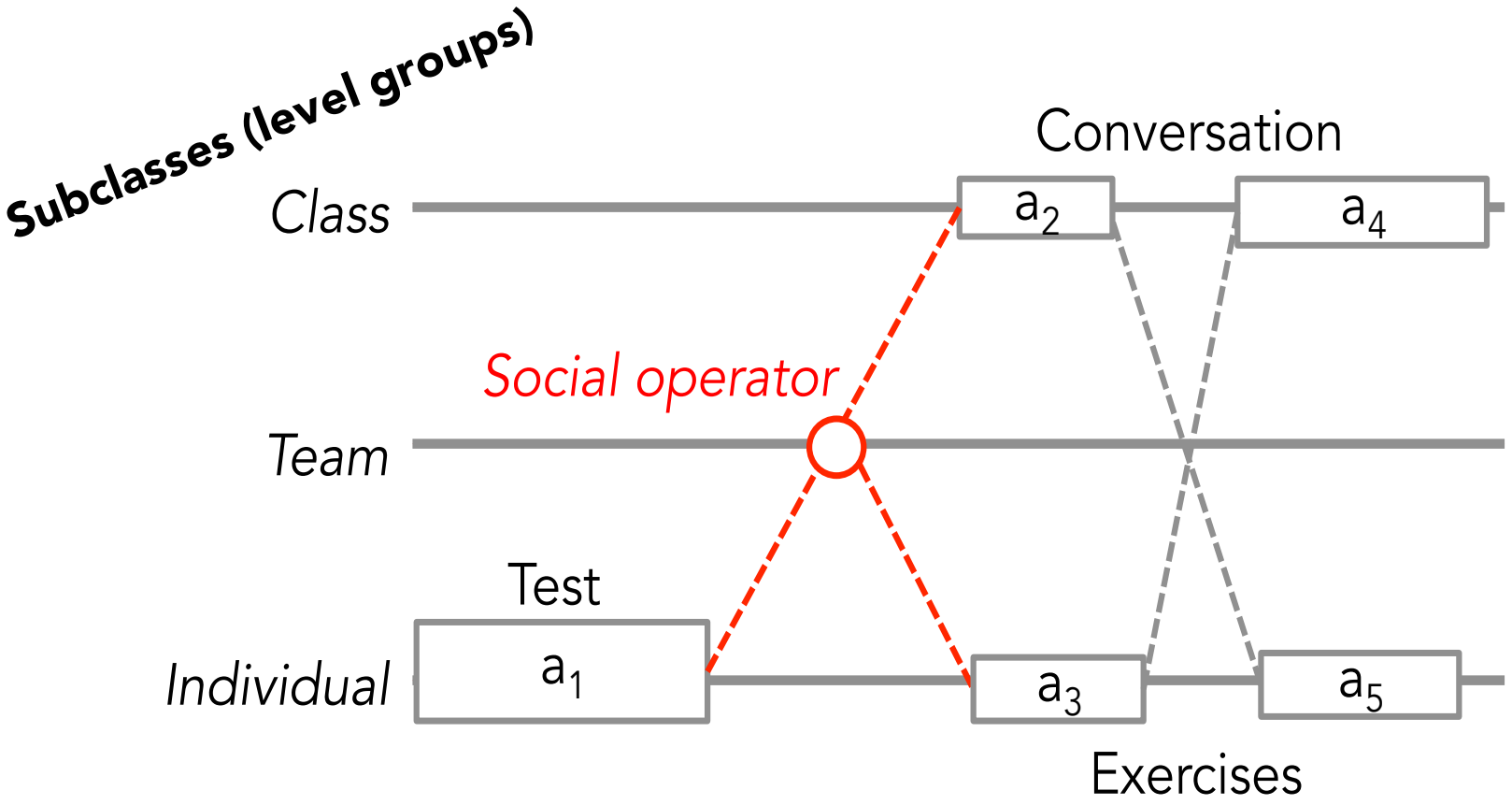
**Branching**






Peer Instruction (E. Mazur)

**Looping**




Parallel independent activities for subclasses with different levels. The graph illustrates a German lesson. All students start with exercises on sentence construction ($a_1$), which are automatically graded. In the edge $e_{1,2}$, the social operator forms two subclasses, based on $a_1$ scores. Then, the best students participate in dialogue activities with the teacher ($a_2$) while the others continue individual exercises ($a_3$). It is easier for the teacher to manage dialogue among students who have a homogenous level of dialogue skills in German. After a break, the groups switch activities.

Competencies
(mastery learning)

Next Slide

G= (V, E) where E= V X V

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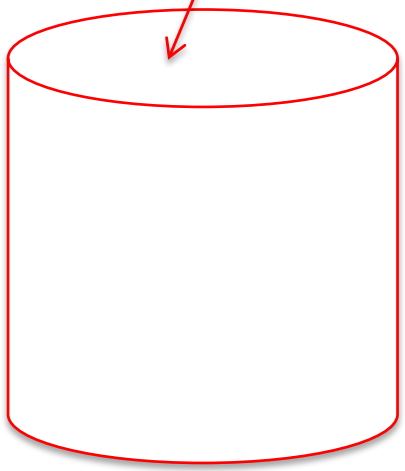
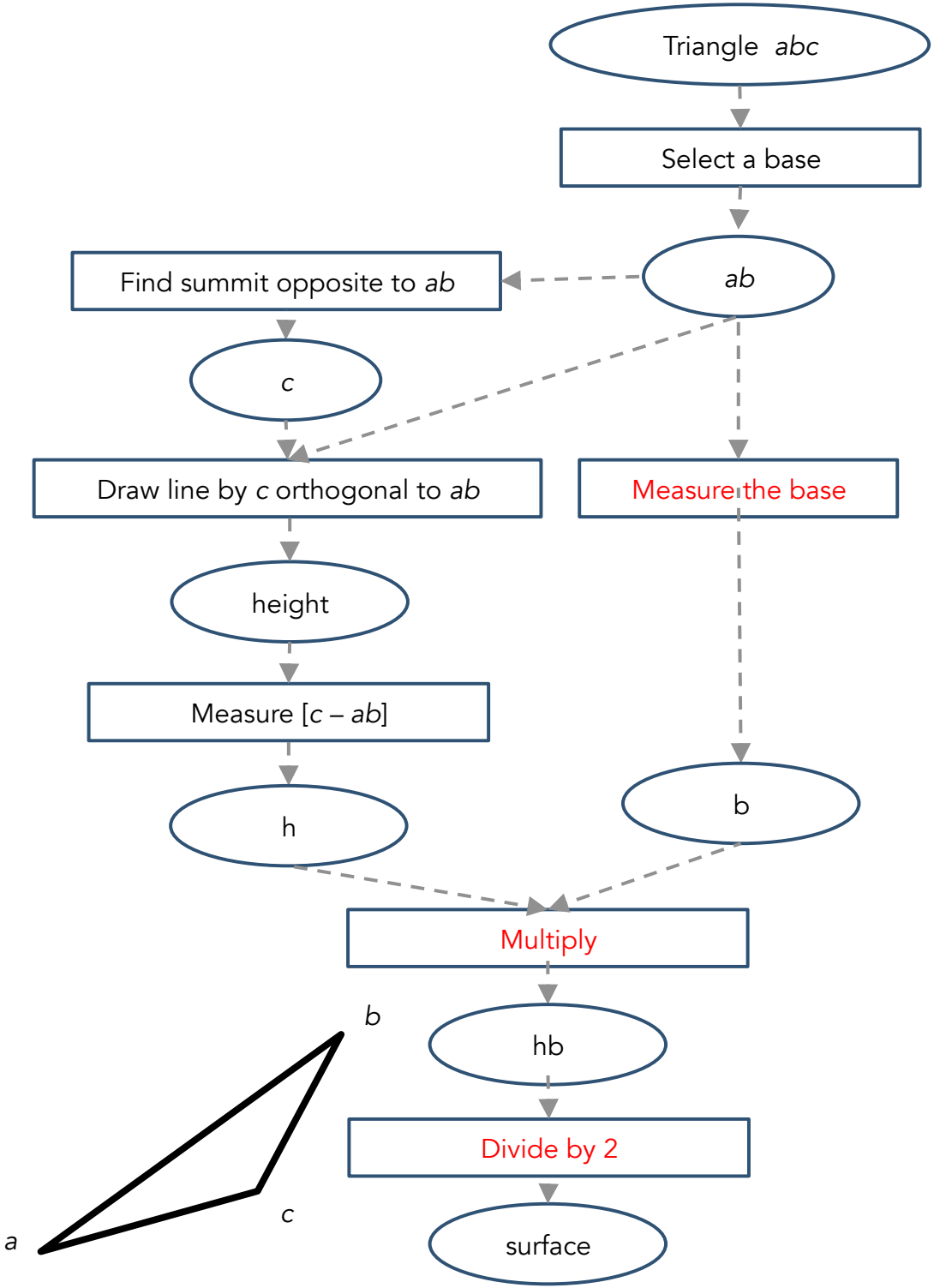


Learning Analytics

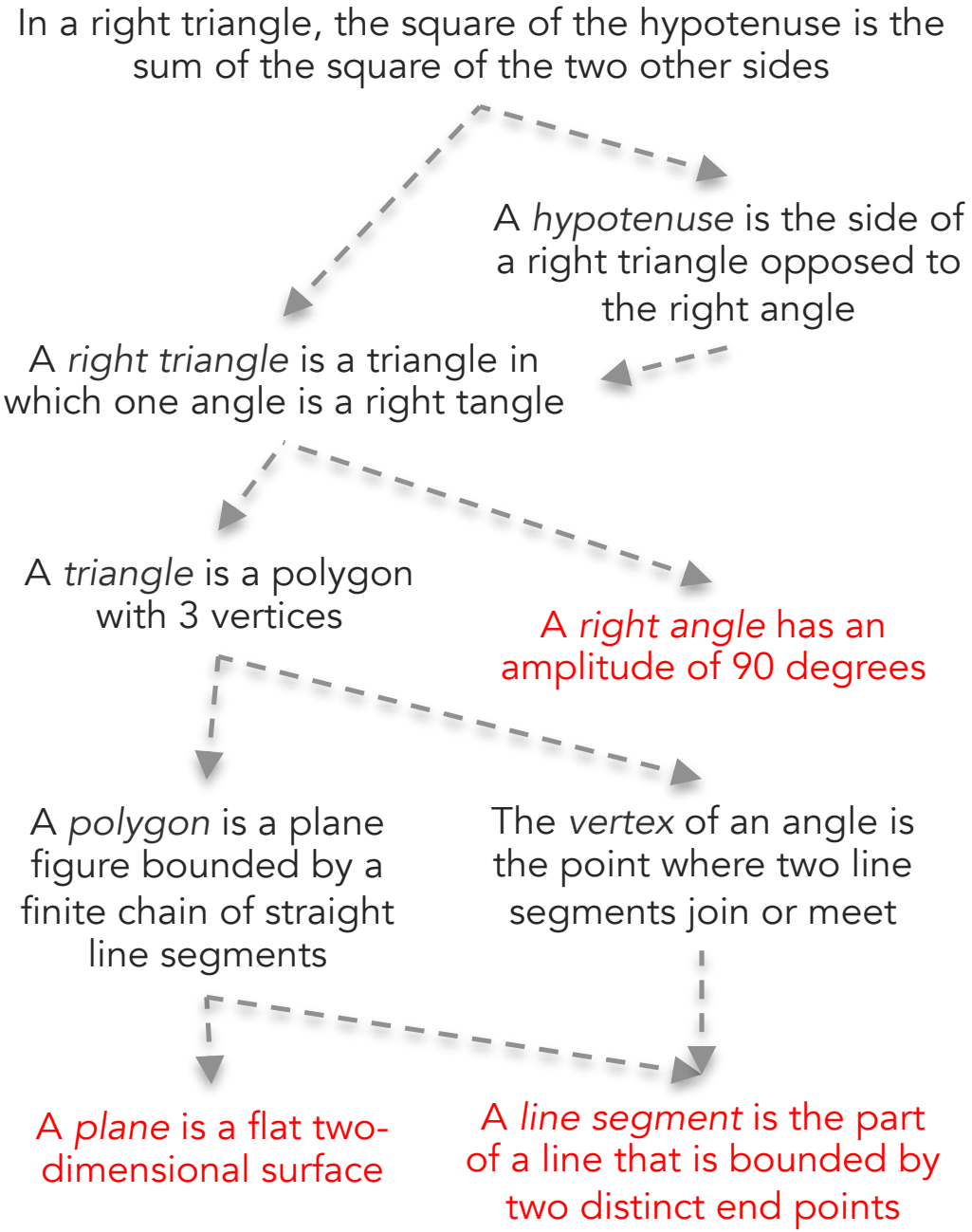



Skills decomposition for

procedural knowledge

The target learning outcome is decomposed into intermediate skills. The quality of this decomposition determines the effectiveness of the instruction

(Mastery Learning)




Skills decomposition for

declarative knowledge

The target learning outcome is decomposed into intermediate skills. The quality of this decomposition determines the effectiveness of the instruction

(Mastery Learning)

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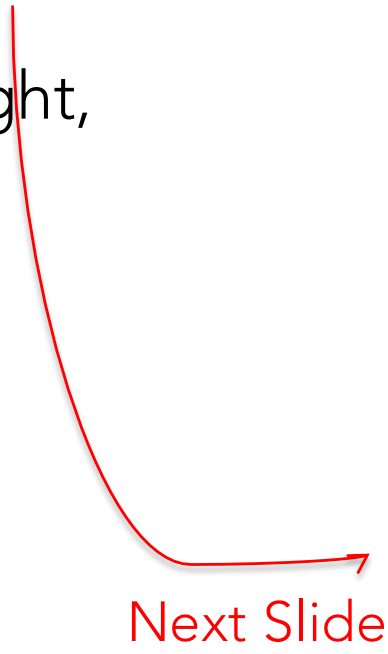

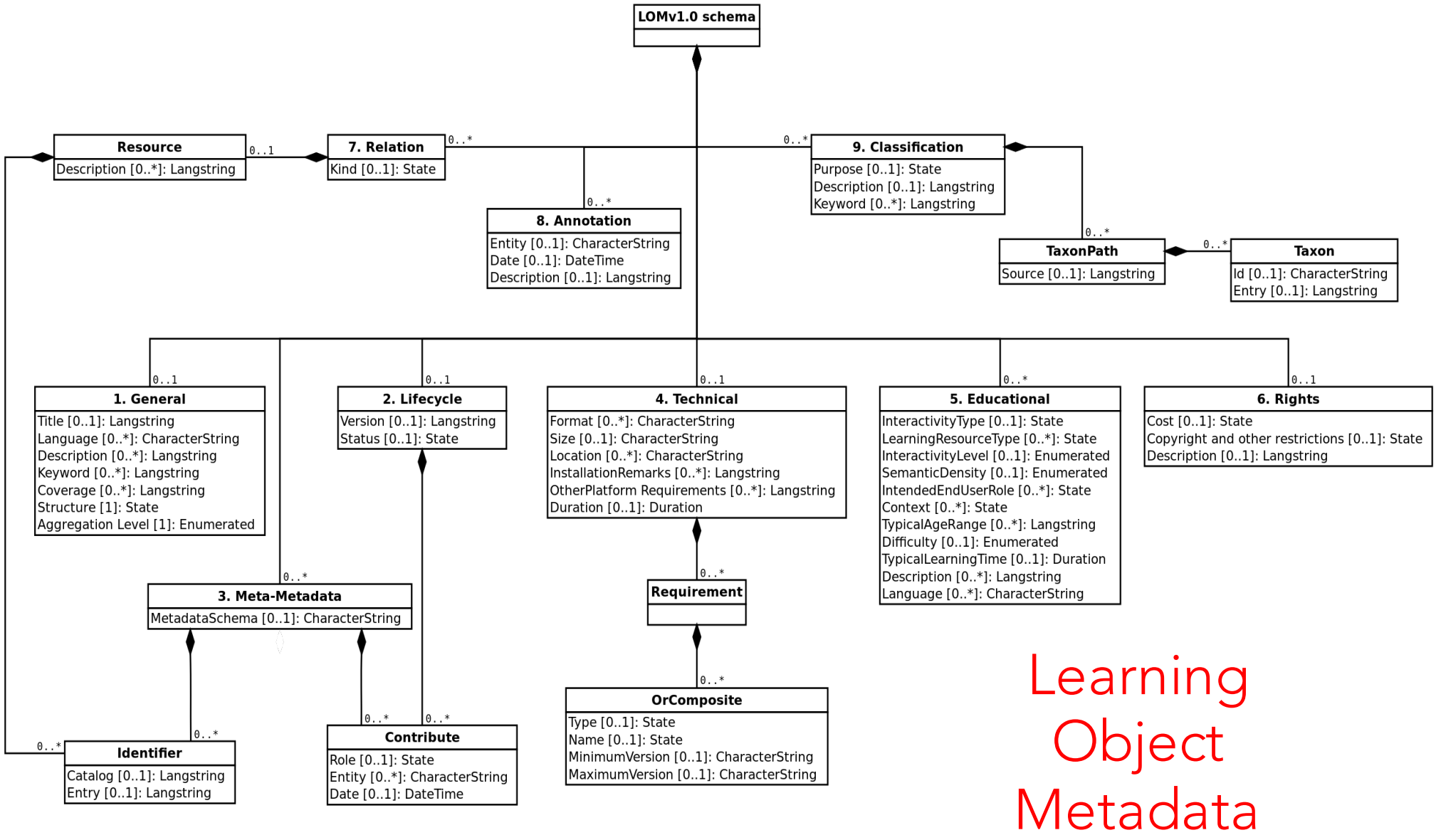


# Learning Object Metadata

Learning Object Metadata is a data model, usually encoded in XML, used to describe a learning object and similar digital resources used to support learning. The purpose of learning object metadata is to support the reusability of learning objects, to aid discoverability, and to facilitate their interoperability, usually in the context of online learning management systems (LMS). The IEEE 1484.12.1 – 2002 Standard for Learning Object Metadata is an internationally recognised open standard (for the description of "learning objects". Relevant attributes of learning objects to be described include: type of object; author; owner; terms of distribution; format; and pedagogical attributes, such as teaching or interaction style.

Competencies

(mastery learning)

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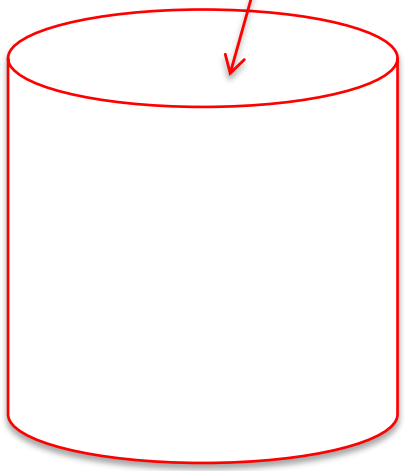
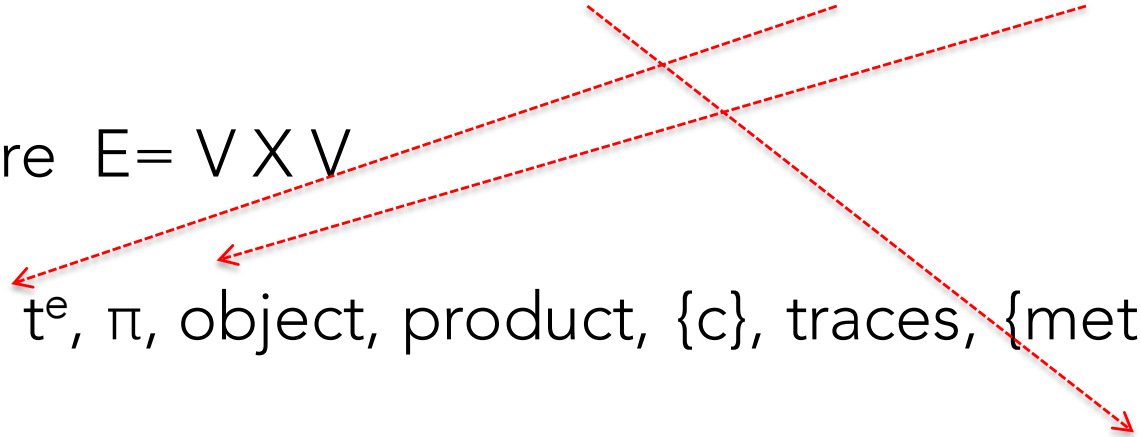


Learning Analytics

An orchestration graph is a weighted directed geometric graph.



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*Workflow*

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| | | (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 |

*Learning Analytics*

# Why is $a_i$ necessary for $a_j$ ?

| Preparation | Set | Translation | Generalization |
|---|---|---|---|
| (P) Pre-requisite | (S+) Aggregation | (T) Proceduralisation | (G+) Induction |
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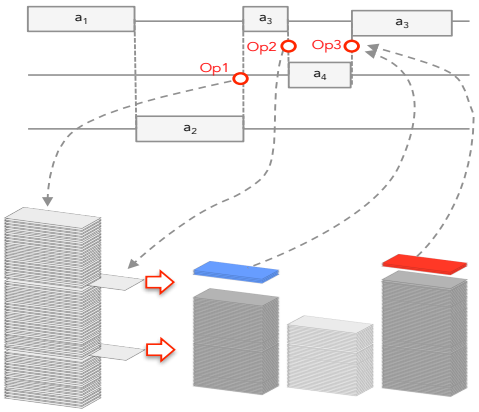


# Orchestration Graphs

1. Home-made model, not an established theory
2. Modeling rich pedagogical scenarios in order to bring them at scale
3. Pedagogy is hidden inside technology, e.g. changing an operator changes the pedagogical idea
4. A model is a simplification of the reality; this model does not capture the affective side of learning
5. It does not only apply to learning technologies, but to any situation