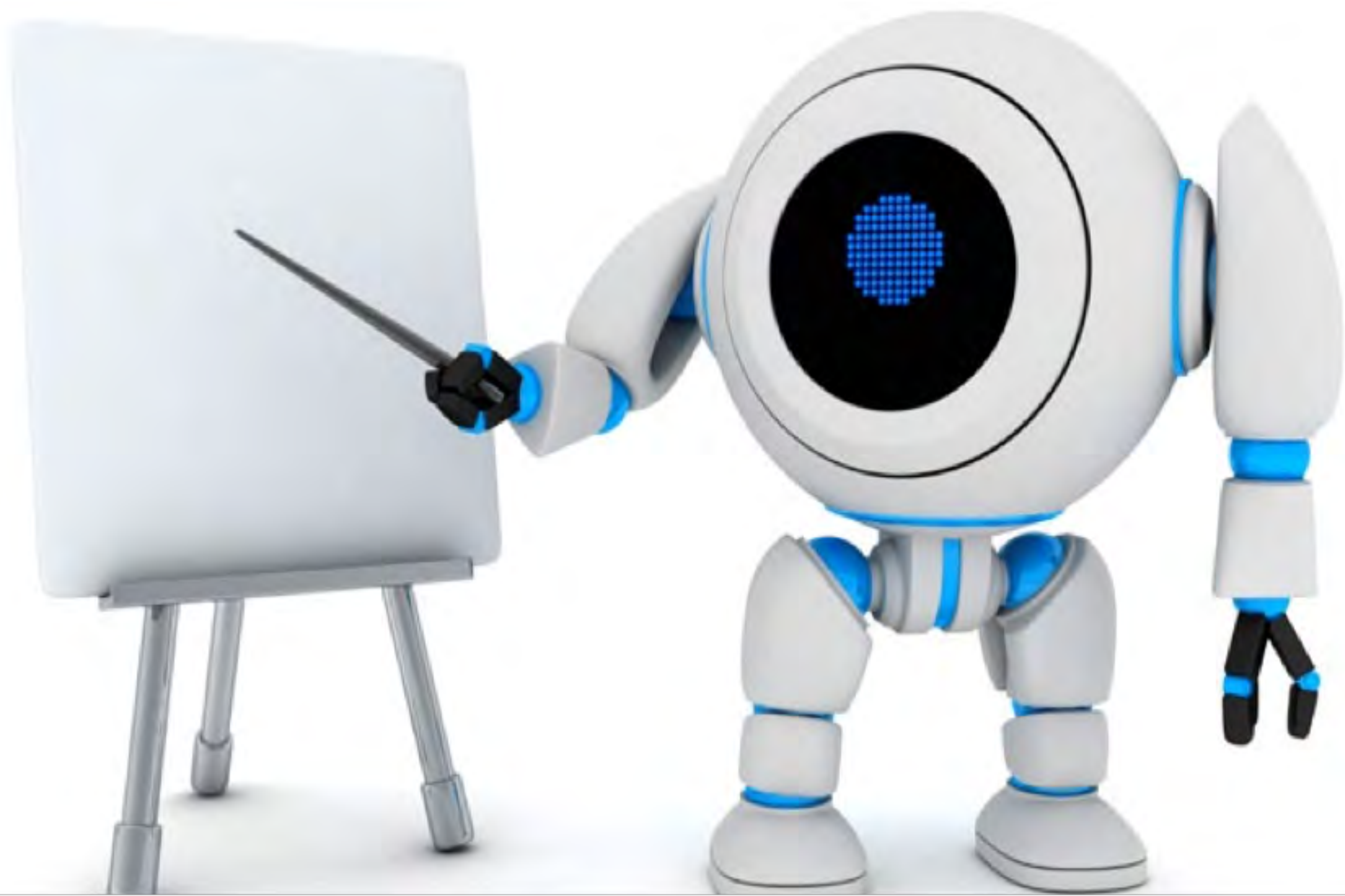
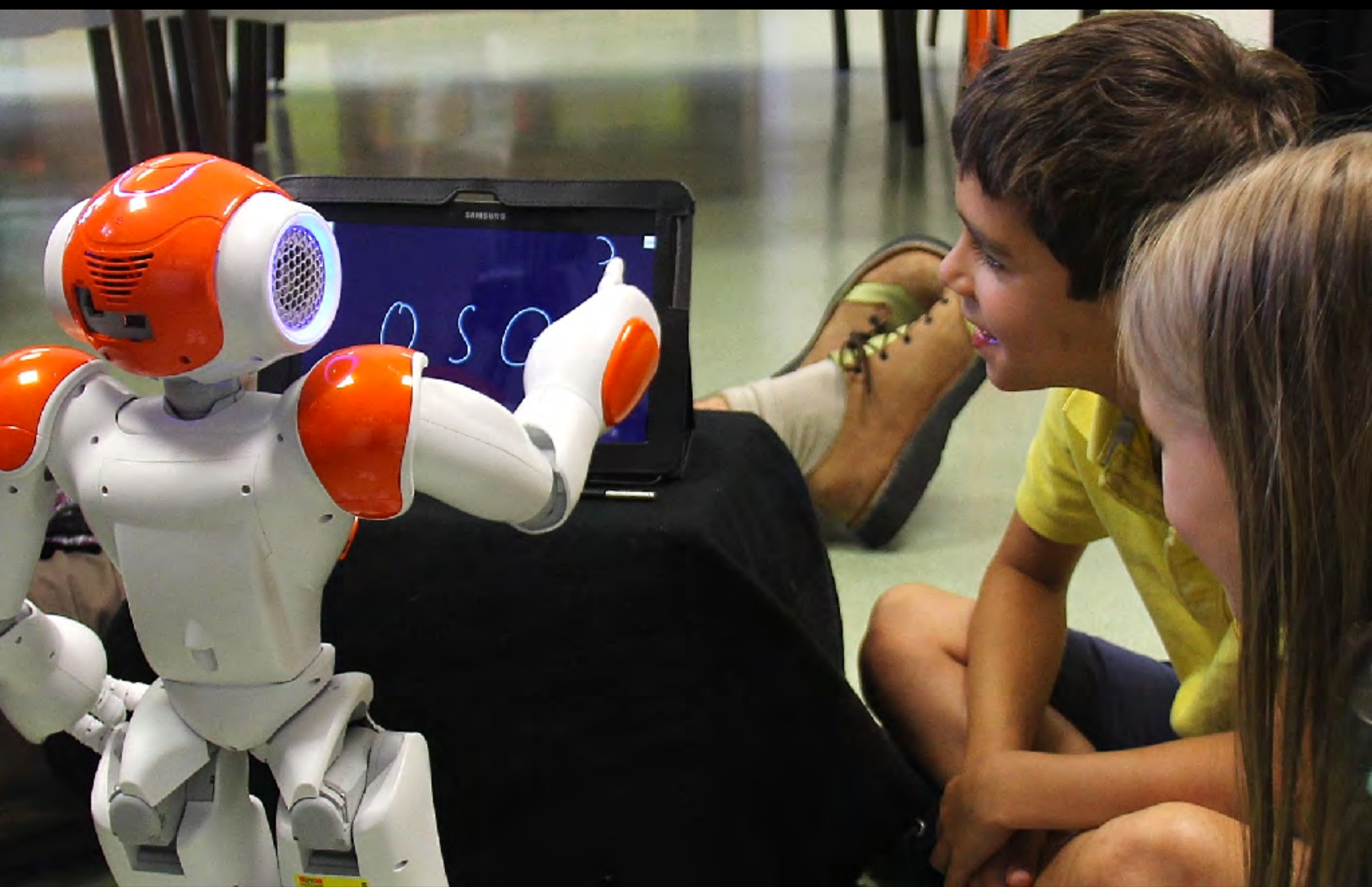


Le long chemin

P. Dillenburg





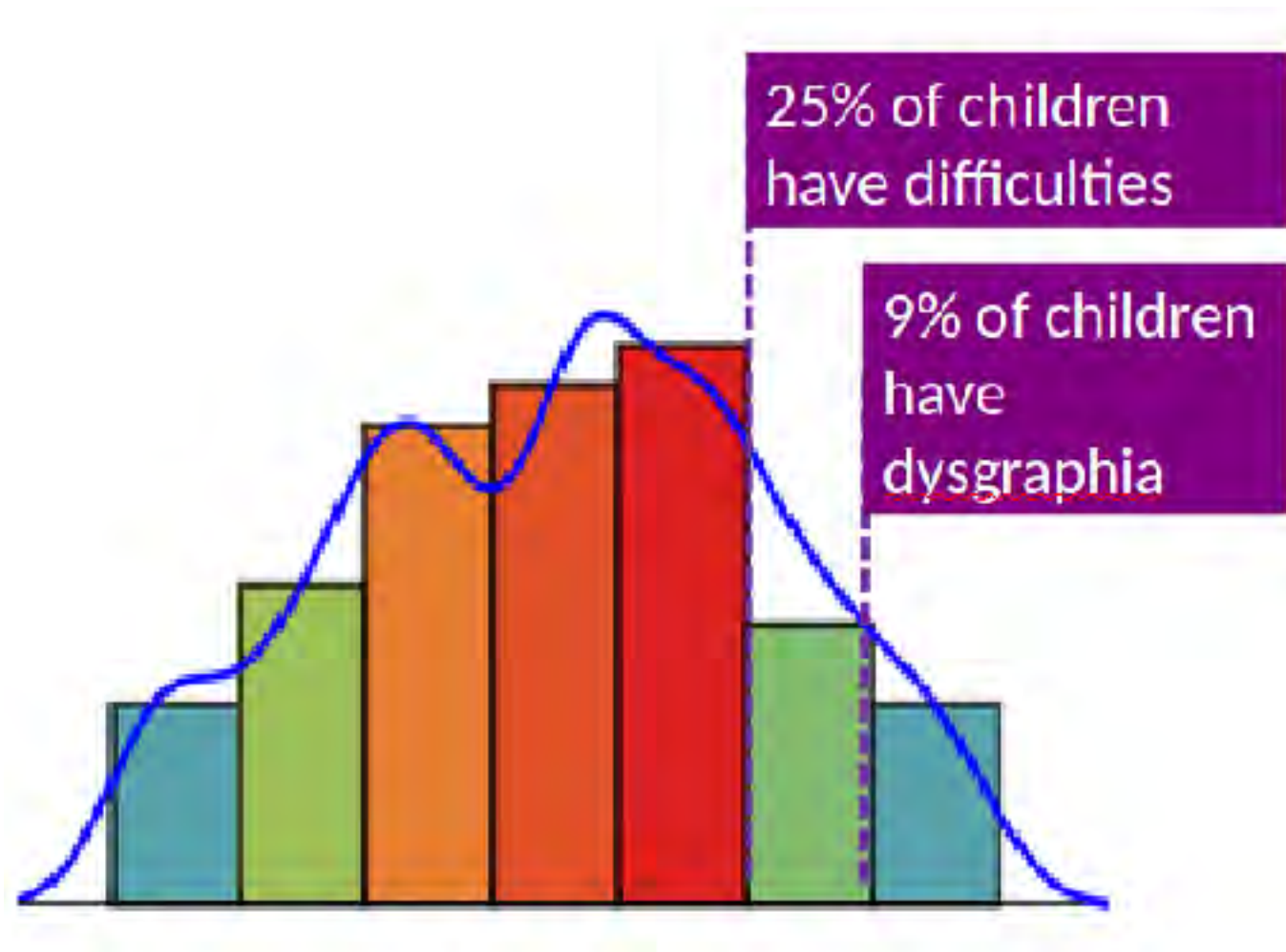


Thibault Asselborn, Wafa Johal, Konrad Zolna, Luckaz Kidzinski, Caroline Joly, Corinne Lebourgeois, Severin Lemaignan, Ana Paiva, Aude Billard, Frédéric Kaplan, P. Dillenbourg

robotics⁺

What is dysgraphia ?

Critical consequence on child's academic, behavioral progress and well being

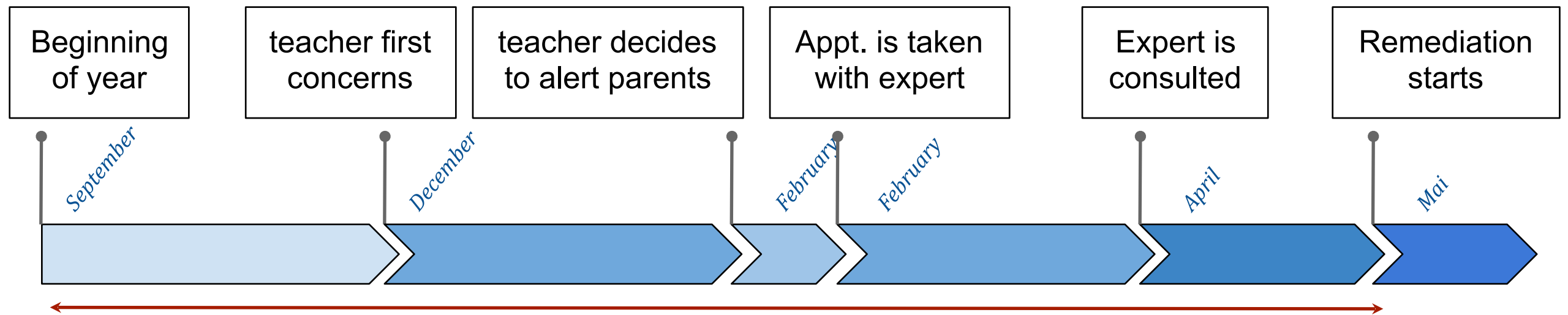


BHK, gold standard to diagnose dysgraphia

This is
the best
I can do

le petit cheval gambade

CRITÈRES						TOTAL
1. Écriture grande						
2. Inclinaison de la marge vers la droite						
	Phrases	1	2	3	4	5
3. Lignes non planes						
4. Mots serrés						
5. Écriture chaotique						
6. Liens interrompus entre les lettres						
7. Telescopages						
8. Variation dans la grandeur des lettres troncs						
9. Hauteur relative incorrecte						
10. Distorsion des lettres						
11. Formes de lettres ambiguës						
12. Lettres retouchées						
13. Hésitations et tremblements						
Score Total						



child accumulate problems, self-esteem drops down, ...

The BHK test

A test that needs to be adapted to digitalisation



Subjective

Relies on human judgement.

Small (60%) inter-raters agreement.



Time consuming

Takes 5 minutes to pass the test, and around 15 minutes to score it.



Costly

Expert needs to be trained to acquire the expertise for grading.

Grading takes time



Neglect informations

Test done on paper: all the dynamic, pressure, tilt aspects of handwriting are not perceivable.

Tegami diagnostic

An accurate and quick way to help diagnosis

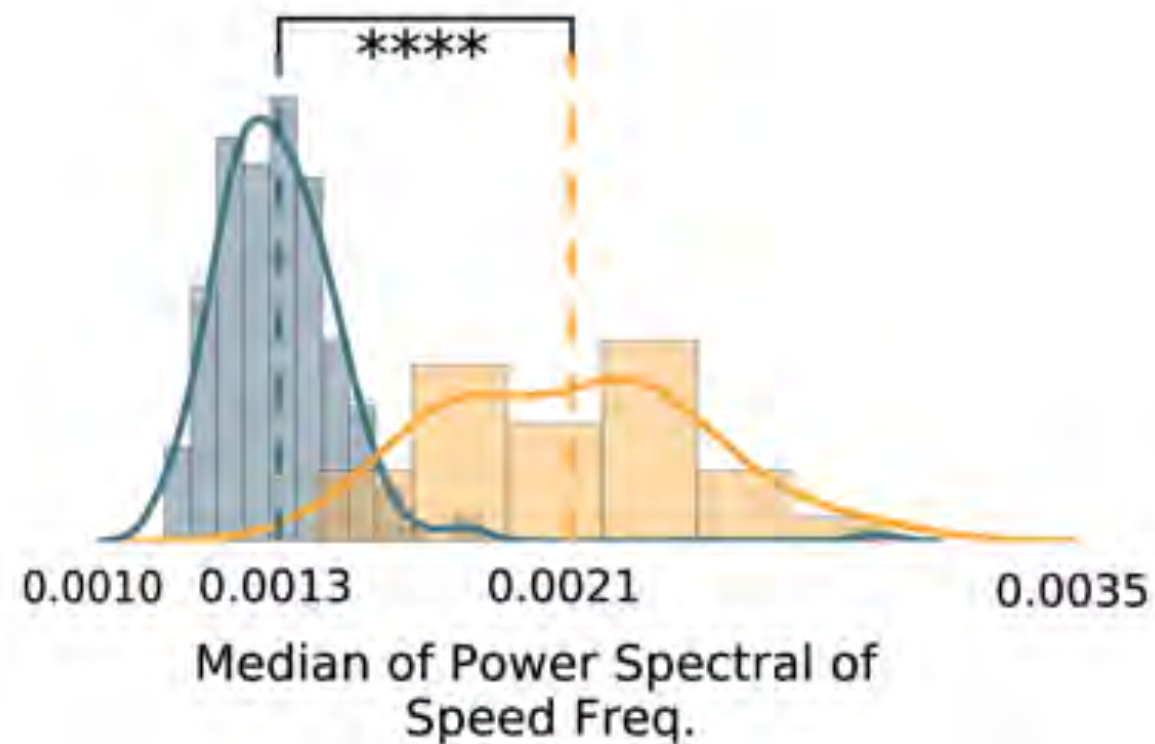
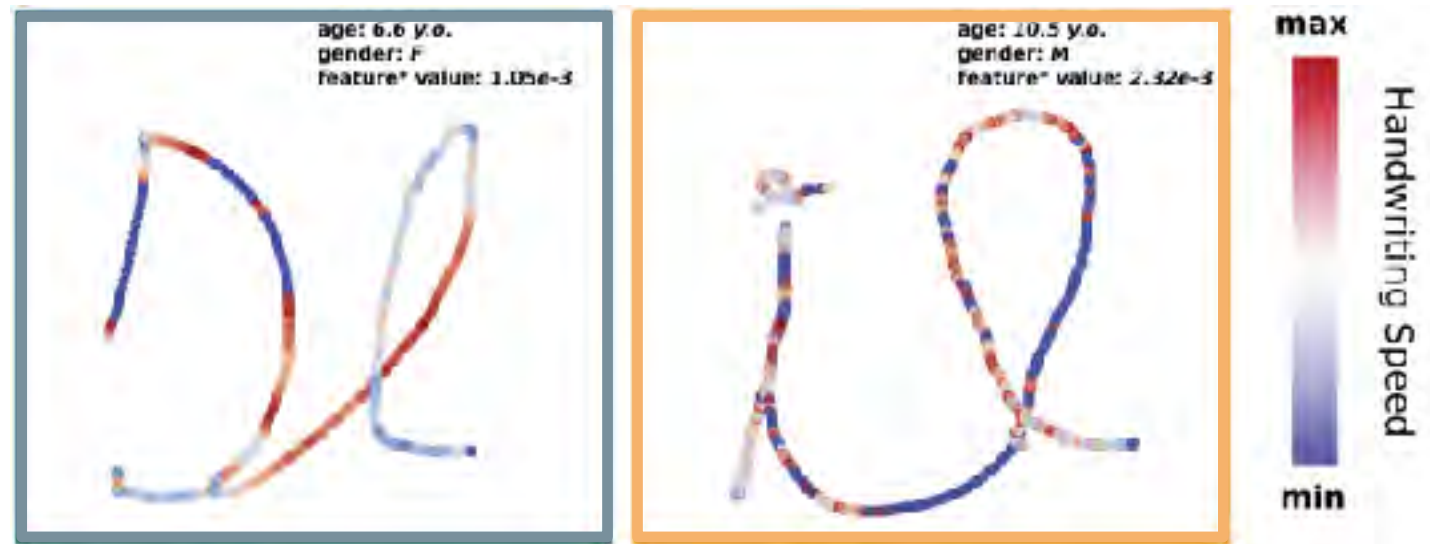
Machine learning algorithm (Random Forest classification) trained on ~ 400 children.



Automated human level of dysgraphia using a consumer tablet,
Nature digital medicine

Tegami diagnostic

Beyond the binary diagnosis



Tegami diagnostic

Handwriting is not static !

Table 2. The most important features found by the Random Forest model, using Gini importance as a metric

Rank	Category	Name	Importance (Std.) [%]
1	Kinematic	Median of Power Spectral of Speed Frequencies	15.71 (9.06)
2	Kinematic	Bandwidth of Speed Frequencies	12.08 (8.00)
3	Pressure	Mean Speed of Pressure Change	9.81 (6.52)
4	Static	Space Between Words	7.45 (6.73)
5	Tilt	Distance to Mean of Speed of Tilt-X Change Frequencies	6.07 (4.30)
6	Kinematic	Distance to Mean of Speed Change Frequencies	5.18 (4.73)
7	Tilt	Bandwidth of Speed of Tilt-X Change Frequencies	4.10 (4.64)
8	Tilt	Median of Power Spectral of Tilt-Y Change Frequencies	2.97 (3.33)

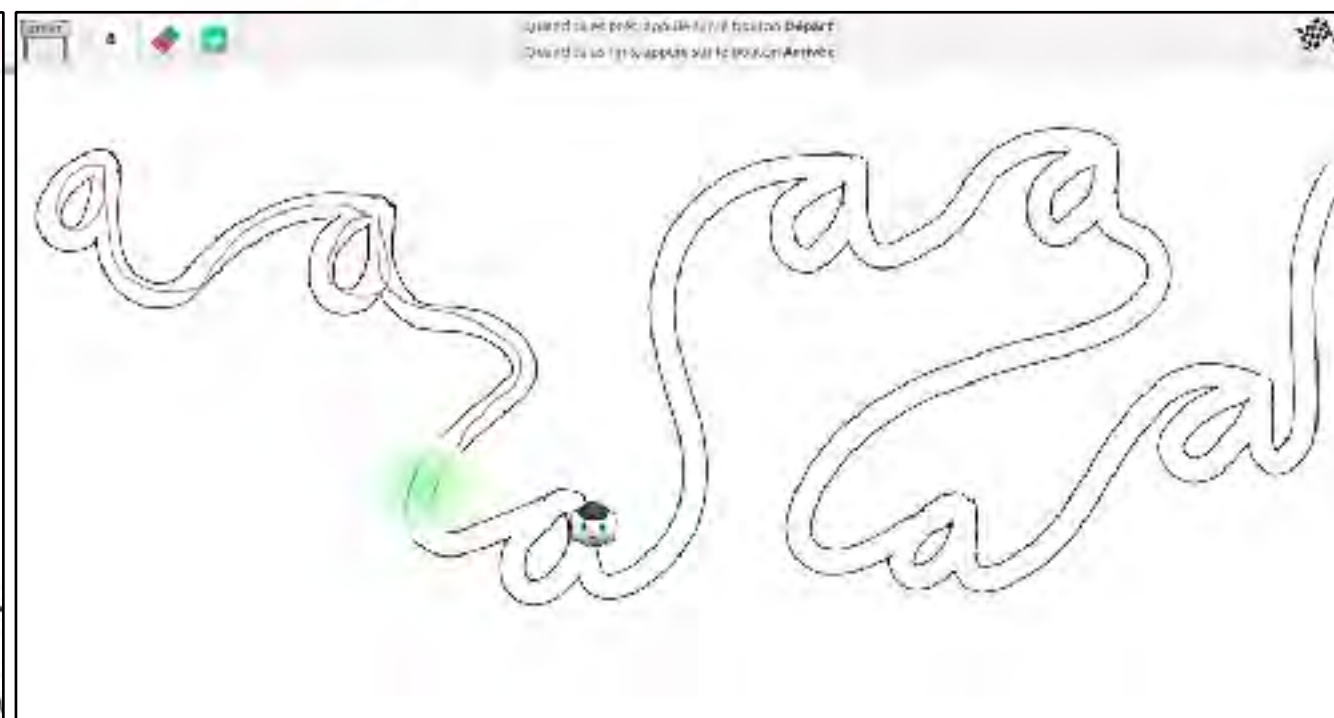
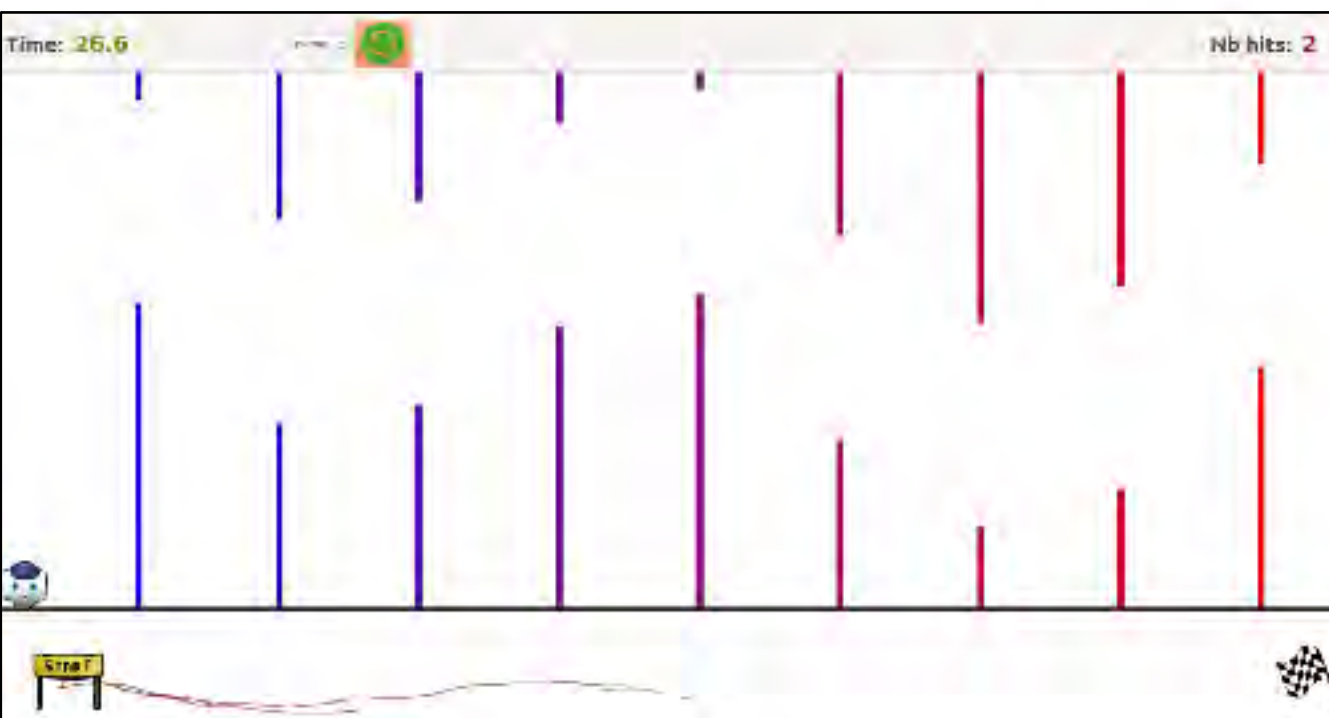
We report the ranks, feature categories, and their importance averaged for the 25 folds and the standard deviation of importance over all folds

Only one of this feature can potentially be extracted with a pen/
paper test !



Static			
Space Between Words	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>
Tremolo	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>
Moment of handwriting	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>
Kinematic			
In air time	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>
Max speed	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>
Mean speed	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>
Std. speed	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>
Frequencies speed	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>
Pressure			
Number of peaks pressure change	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>
Max speed of pressure change	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>
Mean speed of pressure change	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>
Frequencies pressure	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>
Tilt			
Maximum tilt	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>
Std. tilt	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>
Frequencies tilt	<input checked="" type="checkbox"/>	<input type="text"/>	<input checked="" type="checkbox"/>

Extracting the child handwriting profile in 15 seconds



Tegami remediation

Building the map exercise - benefits

Static

Space Between Words ☒ ☐ ☒

Tremolo ☒ ☐ ☒

Moment of handwriting ☒ ☐ ☒

Kinematic

In air time ☒ ☐ ☒

Max speed ☒ ☐ ☒

Mean speed ☒ ☐ ☒

Std. speed ☒ ☐ ☒

Frequencies speed ☒ ☐ ☒

Pressure

Number of peaks pressure change ☒ ☐ ☒

Max speed of pressure change ☒ ☐ ☒

Mean speed of pressure change ☒ ☐ ☒

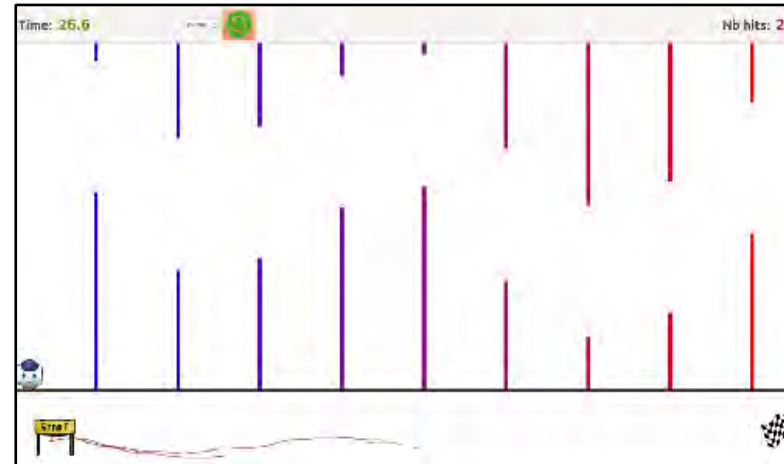
Frequencies pressure ☒ ☐ ☒

Tilt

Maximum tilt ☒ ☐ ☒

Std. tilt ☒ ☐ ☒

Frequencies tilt ☒ ☐ ☒



Static

Space Between Words ☒ ☐ ☒

Tremolo ☒ ☐ ☒

Moment of handwriting ☒ ☐ ☒

Kinematic

In air time ☒ ☐ ☒

Max speed ☒ ☐ ☒

Mean speed ☒ ☐ ☒

Std. speed ☒ ☐ ☒

Frequencies speed ☒ ☐ ☒

Pressure

Number of peaks pressure change ☒ ☐ ☒

Max speed of pressure change ☒ ☐ ☒

Mean speed of pressure change ☒ ☐ ☒

Frequencies pressure ☒ ☐ ☒

Tilt

Maximum tilt ☒ ☐ ☒

Std. tilt ☒ ☐ ☒

Frequencies tilt ☒ ☐ ☒

Dillenbourg P. [1989] The design of a self-improving tutor: PROTO-TEG. *Instructional Science*, vol. 18, n° 3, pp. 183-216.

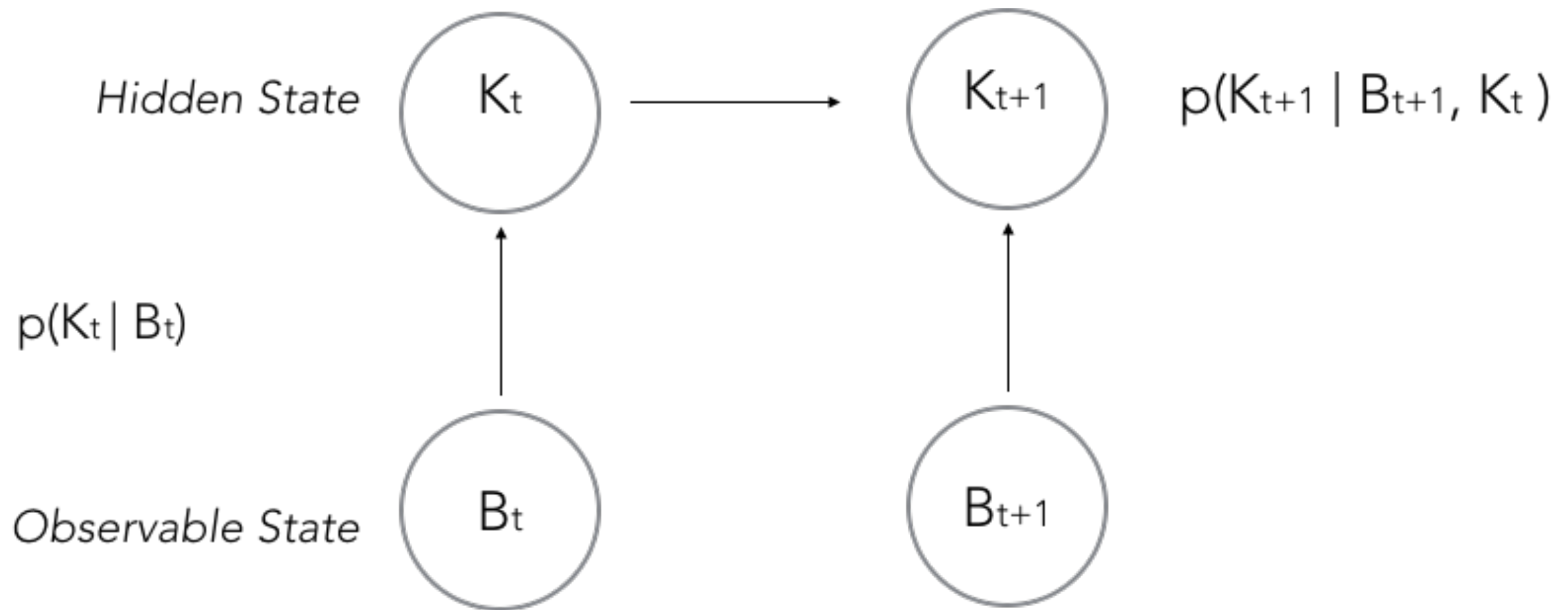
δ

The Design of a Self-Improving Tutor : PROTO-TEG

By Pierre DILLENBOURG

Unité de Technologie de l'Education
Université de l'Etat à Mons (Belgium)

if $B_t = \text{correct}$ then $p(K_t = \text{correct}) = 1 - p(\text{guess})$ else $p(K_t = \text{correct}) = 0 + p(\text{slip})$

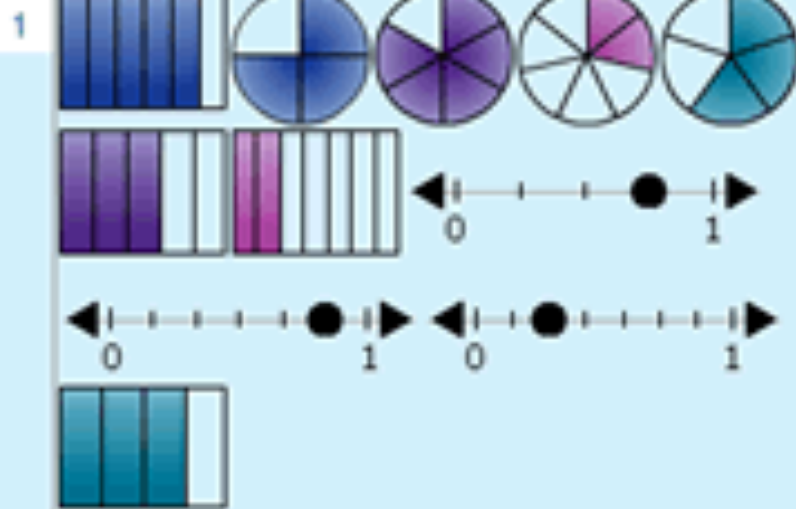


Bayesian Knowledge Tracing

Mixed Representations

Let's look at representations of fractions to sort them!

Which of these representations show the same fractions? Drag and drop the representations into the slots next to the fraction they show.



$$\frac{3}{5}$$



$$\frac{5}{6}$$

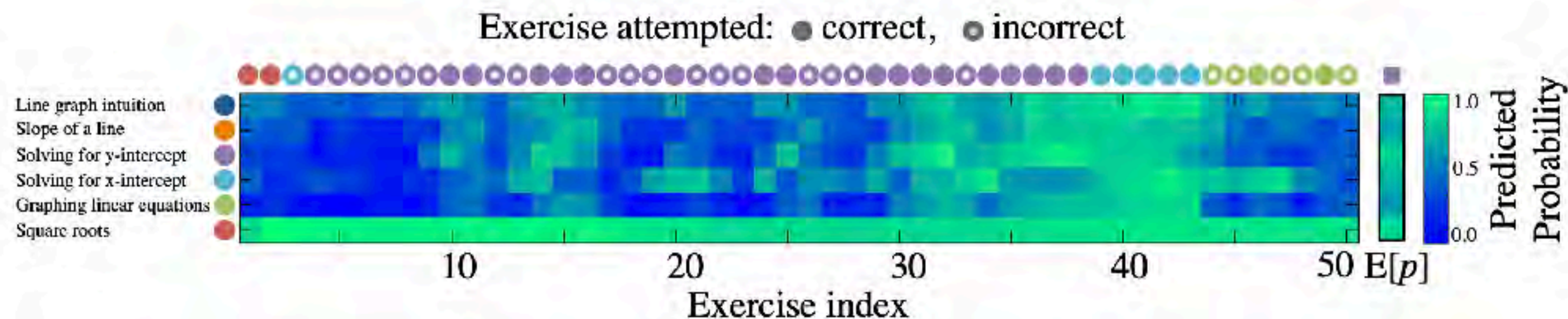
$$\frac{3}{4}$$

$$\frac{2}{7}$$

?
Hint

← Previous

Next →



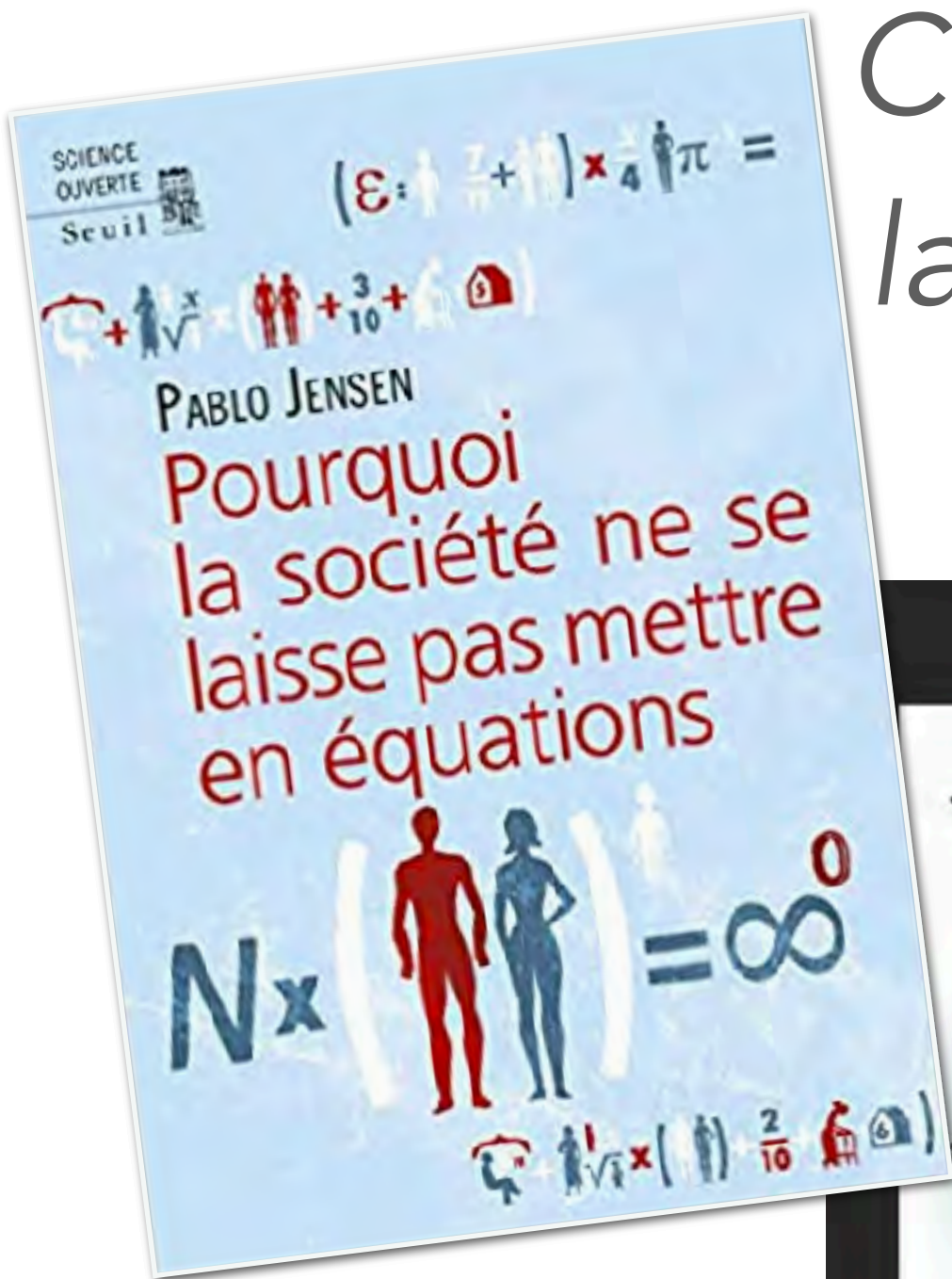
Dataset	Overview			AUC			
	Students	Exercise Tags	Answers	Marginal	BKT	BKT*	DKT
Simulated-5	4,000	50	200 K	?	0.54	-	0.75
Khan Math	47,495	69	1,435 K	0.63	0.68	-	0.85
Assistments	15,931	124	526 K	0.62	0.67	0.69	0.86

Deep Knowledge Tracing

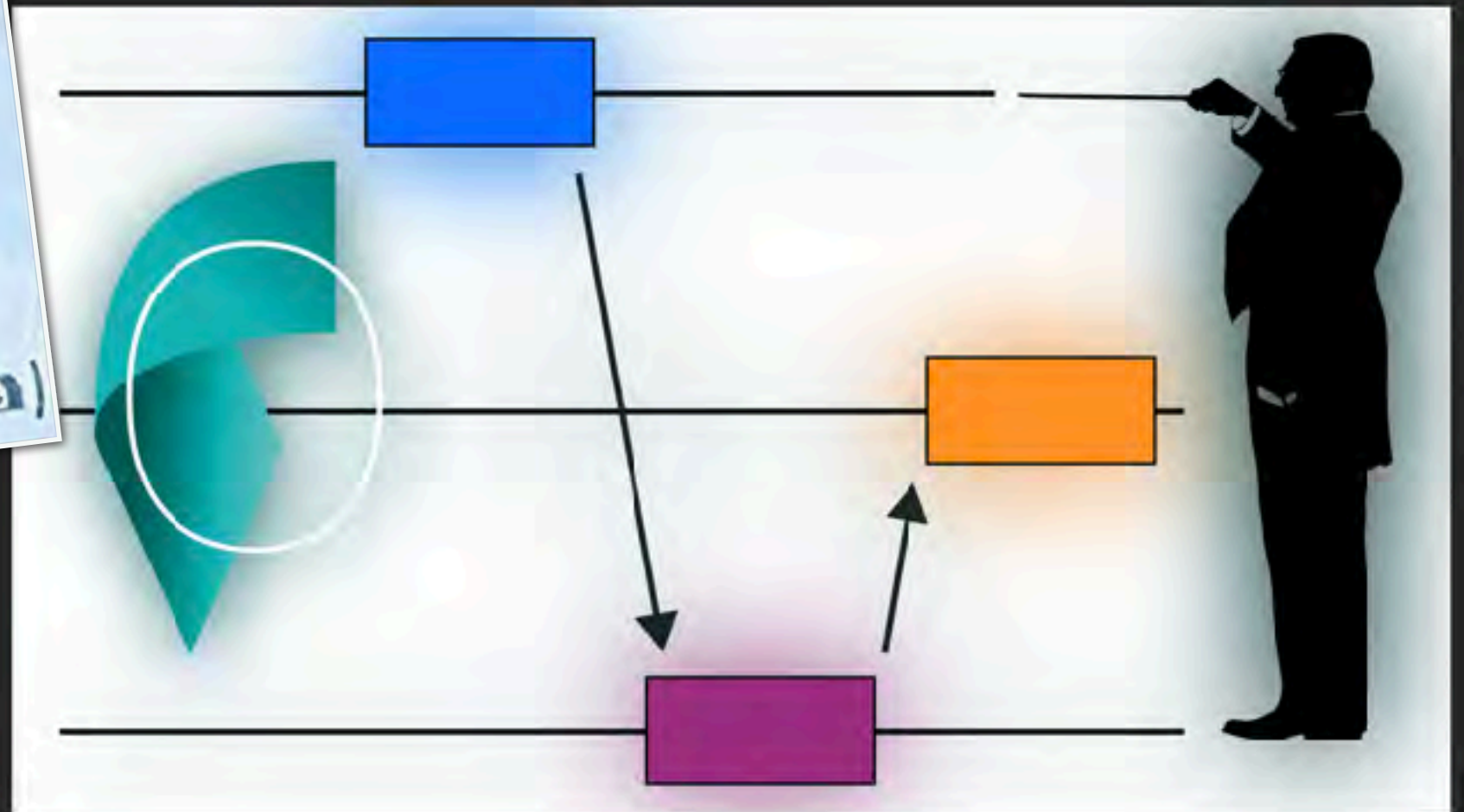
Chris Piech*, Jonathan Bassen*, Jonathan Huang*[‡], Surya Ganguli*,
Mehran Sahami*, Leonidas Guibas*, Jascha Sohl-Dickstein*[†]

Limitations de BKT & Cie

- (Modèle monotone)
- $p(\text{guess})$ et $p(\text{slip})$ sont constants
- K et B sont binaires
- réponses vs processus
- pédagogie de maîtrise



Comment ne pas sacrifier la richesse pédagogique à la rigueur analytique ?



EPFL CS-211 HCI

Question

Please order a standard one-way 1st class ticket from Fribourg to Lausanne without bike.

Enter command
|

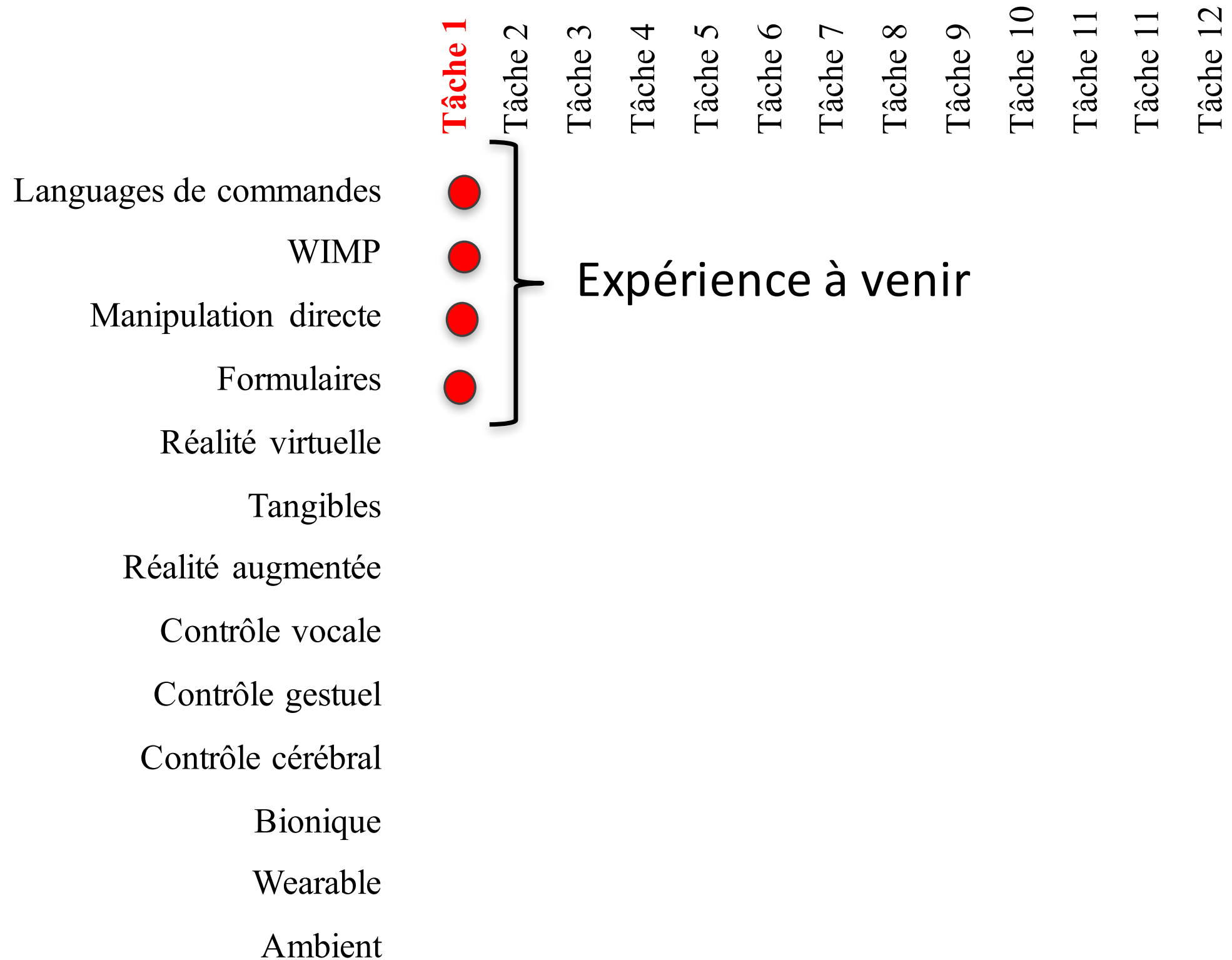
⌚ :50

HELP

BUY

Interaction style « Command Line »

EPFL CS-211 HCI



Question

Please order a half-fare one-way 2nd class ticket from Zurich to Lausanne with a bike.

Your Ticket

From	To
Travel	Fare
Class	Bike

⌚ :54

City

Basel	Davos	Fribourg
Geneve	Lausanne	Neuchatel
Zurich		

Travel

One-way	Return
---------	--------

Class

1st	2nd
-----	-----

Fare

Standard	Young	Half-fare
----------	-------	-----------

Bike

Yes	No
-----	----

HELP

BUY

Interaction style « Direct Manipulation »

Question

Please order a standard return 2nd class ticket from Geneve to Fribourg without bike.

From:

To:

Travel:

Fare:

Class:

Bike:

⌚ :53

HELP

BUY

Interaction style « Form »



From
Basel

To
Zurich

Travel

☐ One-way

☐ Return

Class

☐ 1st

☐ 2nd

Fare

☐ Standard

☐ Young

☐ Half-fare

Bike

☐ Yes

☐ No

⌚ :36

HELP

BUY

Interaction style «Menu »

Please select the interfaces and rank them with 1 being the best and 4 being the worst. Please justify your ranking.



If you rarely buy a train ticket rank the Interfaces in the order that you would most prefer them.

Ryan's List

1 Command

2 Drag and Drop

3 Form

4 Map



The command is fastest once you have practice.

Submit

Chat (group/alone)

Group Chat

Friendly robot

Hello Guys :) I <3 CHILLians

Friendly robot

Ryan ranked the interfaces in the following order: Command, Drag and Drop, Form, Map, with the justification "The command is fastest once you have practice."

Group Preference (group/alone)

You and your partner must have the same ranking to submit.

Rank the interfaces in the order that you would most prefer them.

Ryan's List

At rank 1, add item:

Form

Drag and Drop

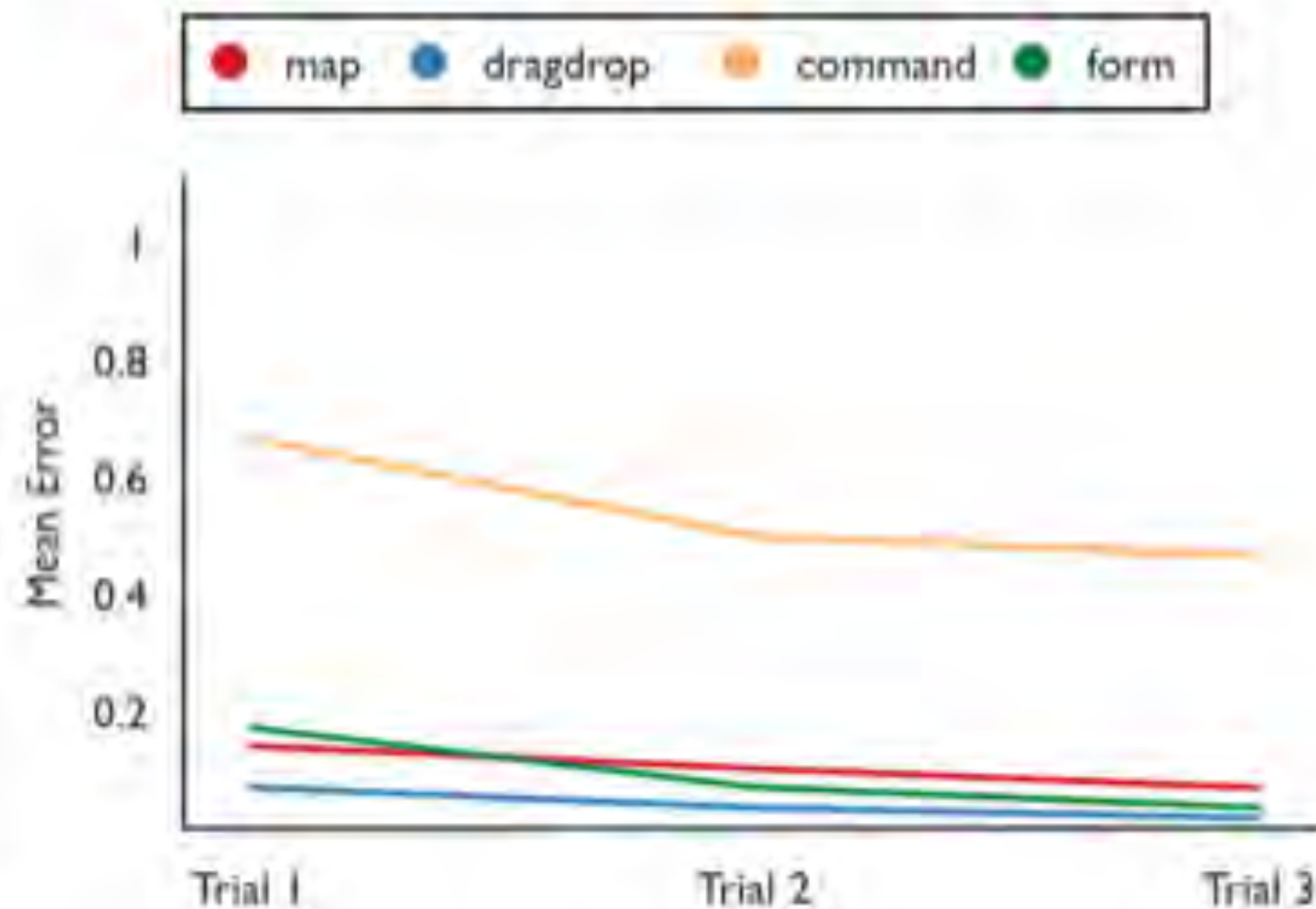
Command

Map

Justify your answer

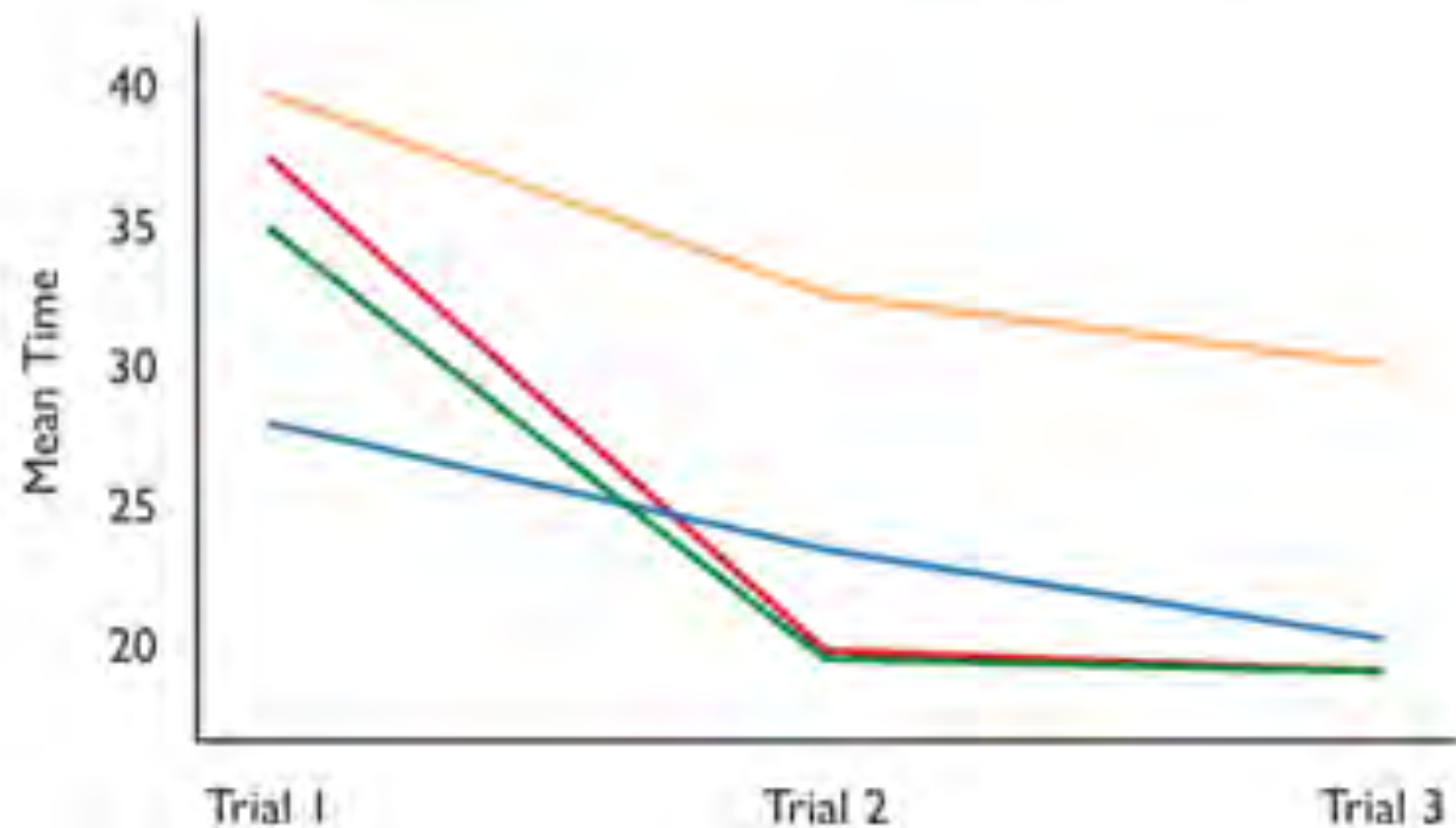
Submit

MEAN ERROR PER TICKET FOR EACH INTERFACE



MEAN TIME PER TICKET FOR EACH INTERFACE

map dragdrop command form



Chat (group/A1)

Group Chat

I think it is data from the activity

Ryan

Is it from just us or from everyone?

Jenny

uh, I don't know

Jenny

It actually looks like the data might confirm that the form is best. The time looks like it was less.

Ryan

Yeah, let's stick with what we had

Group Preference with Data (group/A1)

Experiment before

Training for future

1 Form

2 Drag and Drop

3 Command

4 Map

1 Form

2 Drag and Drop

3 Command

4 Map



Same as before

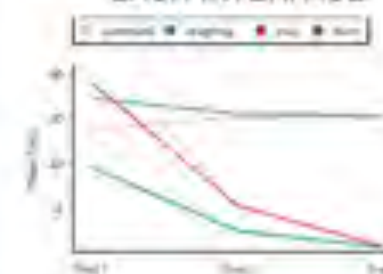
Train Data (group/A1)

STATS

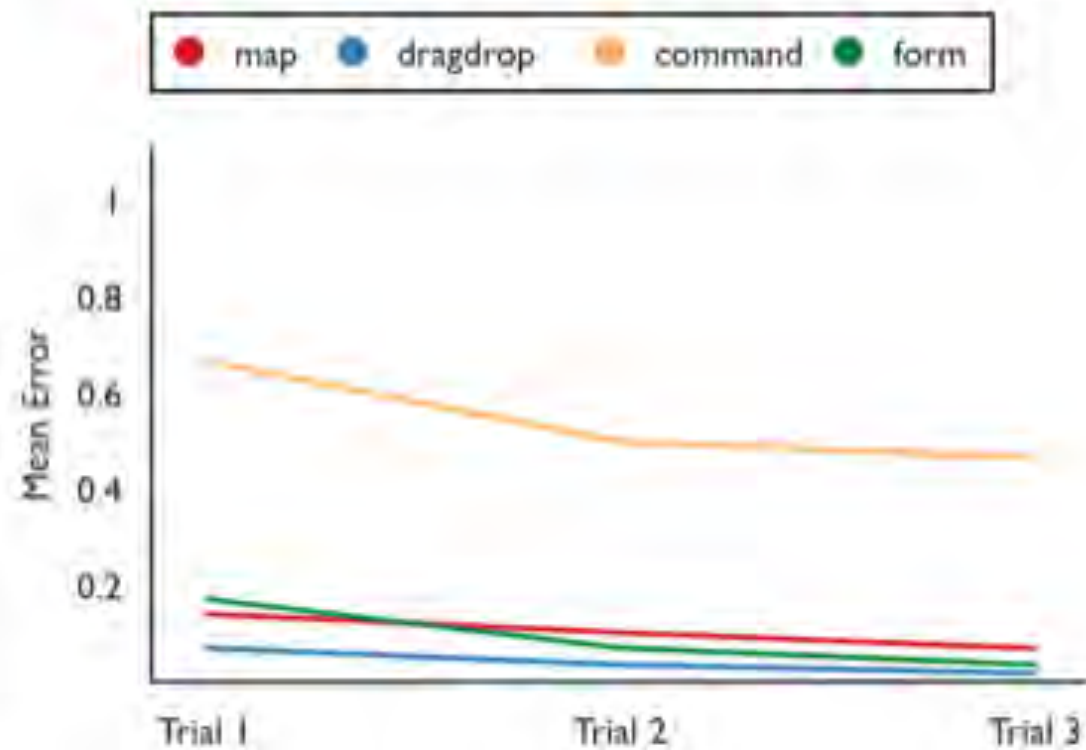
MEAN ERROR PER TICKET FOR EACH INTERFACE



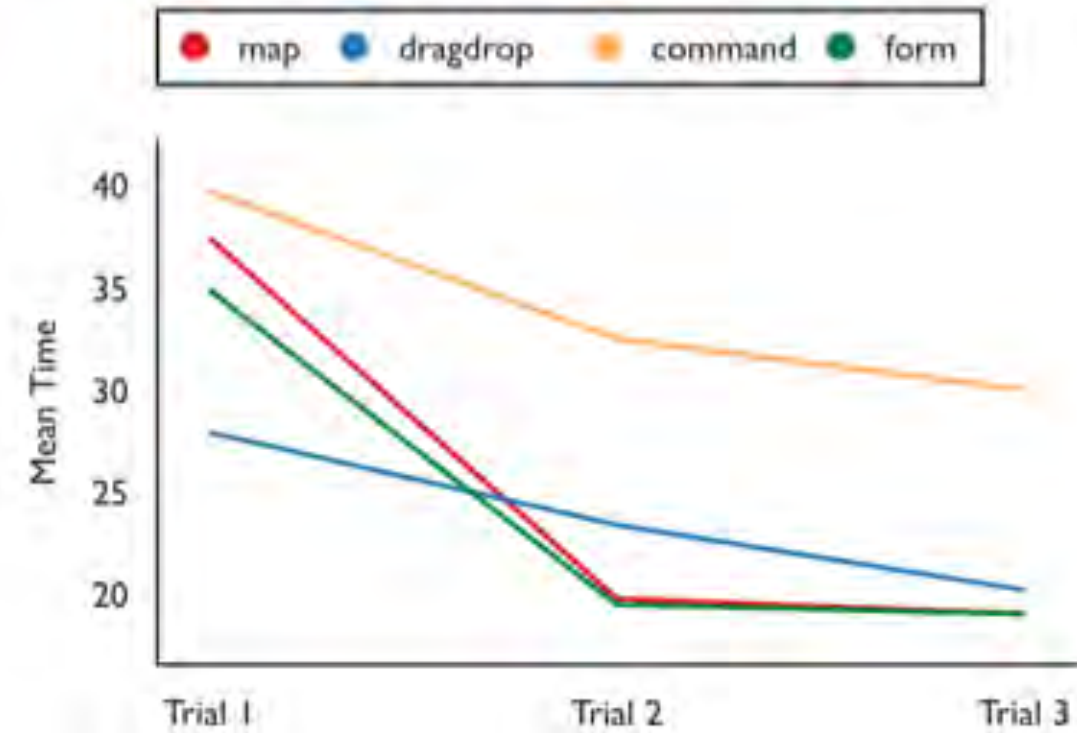
MEAN TIME PER TICKET FOR EACH INTERFACE



MEAN ERROR PER TICKET FOR EACH INTERFACE



MEAN TIME PER TICKET FOR EACH INTERFACE



	(1) Connaissances sémantiques liées à la tâche	(2) Connaissances sémantiques liées à la transposition informatique de la tâche	(3) Connaissances syntaxiques, arbitraires
NOVICES	✓		
INTERMITTENTS	✓	✓	
EXPERTS	✓	✓	✓

Expérience

Classer

Argumenter

Argumenter + data

Analyse & Théorie

Classe

Equipe

Individuel

Classe

Analyse & Théorie

Equipe

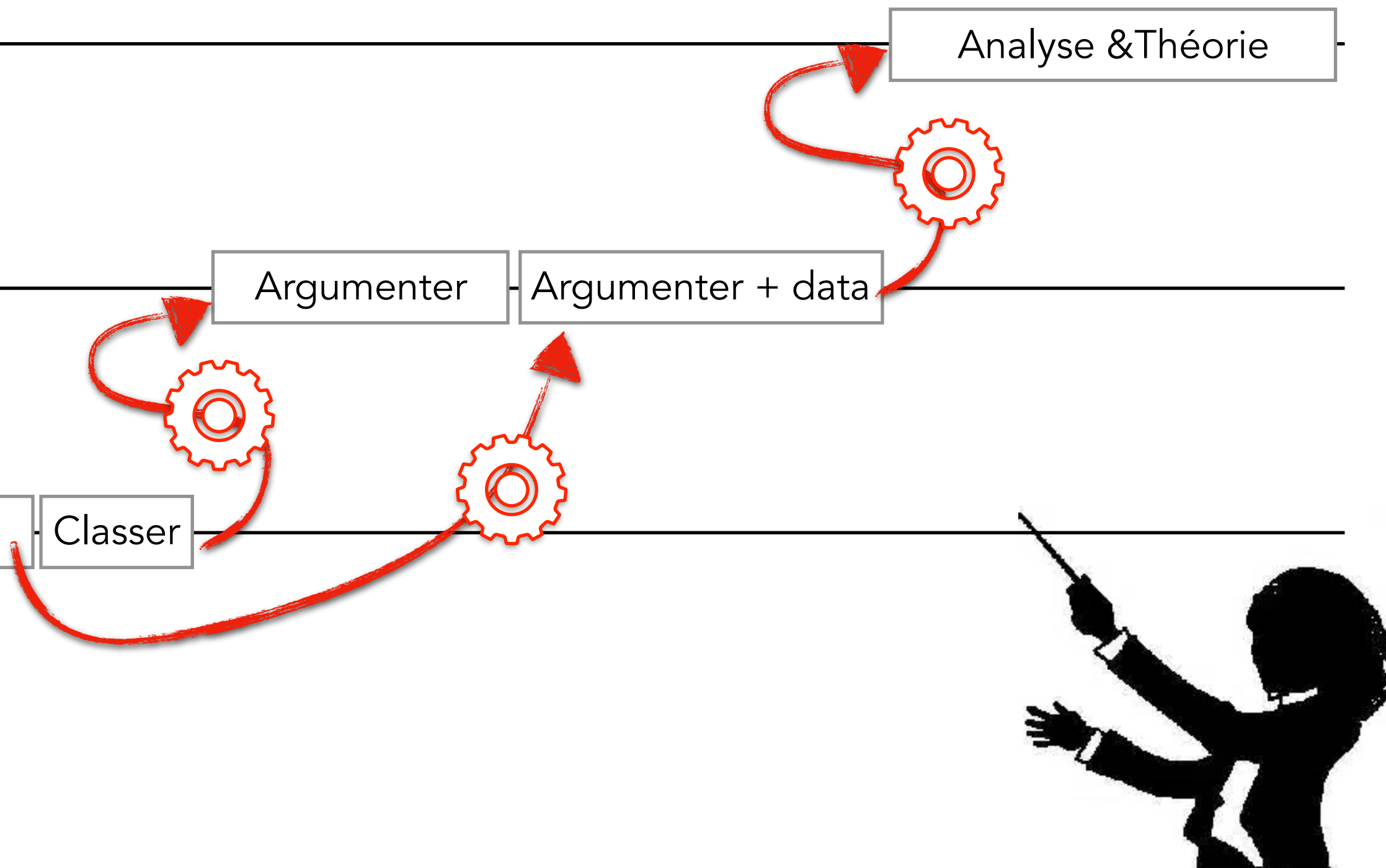
Argumenter

Argumenter + data

Individuel

Expérience

Classer



Orchestration Graph

Secure | <https://icchilisrv3.epfl.ch/teacher/cjdv9y6nm000i06y11o0prs15>

Admin Graph Editor Preview **Teacher View**

Next Activity Toggle dashboard/graph view Pause Stop Edit student list Restart session Start Countdown +10s -10s Download log csv Export session 10s session: UY56

Debrief

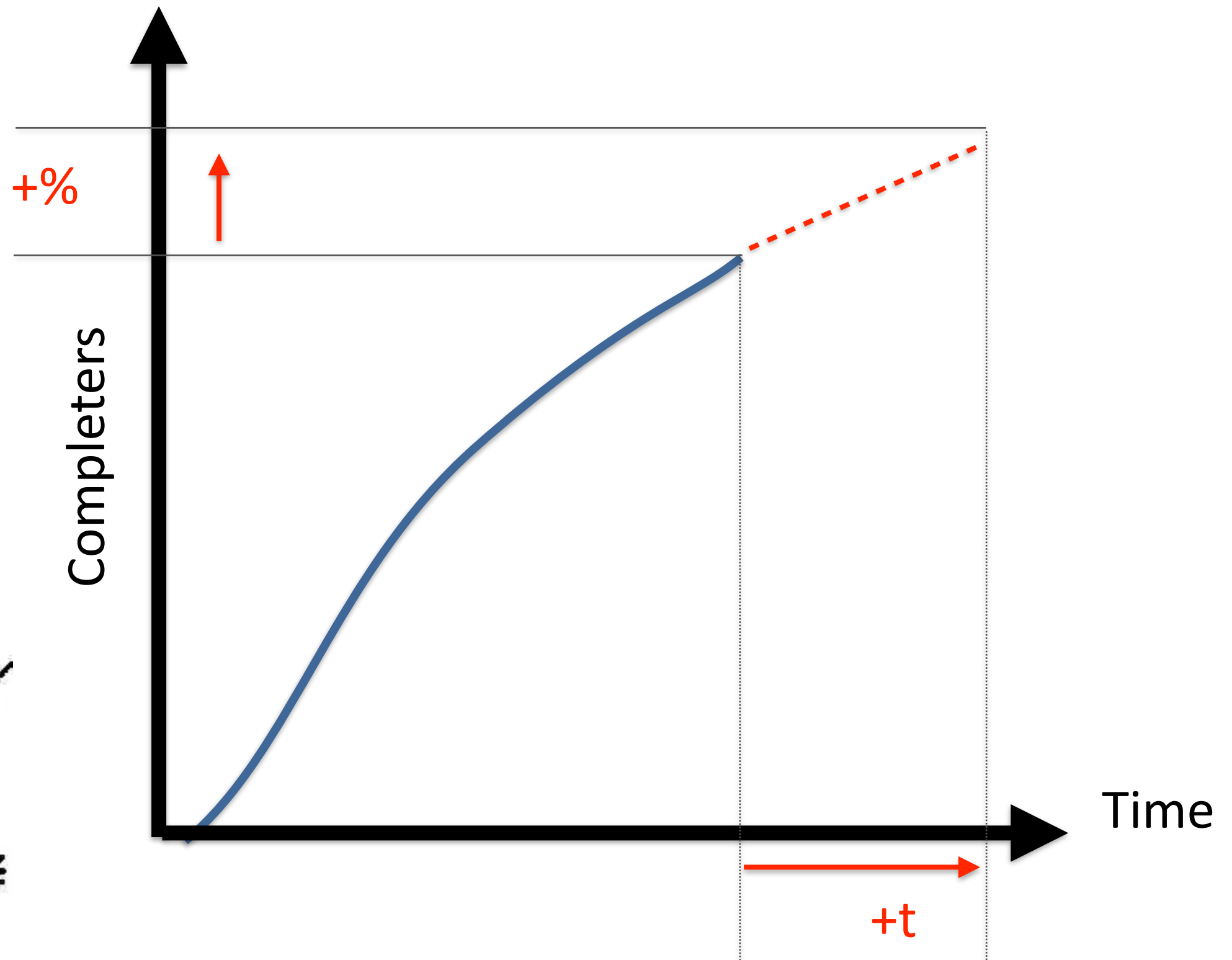
Stoop

5 min. 10 min. 15 min. 20 min. 25 min.

Create Session Switch Session

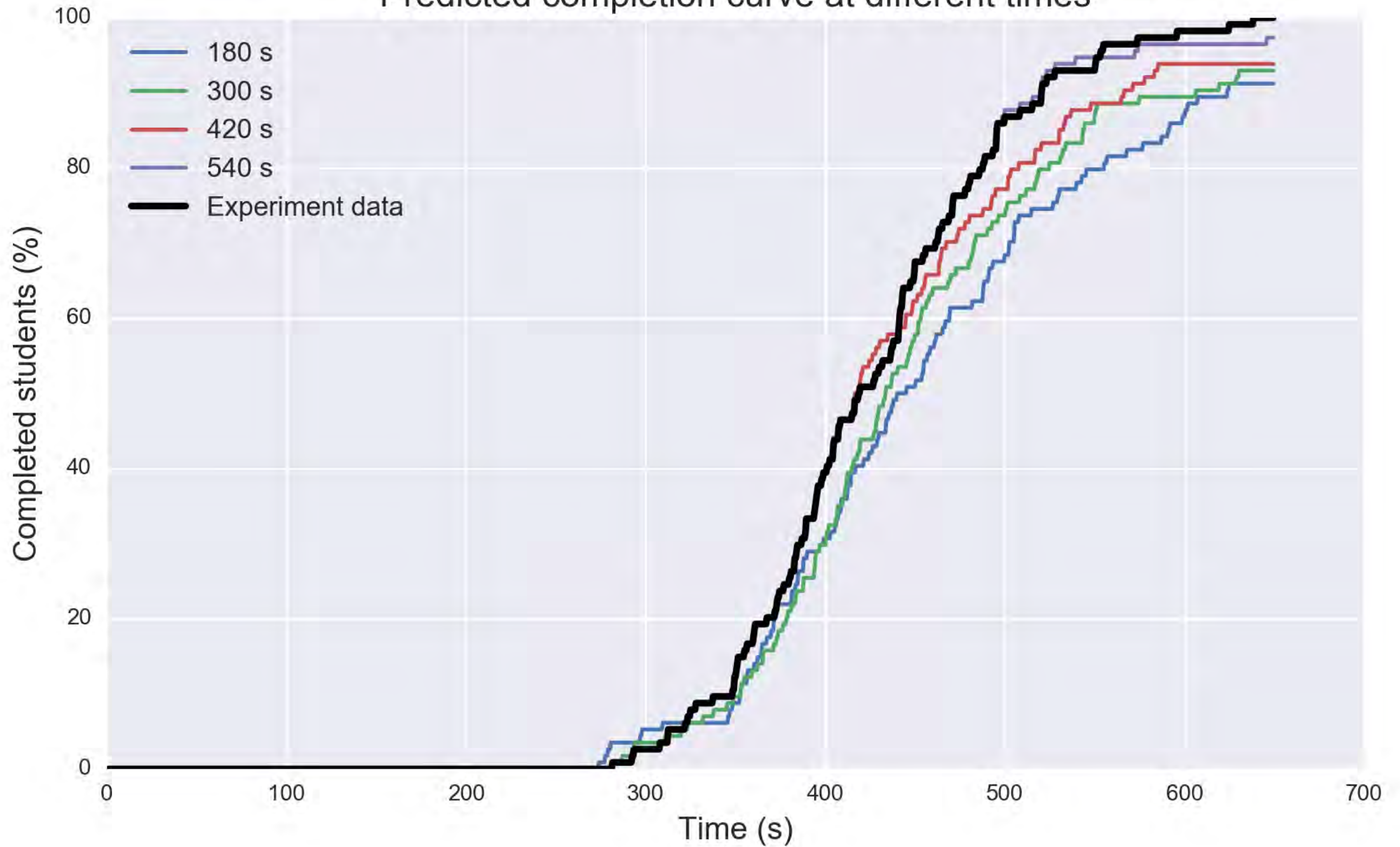


Stian Haklev, Louis Faucon, Jennifer Olsen (EPFL)



Orchestration de la classe

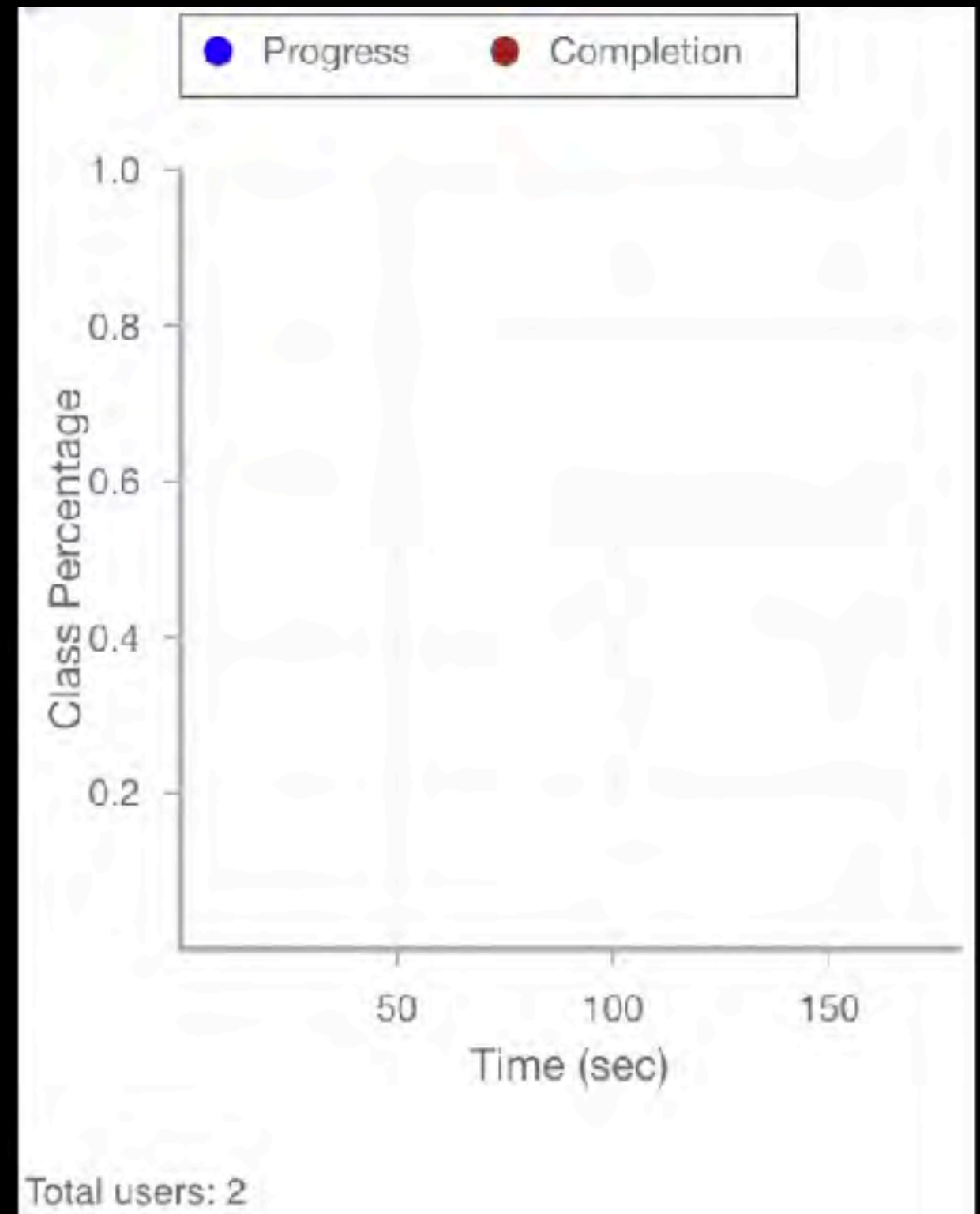
Predicted completion curve at different times

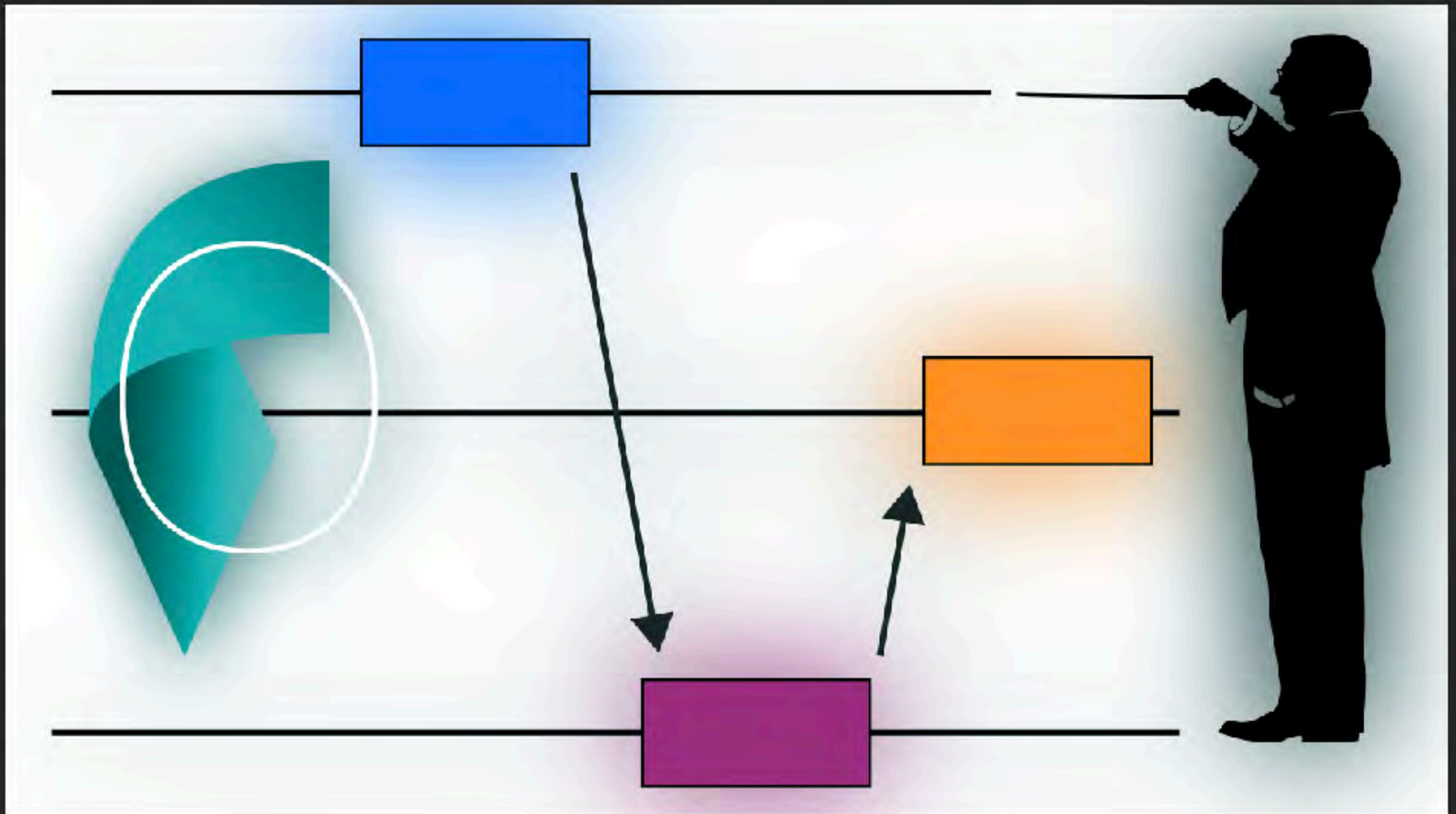


2017 Train Activity

Jiaxi Gu, Jennifer Olsen (EPFL)

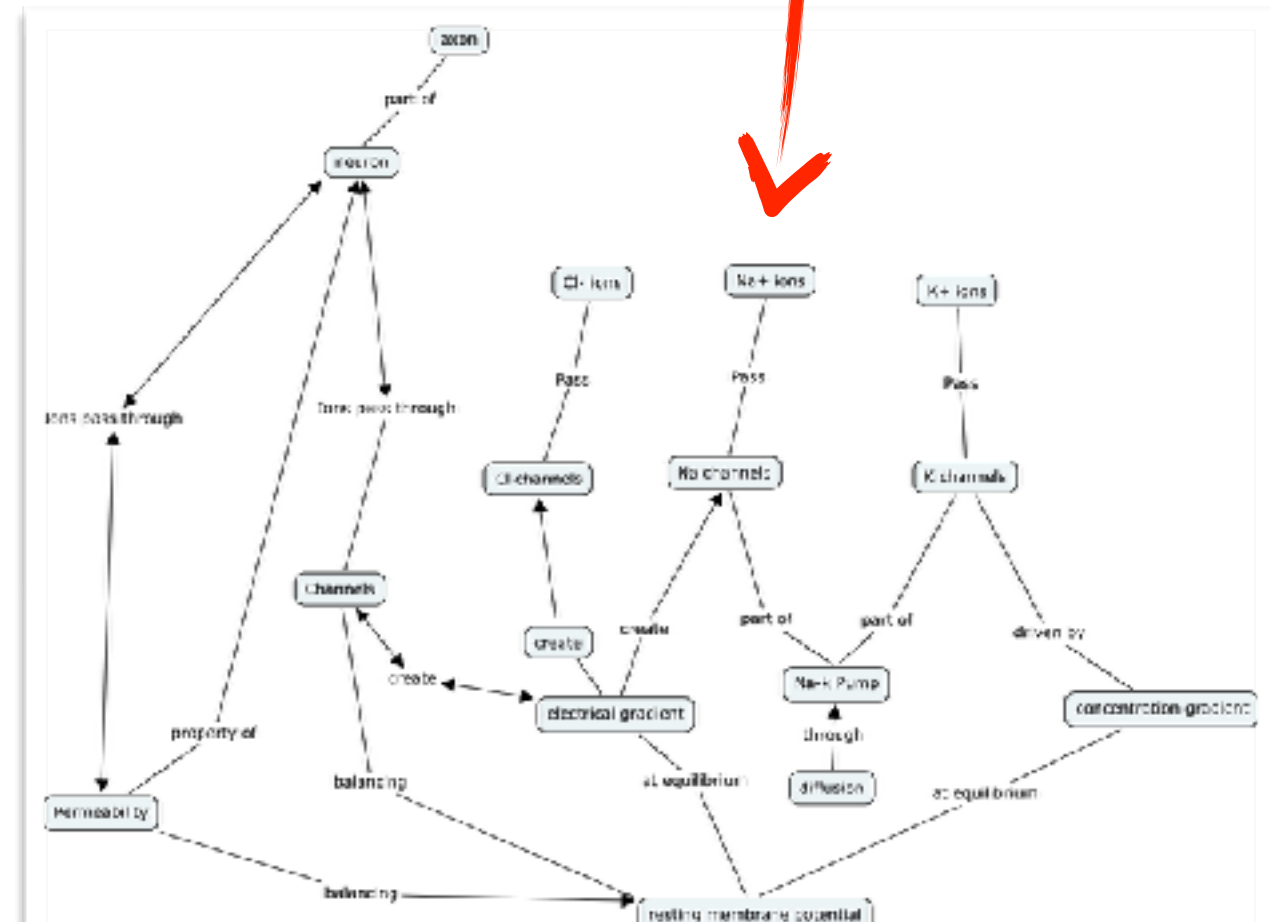
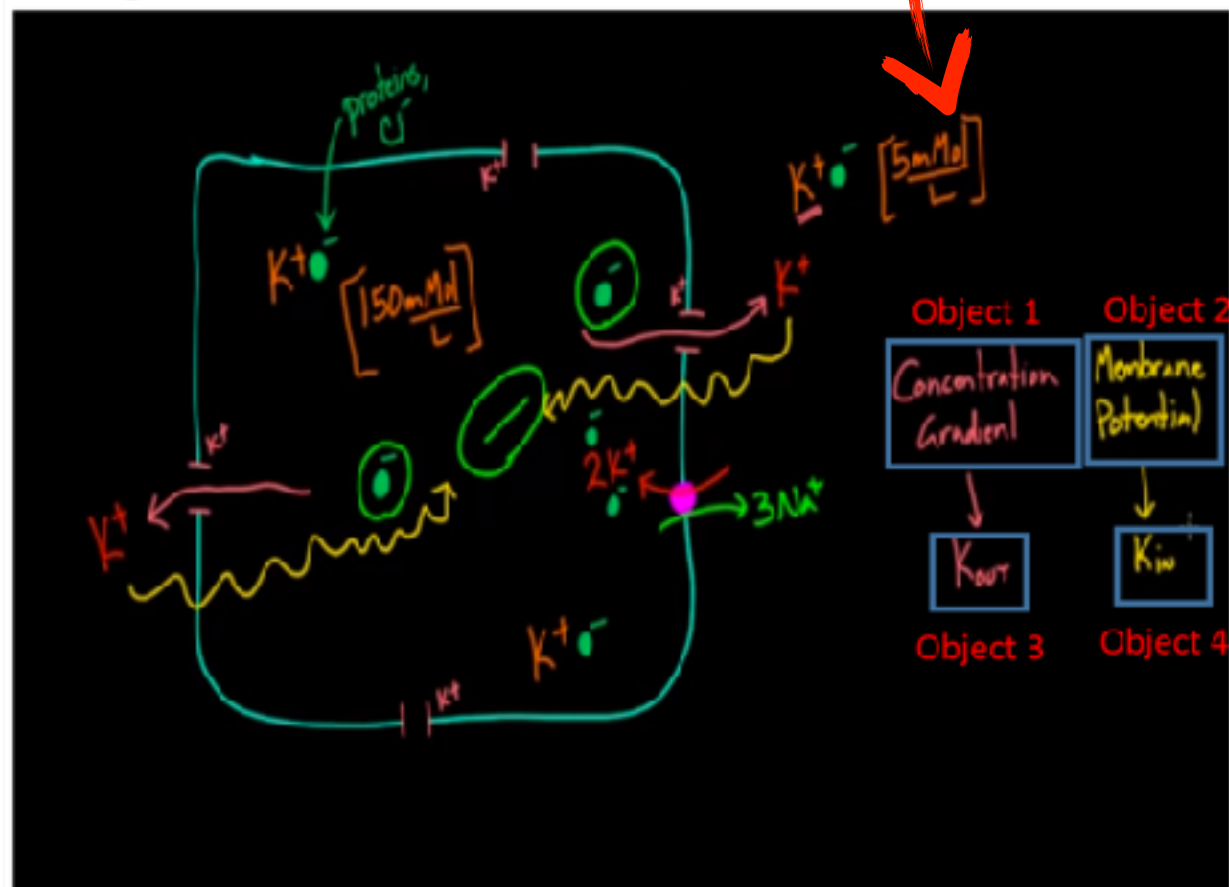
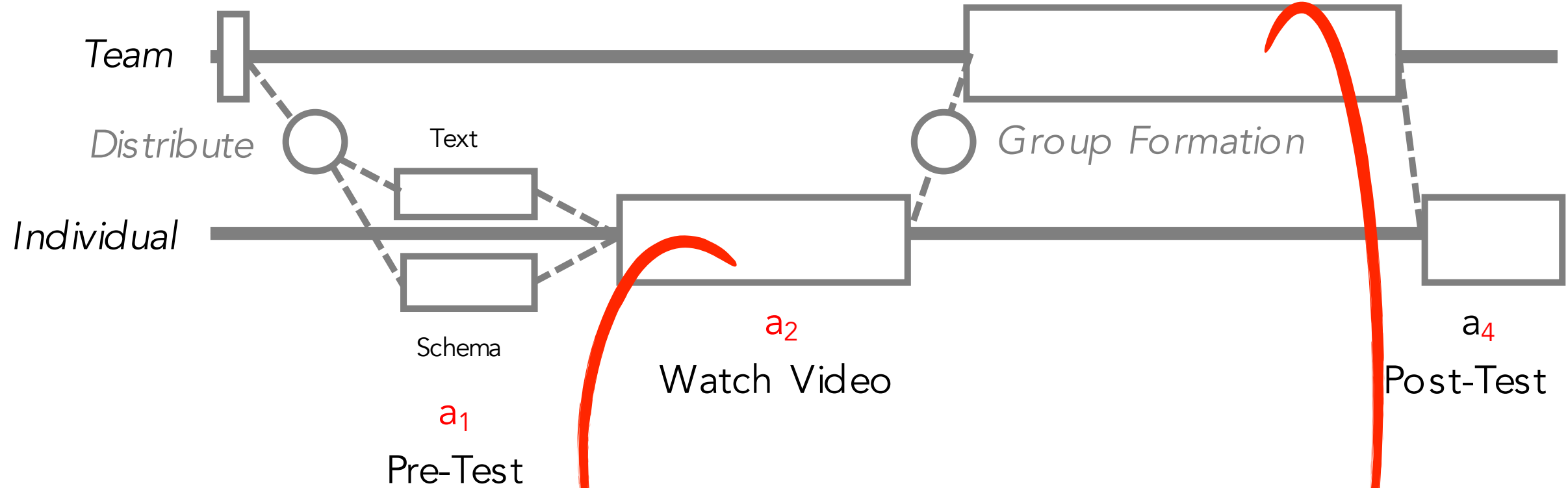
AI-free Learning Analytics

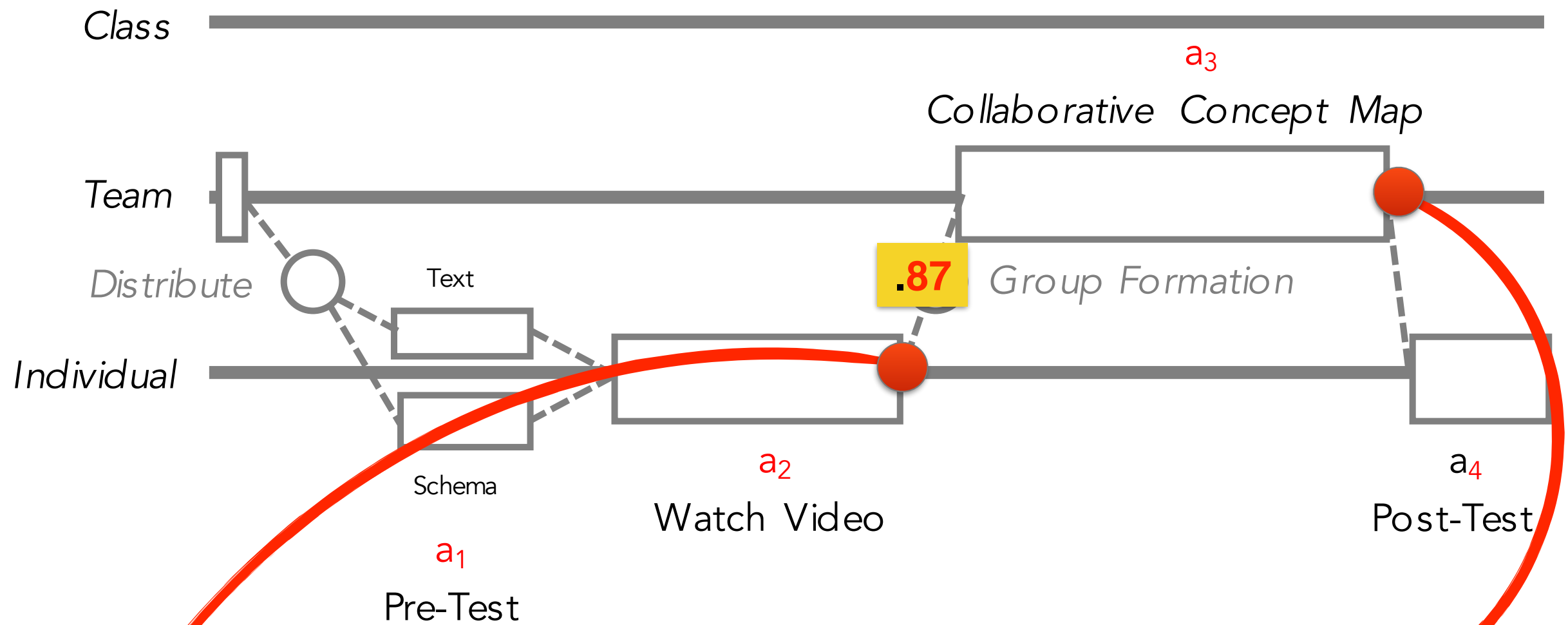




MOOC on  orchestration

Class





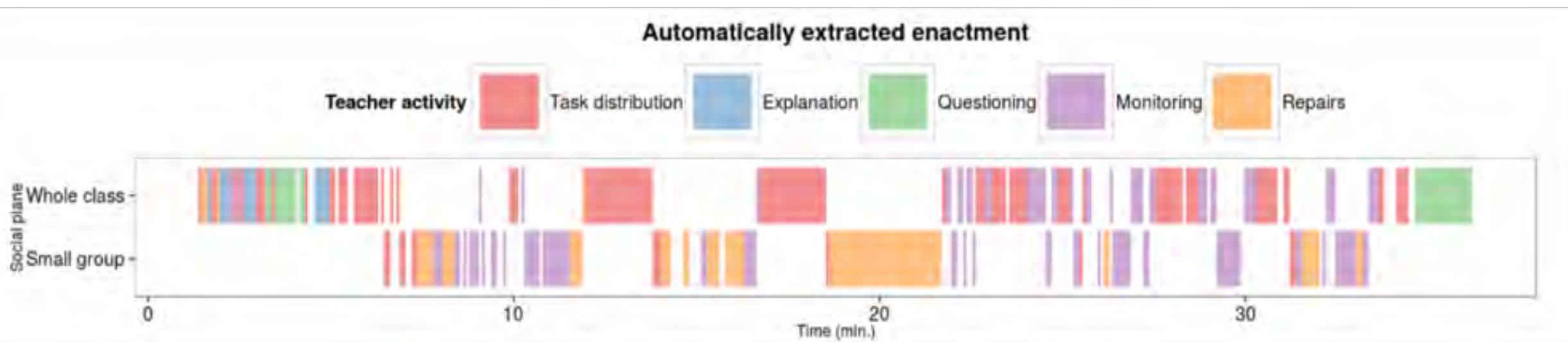
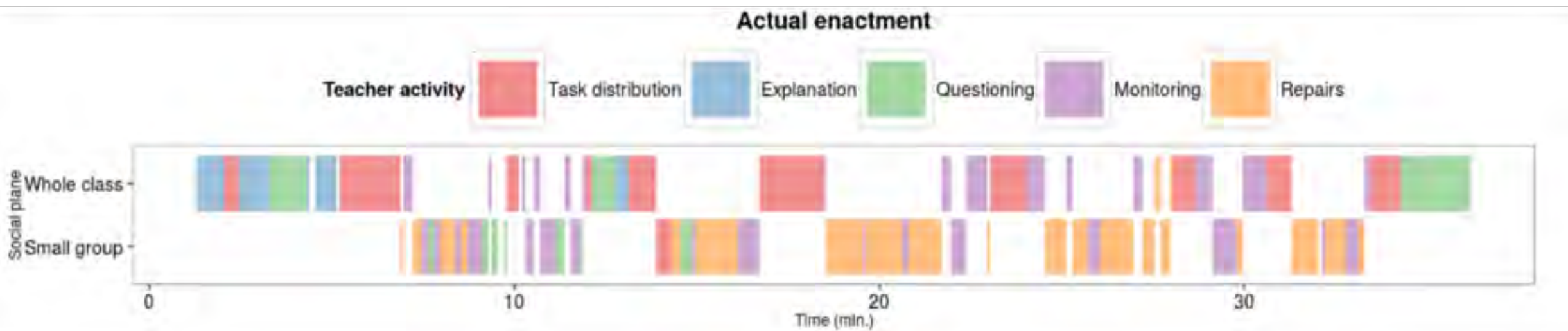
Weight (a_2 a_3)		Gaze Similarity		
		during collaborative concept map		
Perceptual with-me-ness during video	high	0,92	0,08	0
	medium	0,08	0,92	0
	low	0	0	1

We can choose whatever variable we consider do describe the state of the learner,
but the number of states should be the same

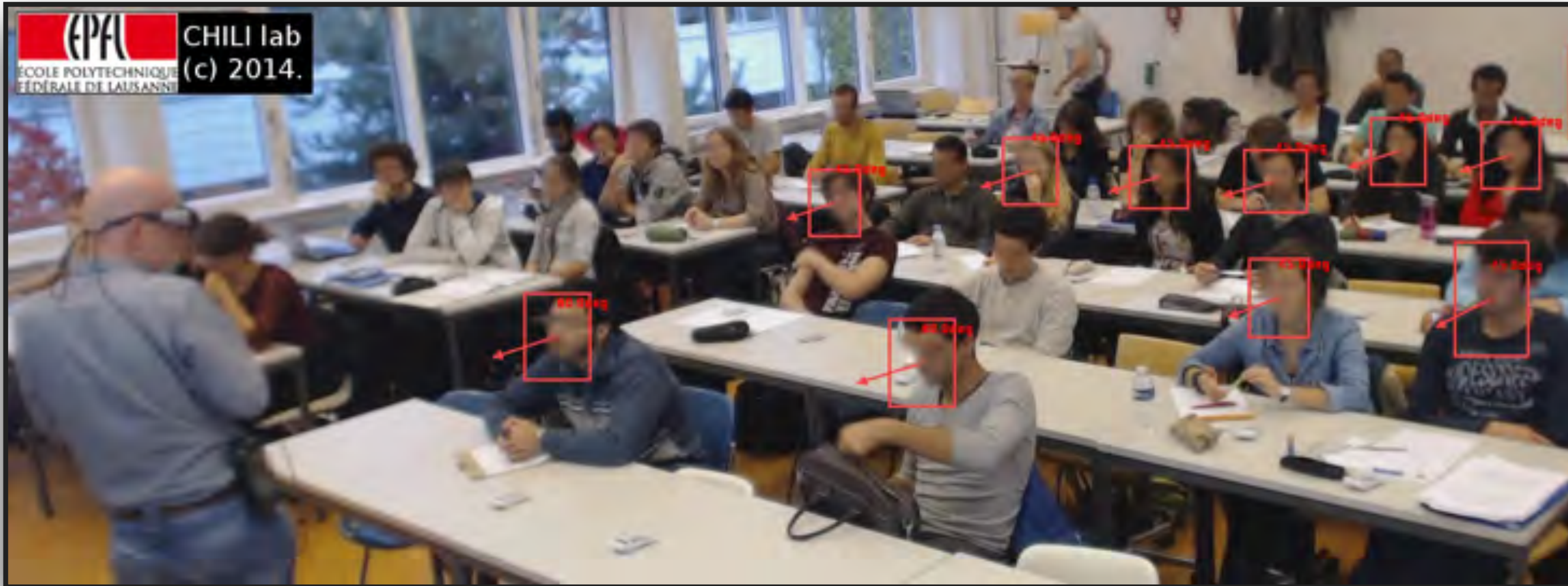


Data source	Features	Best model	In-session perf.		Out-of-session perf.	
			Accuracy	κ	Accuracy	κ
Eye-tracking only	All	Gradient Boosted T.	87.5%	0.75	86.1%	0.72
EEG only	All	Gradient Boosted T.	55.1%	0.08	50.9%	-0.02
Accelerometer only	All	Gradient Boosted T.	67.6%	0.34	61.2%	0.19
Audio only	All	Gradient Boosted T.	81.4%	0.62	79.3%	0.58
Video only	All	Gradient Boosted T.	81.7%	0.63	81.9%	0.63
All	All	Gradient Boosted T.	90.6%	0.81	89.6%	0.79
Audio+video	All	Gradient Boosted T.	86.1%	0.72	84.8%	0.69
All	Top 5	(SVM)			88.2%	0.76
All	Top 81	Gradient Boosted T.	90.6%	0.81	89.9%	0.80

L. Prieto, K. Sharma, L. Kidzinsky, P. Dillenbourg



Computational Modelling of Education



Kernel	Features	Score	Cohen's kappa
RBF($c=1.31$, $g=0.0211$)	Distance, Head travel norm., Num. still periods	61.86%	0.30
RBF($c=1.21$, $g=0.11$)	Period, Row, Head travel norm., Mean duration still	61.72%	0.32
RBF($c=1.11$, $g=0.061$)	Head travel norm., Mean duration still	60.42%	0.28
RBF($c=1.4$, $g=0.04$)	Period, Distance, Row, Mean duration still	59.23%	0.30

Raca, Tormey & Dillenbourg

*Modéliser les connaissances
à partir des
poussières de comportements*



Cold start

Optimal Stopping

Explainability

Transfert

Causality

Biases

Individualism

Mimetism

Determinism

Cold start



[booking.com](https://www.booking.com)

Optimal Stop

Explainability

Transfert

Causality

Biases

Individualism

Mimetism

Determinism

Cold start



Optimal Stop

Explainability

Transfert

Causality

Biases

Individualism

Mimetism

Determinism

Dataset	Overview			AUC			
	Students	Exercise Tags	Answers	Marginal	BKT	BKT*	DKT
Simulated-5	4,000	50	200 K	?	0.54	-	0.75
Khan Math	47,495	69	1,435 K	0.63	0.68	-	0.85
Assistments	15,931	124	526 K	0.62	0.67	0.69	0.86

Cold start

Progressivité

Si $\text{score}(a_i) > X$, $\text{diff}(a_{i+1}) > \text{diff}(a_i)$, sinon $\text{diff}(a_{i+1}) < \text{diff}(a_i)$

Optimal Stop

Explainability

Pré-requis (+ structurant préalable)

Si $p(a_i|a_j) > p(a_i|\neg a_j)$, (a_j, a_i)

Transfert

Causality

Biases

Individualism

Mimetism

Determinism

Ne pas réinventer la roue π

Cold start

Optimal Stop



Expainability

Transfert

Causality

Biases

Individualism

Mimetism

Determinism

Student 1

✓ Method A

Student 2

✗ Method B

Student 3

✓ Method A

Student 4

✓ Method A

Student 5

✓ Method A

Student 6

✓ Method A

Student 7

✓ Method A

Student 8

✓ Method A

Student 9

????

Compromis Exploitation/Exploration

Cold start

Optimal Stop

Expainability

Transfert

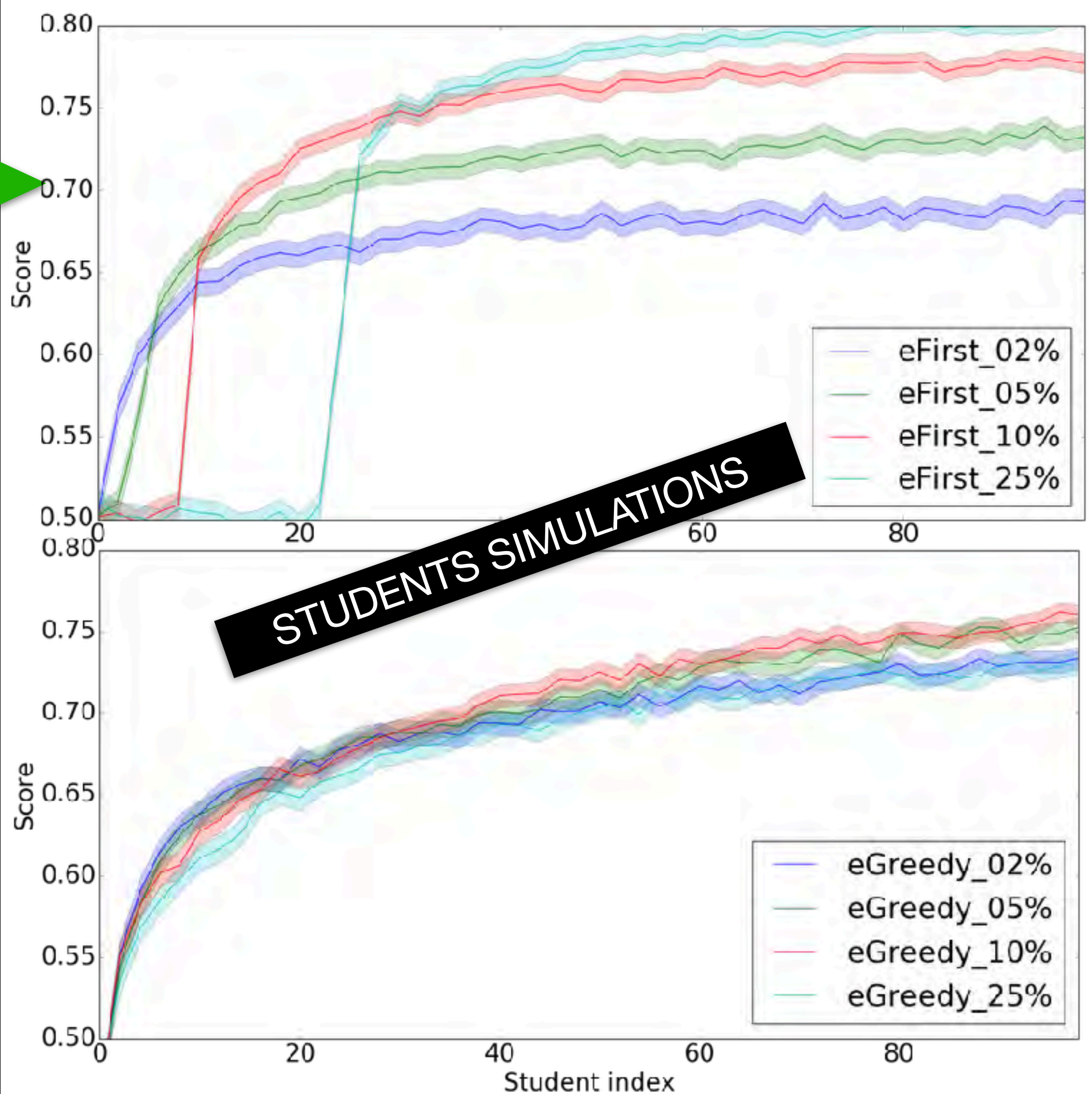
Causality

Biases

Individualism

Determinism

Mimetism



Cold start

Optimal Stop

Explainability 

Transfert

Causality

Biases

Individualism

Mimetism

Determinism

Notre algorithm vous recommande :

Passer à l'exercice 23.

Accepter

Refuser

Cold start

Optimal Stop

Expainability



Transfert

Causality

Biases

Individualism

Determinism

Mimetism

ID	Writing diagnosis			Score
97	 Inefficient	 Illegible	 Illegible	8
121		 Extra	 Ambiguous	6
150	 Shaky			3
190	 Inefficient			3

Teresa Yeo

Cold start

Optimal Stop

Explainability

Transfert

Causality

Biases

Individualism

Mimetism

Determinism



Cold start

Optimal Stop

Expainability

Transfert

Causality

Biases

Individualism

Mimetism

Determinism

Combiner ML avec une
approche (quasi-)expérimentale
(intervention)

Cold start

Optimal Stop

Expainability

Transfert

Causality

Biases



Individualism

Mimetism

Determinism

La sur-représentation d'une sous-population
entraîne une sous-représentativité des résultats

Cold start

Optimal Stop

Expainability

Transfert

Causality

Biases

Individualism

Mimetism

Determinism

**Human Cognition =
Personal Hardware + Social Software**

« grâce à l'intelligence
on va pouvoir adapter l'apprentissage
aux besoins de chaque individu »

Cold start

DUET - Dual Eye-Tracking
Pair programming experiment

Optimal Stop

Low gaze recurrence

Expainability

Transfert

Causality



ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

P. Jermann, M.-A. Nüssli & P. Dillenbourg
© CRAFT - <http://craft.epfl.ch/>

Supported by the Swiss National Science Foundation
(grants #K-12K1-117909 and #PZ00P_126611)

Biases

DUET - Dual Eye-Tracking
Pair programming experiment

Individualism



High gaze recurrence

Mimetism

Determinism



ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

P. Jermann, M.-A. Nüssli & P. Dillenbourg
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Cold start

Optimal Stop

Explainability

Transfert

Causality

Biases

Individualism

Mimetism

Determinism



A test at age 3 can predict whether children will grow and go to jail and lead a troubled life, scientists say

A professor says early intervention could 'change their trajectories for everyone's benefit and could bring big returns on investment for government'

Problems

Solutions (?)

Cold start

La roue des learning sciences

Optimal Stopping

Student Simulations

Explainability

Simplicity

Transfert

Transfert

Causality

Intervention

Biases

Underfitting

Individualism

Collaboration

Mimetism

Escape

Determinism

Freedom

Cold start

Optimal Stop

Explainability

Transfert

Causality

Biases

Individualism

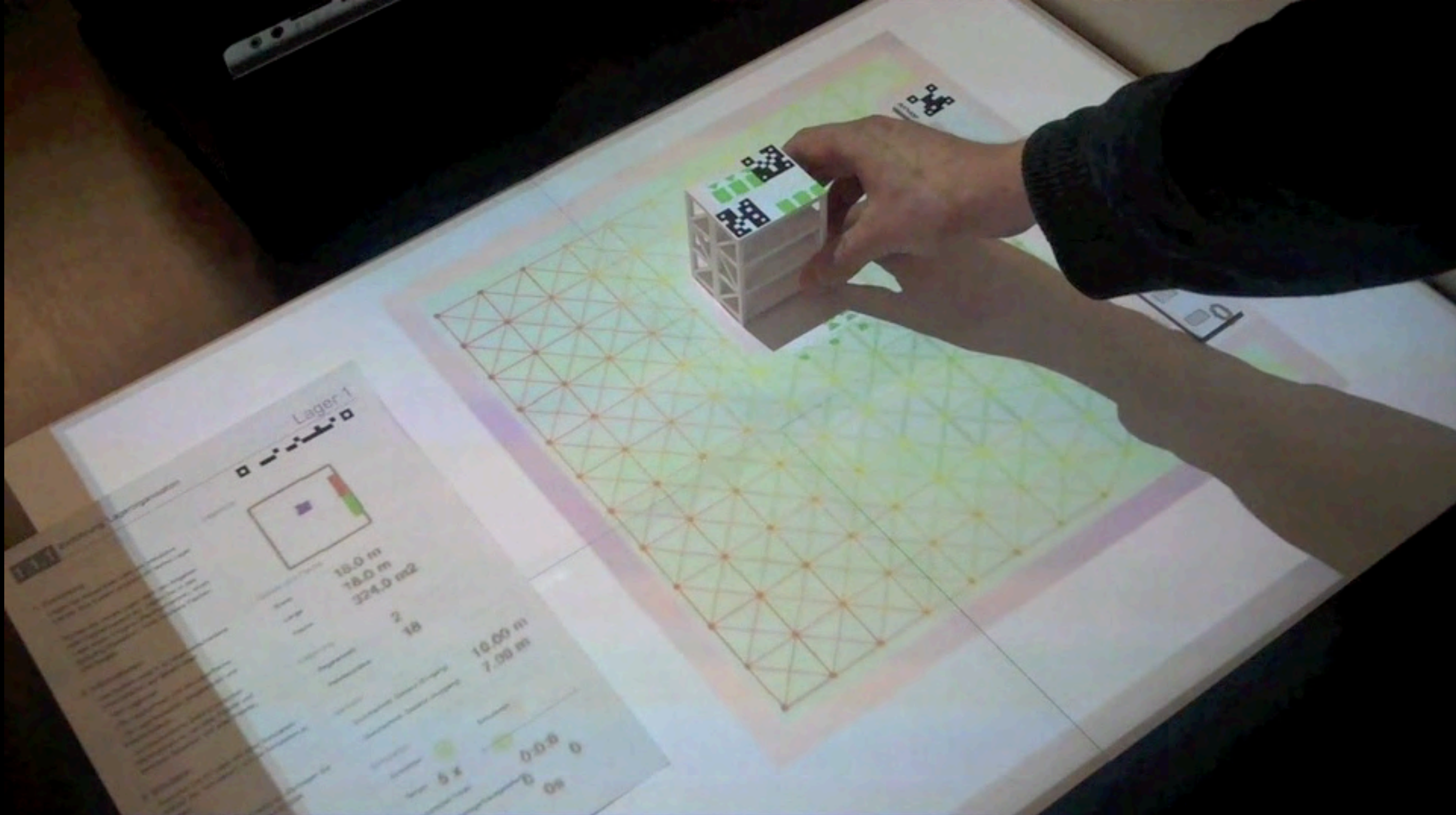
Mimetism



Determinism

« *Natural Interaction* »

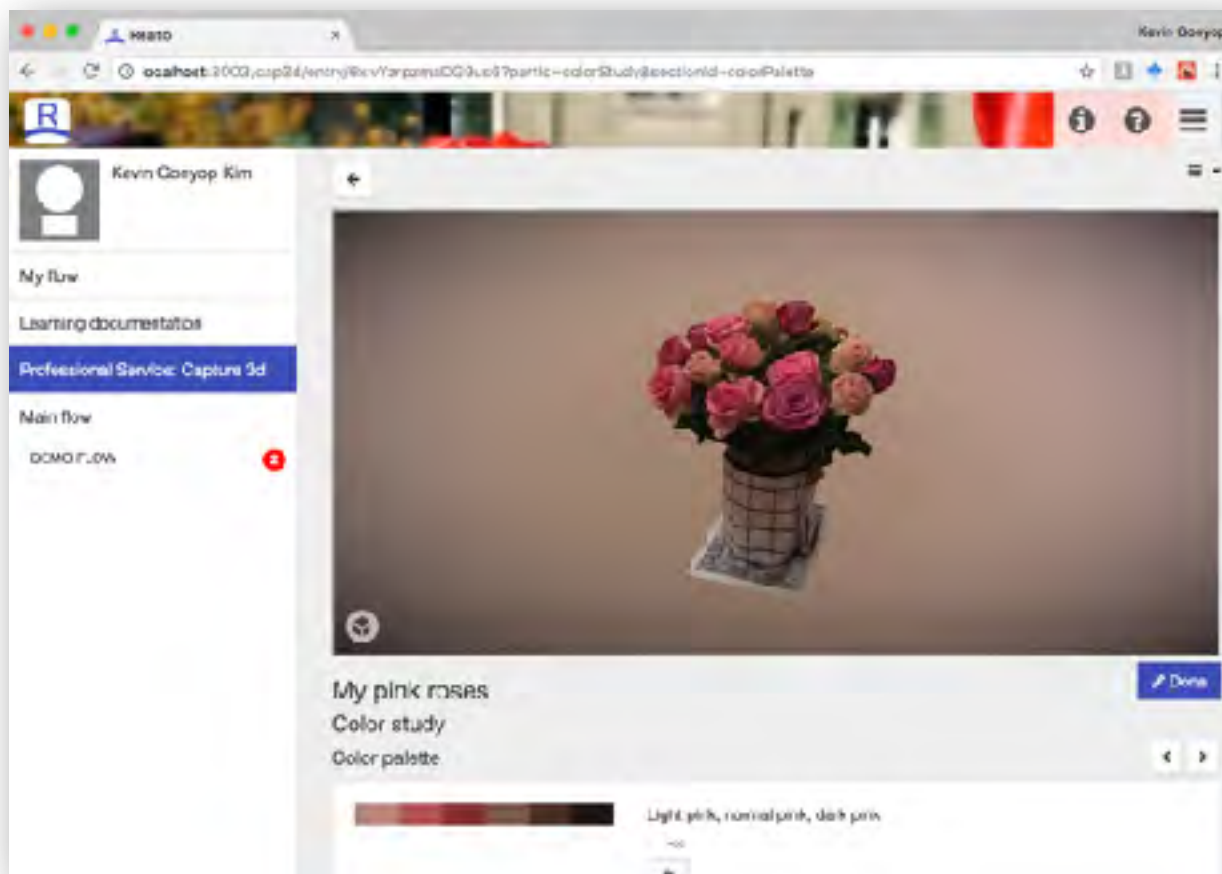
Au + elle ressemble à une interaction dite
'naturelle' au ell est plus efficace



In the real world,
we do not move shelves with 2 fingers !



In the real world, we do not see forces !



In the real world,
we do not change
the color of flowers !



In the real world, we do not change seasons !



Joseph Vavala, Kevin Kim, Catharina Oertel

Gouvernance

3

Objectifs / Contenus

2

Méthodes

1

Pédagogie



Cellulo



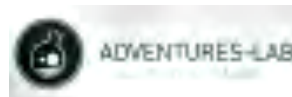
EPFL



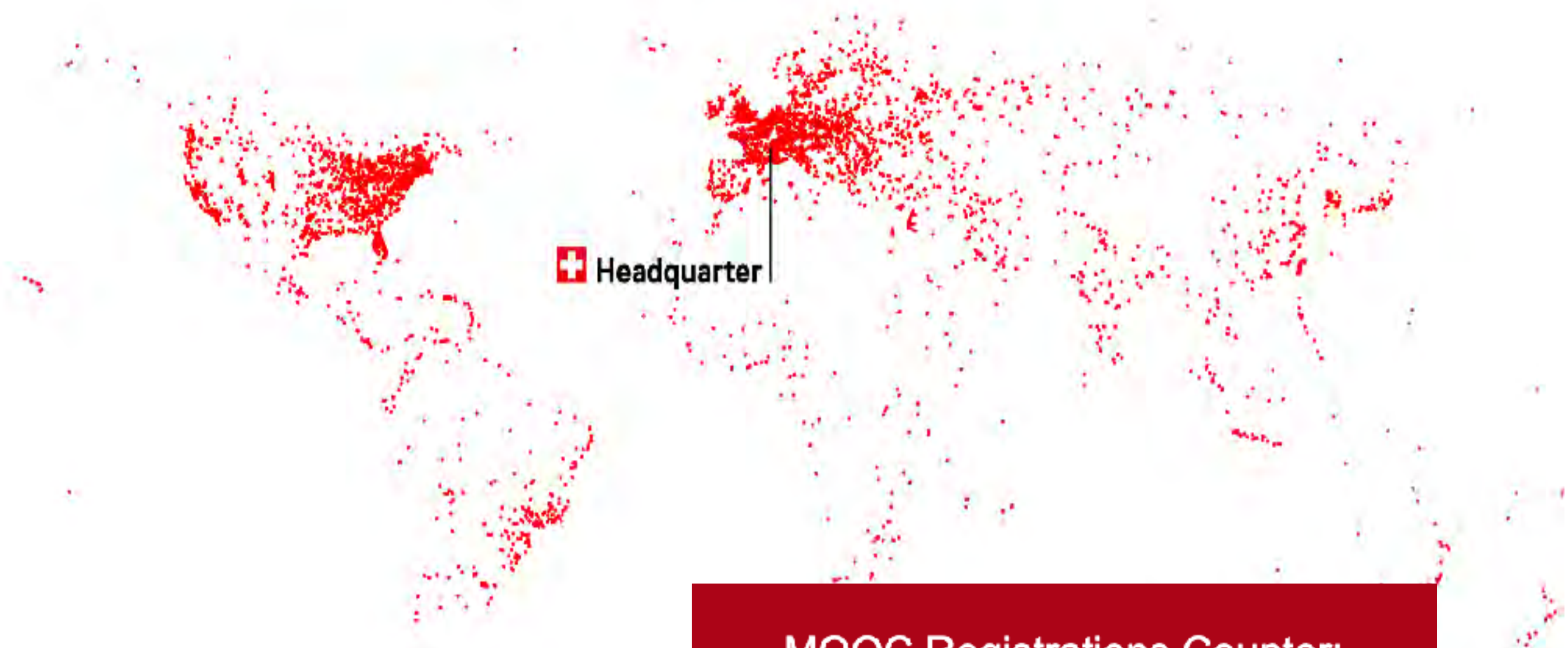
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explore-it



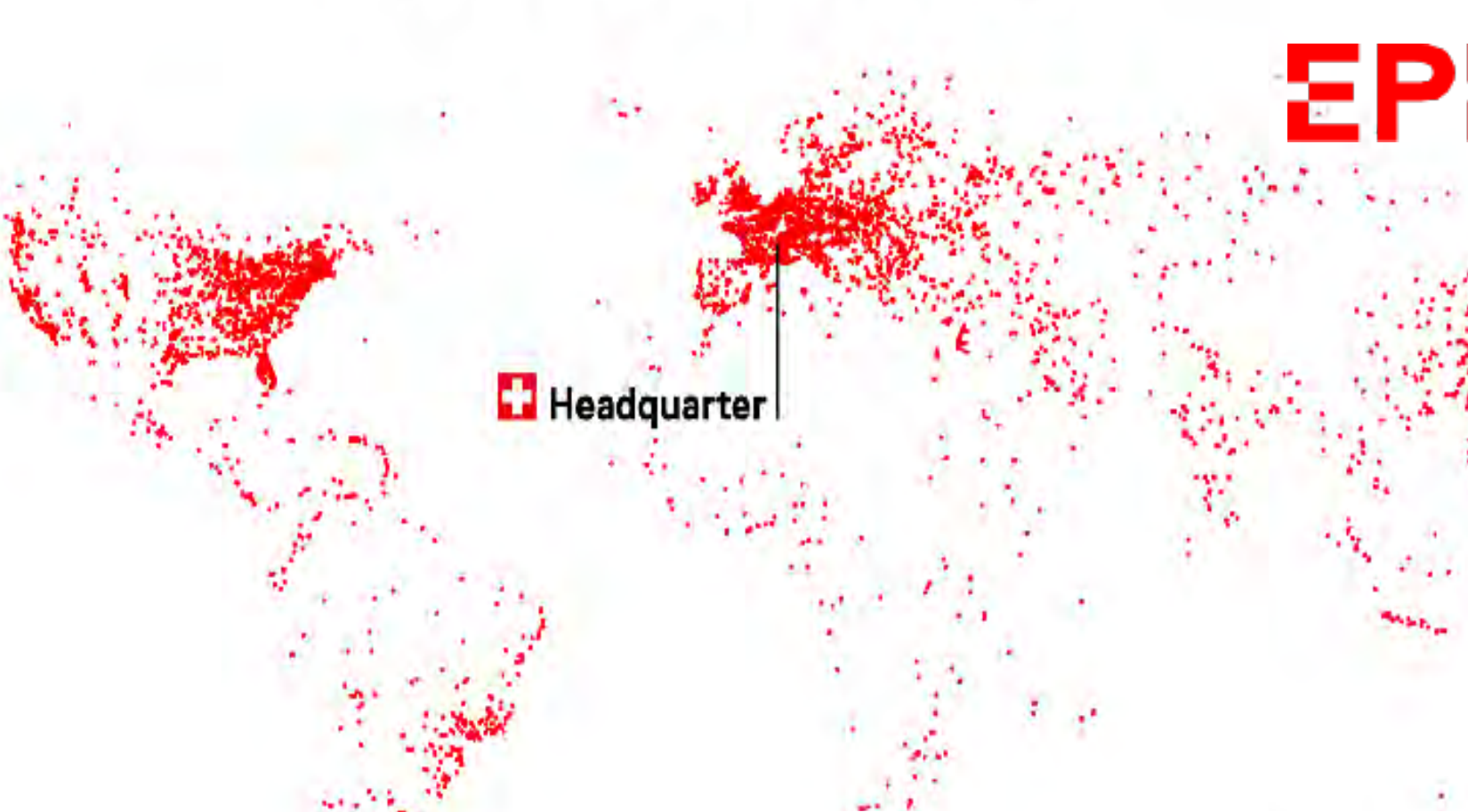
EPFL CAMPUS



MOOC Registrations Counter:

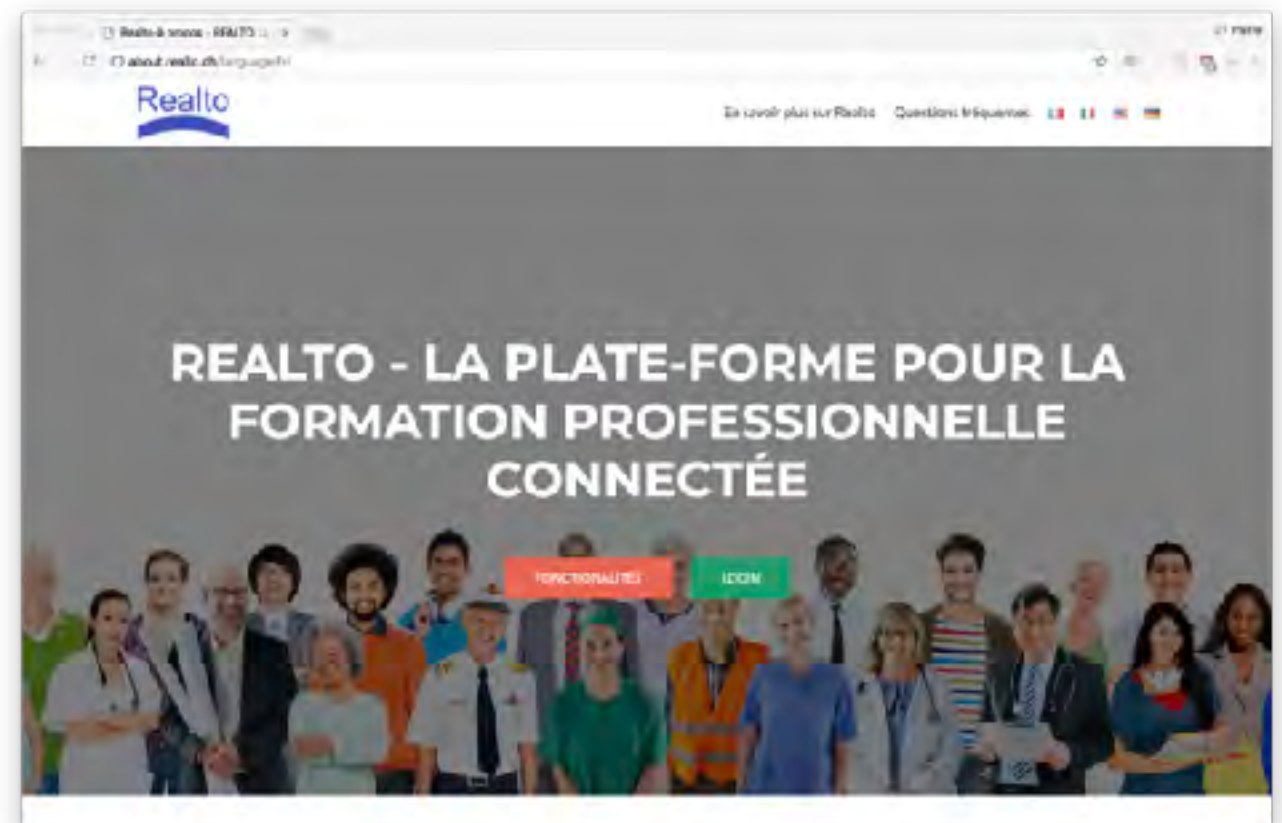
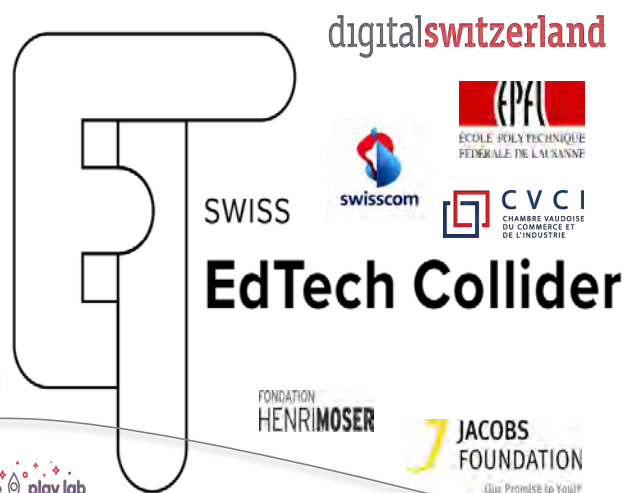
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EPFL Center for Learning Sciences

EPFL
Innovation Park



« Qui trop promet ne tiendra guère »

P. Dillenbourg