CS-411 : Digital Education

Chapter 11:
GenAI & Education

1. Learner modeling (for exam)
2. Generative AI (not for exam)
3. Classroom Analytics (not for exam)

EPFL

Prof. Pierre Dillenbourg

1. Learner modelling

What if the learning activity
that you have designed
does not work well for Pierre ?

The learner adapts

If you don’t understand the video, play it again but slower

The teacher adapts

If students don’t understand the lecture, re-explain

The system adapts

If students don’t master the skill, select a more effective learning activity

Adaptive instruction
Personalized instruction
Individualized instruction

~~Recommender system~~

Learner Modelling

$5^2 = ?$

Learner Modelling

From the learner's behaviour, infer his/her knowledge state

$5^2 = 25$ ➔ knows X^2

$5^2 \neq 25$ ➔ doesn't know X^2

Learner Modelling

From the learner's behaviour, infer his/her knowledge state

?

confusion (iteration, recursion)

Learner Modelling

$5^2 =$

- ☐ 52
- ☑ 25
- ☐ 15
- ☐ 10
- ☐ 7

p (knows X^2)= 1 ?

Cognitive Diagnosis

$5^2 = ??$	Knowledge States										
Behavior (Answer)	$5^2 = 25$	$5^n = ...$	$n^2 = n \cdot N$	$x^n = x.x....$	$x^n = x \cdot x$ but bad mult.	$x^n = x.n$	$x^n = x + n$	$x^n = ???$	Sum	Entropy	Normalized entropy
25	**0.10**	**0.20**	**0.30**	**0.40**	0.00	0.00	0.00	0.00	1	1.89	0.63
35	0.00	0.00	0.00	0.00	**0.40**	0.10	0.00	**0.50**	1	1.41	0.47
10	0.00	0.00	0.00	0.00	0.00	**0.79**	0.00	0.20	1	0.79	0.26
27	0.00	0.00	0.00	0.00	0.40	0.00	0.00	**0.59**	1	1.03	0.34
7	0.00	0.00	0.00	0.00	0.00	0.00	**0.59**	0.40	1	1.03	0.34
											0.41

Diagnosis Power

(The lower the better)

Learner Modelling

From the learner's behaviour, infer his/her knowledge state

p (state = knows | correct-answer) = 1 – Guess

p (state = knows | incorrect-answer) = 0 + Slip

Factors that depend upon the response modality

Bayesian Knowledge Tracing, Corbet & Anderson

Learner Modelling

5^2 = ??	Knowledge States										
Behavior (Answer)	5^2 = 25	5^n = ...	n^2 = n . N	x^n = x.x....	x^n = x . x but bad mult.	x^n = x.n	x^n = x + n	x^n = ???	Sum	Entropy	Normalized entropy
25	**0.10**	**0.20**	**0.30**	**0.40**	0.00	0.00	0.00	0.00	1	1.89	0.63
35	0.00	0.00	0.00	0.00	**0.40**	0.10	0.00	**0.50**	1	1.41	0.47
10	0.00	0.00	0.00	0.00	0.00	**0.79**	0.00	0.20	1	0.79	0.26
27	0.00	0.00	0.00	0.00	0.40	0.00	0.00	**0.59**	1	1.03	0.34
7	0.00	0.00	0.00	0.00	0.00	0.00	**0.59**	0.40	1	1.03	0.34
											0.41

5^2 = ??	Knowledge States (with SLIP/GUESS factors)										
Behavior (Answer)	5^2 = 25	5^n = ...	n^2 = n.n	x^n = x.x....	x^n = x . x but bad mult.	x^n = x.n	x^n = x + n	x^n = ???	Sum	Entropy	Normalized entropy
25	**0.05**	**0.15**	**0.25**	**0.35**	0.05	0.05	0.05	0.05	1	2.53	0.84
35	0.05	0.05	0.05	0.05	**0.34**	0.05	0.00	0.41	1	2.16	0.72
10	0.05	0.05	0.05	0.05	0.00	**0.64**	0.00	0.15	1	1.72	0.57
27	0.05	0.05	0.05	0.05	0.25	0.00	0.00	**0.54**	1	1.87	0.62
7	0.05	0.05	0.05	0.05	0.00	0.00	**0.50**	0.30	1	1.92	0.64
											0.68

In a MOOC ?

From the learner's behaviours, infer his/her knowledge state

b(s) = watch video with many pauses

b(s) = select correct definition of SD in a quiz with 5 possible definitions

b(s) = post a message "There is a mistake on the slide" (and there is one indeed)

X(S)={lost, active, fine, brilliant}

x(s)=[.15 .40 .30 .15]

H_0= 0.94

x(s)= [.05 .15 .25. 55]

H_0 = .80

x(s)= [.01 .02 .02 .95]

H_0 = .18

Normalized entropy of the diagnosis vector

Which question has the highest diagnosis power ?

Question 1

The standard deviation of a distribution is the .....of the sum of ..... from the mean

Question 2

Remove two numbers from this distribution to minimize it’s standard deviation : [1 3 3 5 9 9 9 10 11 18 19 25 29]

Basic approach to reduce uncertainty

Decrease uncertainty by collecting multiple answers

5^2 = ??	Knowledge States (with SLIP/GUESS factors)										
Behavior (Answer)	5^2 = 25	5^n = ...	n^2 = n.n	x^n = x.x....	x^n = x . x but bad mult.	x^n = x.n	x^n = x + n	x^n = ???	Sum	Entropy	Normalized entropy
25	**0.05**	**0.15**	**0.25**	**0.35**	0.05	0.05	0.05	0.05	1	2.53	0.84
35	0.05	0.05	0.05	0.05	**0.34**	0.05	0.00	**0.41**	1	2.16	0.72
10	0.05	0.05	0.05	0.05	0.00	**0.64**	0.00	0.15	1	1.72	0.57
27	0.05	0.05	0.05	0.05	0.25	0.00	0.00	**0.54**	1	1.87	0.62
7	0.05	0.05	0.05	0.05	0.00	0.00	**0.50**	**0.30**	1	1.92	0.64
											0.68
7^2 = ??	Knowledge States (second question)										
Behavior (Answer)	7^2 = 25	7^n = ...	n^2 = n.n	x^n = x.x....	x^n = x . x but bad mult.	x^n = x.n	x^n = x + n	x^n = ???	Sum	Entropy	Normalized entropy
49	**0.02**	**0.10**	**0.35**	**0.45**	0.02	0.02	0.02	0.02	1.00	1.95	0.65
56	0.02	0.02	0.02	0.02	**0.61**	0.00	0.00	0.31	1.00	1.43	0.48
14	0.02	0.02	0.02	0.02	0.00	**0.82**	0.00	0.10	1.00	1.04	0.35
72	0.02	0.02	0.02	0.02	0.32	0.00	0.00	**0.60**	1.00	1.44	0.48
9	0.02	0.02	0.02	0.02	0.00	0.00	**0.72**	**0.20**	1.00	1.27	0.42
											0.48
3^3 = ??	Knowledge States (second question)										
Behavior (Answer)	3^3 = 25	3^n = ...	n^3 = n.n.n	x^n = x.x....	x^n = x . x but bad mult.	x^n = x.n	x^n = x + n	x^n = ???	Sum	Entropy	Normalized entropy
49	**0.01**	**0.10**	**0.20**	**0.65**	0.01	0.01	0.01	0.01	1.00	1.53	0.51
26	0.01	0.01	0.01	0.01	**0.81**	0.00	0.00	0.15	1.00	0.94	0.31
9	0.01	0.01	0.01	0.01	0.00	**0.82**	0.00	0.14	1.00	0.92	0.31
33	0.01	0.01	0.01	0.01	0.12	0.00	0.00	**0.84**	1.00	0.86	0.29
6	0.01	0.01	0.01	0.01	0.00	0.00	**0.91**	0.05	1.00	0.63	0.21
											0.33

How does the teacher/system chooses the next question ?

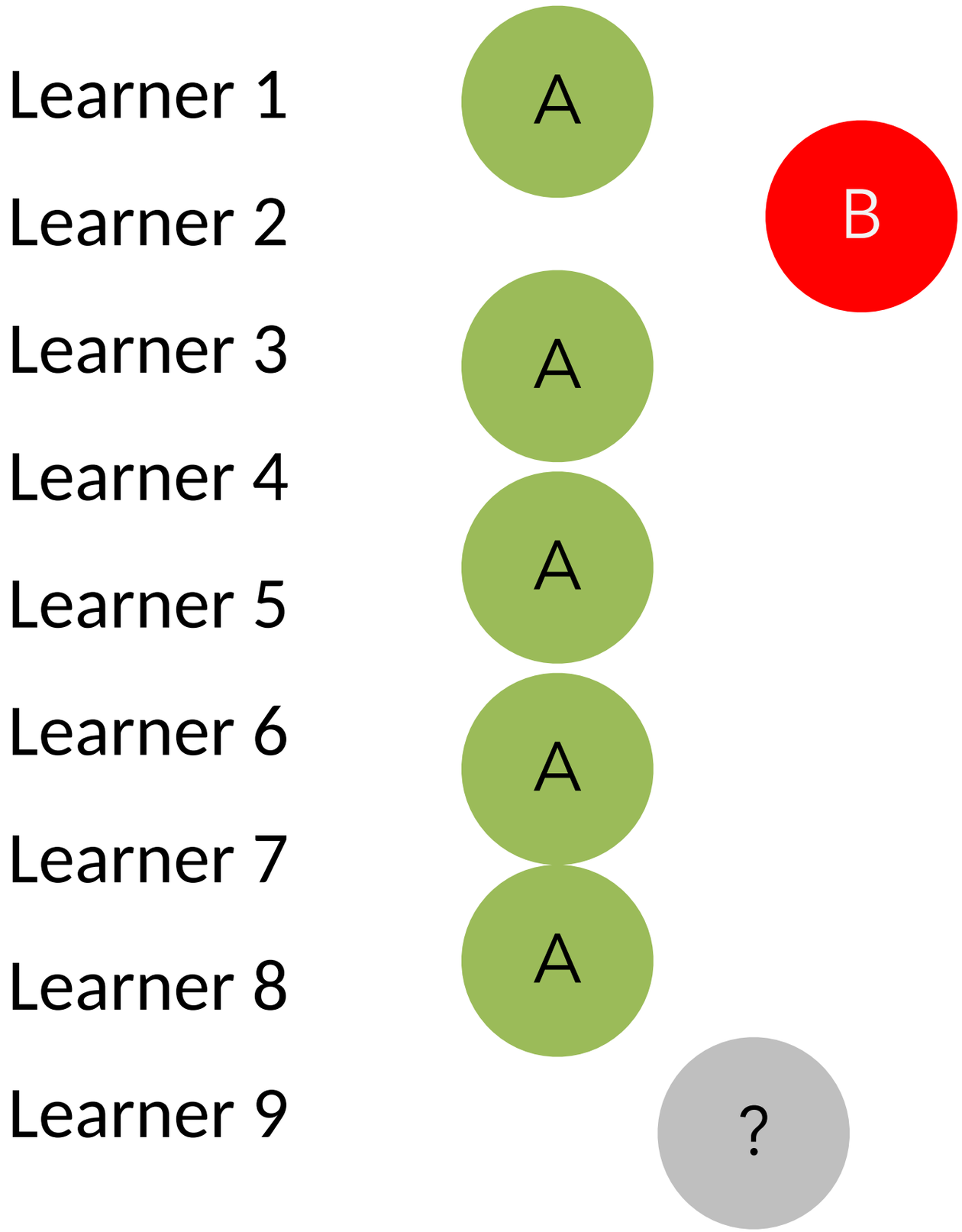
- Because it will maximize the learning gain of the learner ?

Exploitation

- Because it will maximize the system knowledge about the learner ?

Exploration

Exploration Exploitation Tradeoff



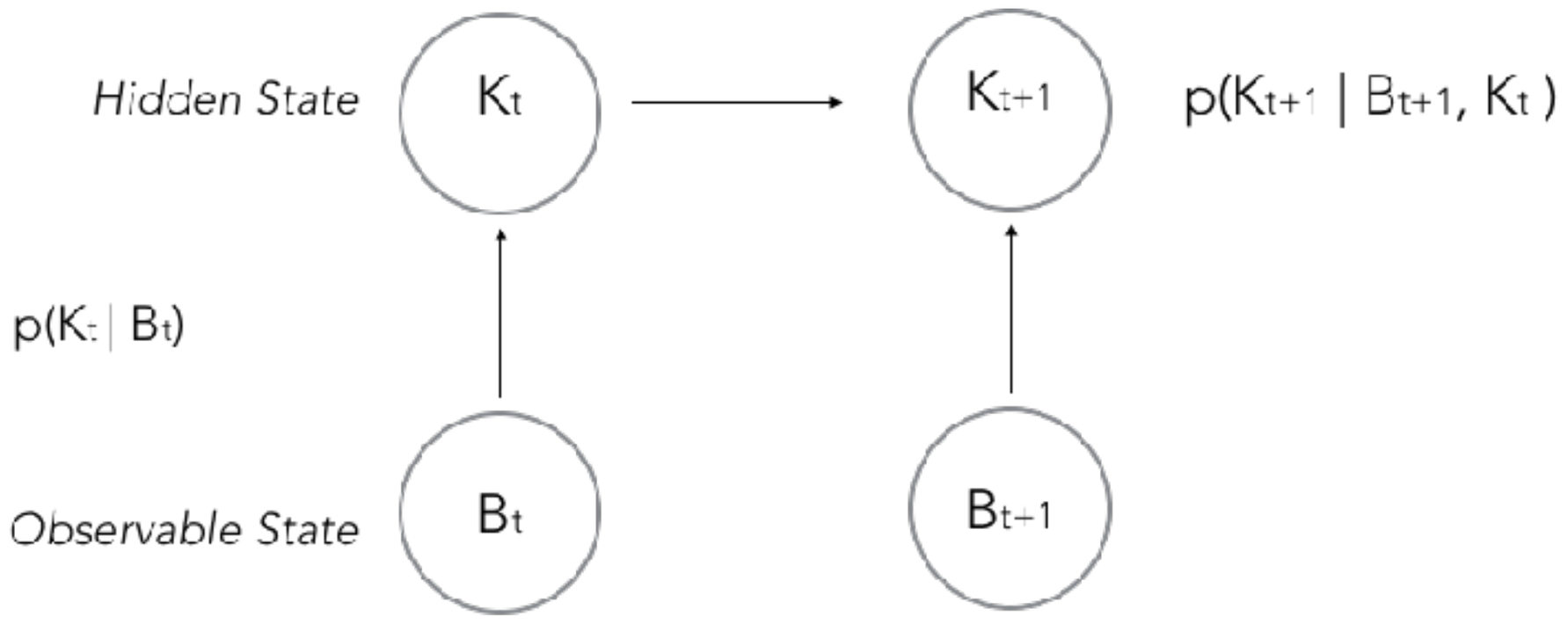
Learner Modelling

From the learner's behaviour, **infer** his/her knowledge state

+

From the learner's previous state, **predict** his/her knowledge state

From the learner's behaviour and **his previous state,** infer his/her knowledge state



Bayesian Knowledge Tracing

EPFL

CS-421 **Machine learning for behavioral data**

Käser Tanja

Cursus	Sem.	Type
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Informatique	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Project	2 weekly
Number of positions	

2. Generative AI

How can I use it in my teaching?

What new skills need to be provided?

How can students use AI in their studies?

How can EPFL take advantage of AI?

Which skills become obsolete, which don’t?

What about vocational education ?

When should you not consider using generative AI tools ?

- Do not use such tools to **learn new things** or to search for information: They often generate plausible nonsense and can lead you to believe that what they generate is true or real when it isn't.
- Do not use it to generate content that [illegible] unable to **check for veracity** or for form: for example a foreign language.

How can students use AI in their studies?

When can you consider using generative AI tools?

- When you want to be **surprised**: for example, to generate ideas.
- When you have the possibility to **check the accuracy** of the result that the AI tool generates: for example, only generate code that you can run and check yourself.
- When you want **help with the form** of your production, rather than with its contents: for example, to improve the wording of your text, to summarise a passage that is too long or to overcome writer's block.

What are the risks?

- **Plausible nonsense** [2]: we generally tend to trust machines more than ourselves (automation bias [4]), which makes us all the more vulnerable to the apparent plausibility of the content generated by this software, even when it is completely false or incorrect.
- **Environmental impact**: this software is among the least energy- and water-efficient, so avoid using it when you have tools that will perform the same task with less impact (for example, searching the web, or even watching videos).
- **Privacy**: by using generative AI tools, you are sharing your data with private companies, so don't enter any personal or sensitive data about yourself or others.
- **Bias**: this software suffers from different types of biases, whether gender bias (e.g. machine translation [5], image generation [6]) or bias based on ethnic origin or religious orientation (e.g. text generation [7]). Evaluate the results carefully and think critically.

What are the rules for using generative AI in your studies?

- Follow your **teachers' instructions**. Teachers can design learning activities that may or may not include certain tools. A common practice is to mention your use of generative AI tools in your academic work. For example: AI tool X was used to improve the grammar of the text and make it more understandable or tool Y was used to generate an illustration.
- You are **responsible for the work** you submit on your behalf and for acting in accordance with society's expectations of future scientists. As part of project evaluations at EPFL, t**eachers may ask you to explain** a paragraph or a fragment of computer code to verify that you are the author of the work you have submitted, without the help of generative AI tools.

EPFL Official Communication - October 2023

How can I use it in my learning?

- Find alternative ideas
- Summarize
- Improve form
- …

You

How has the work of Papert been influenced by the theory of Piaget ?

Seymour Papert, a pioneer in the field of educational technology, was greatly influenced by the work of Jean Piaget, a renowned developmental psychologist. Papert built upon Piaget's theories, particularly in his constructionist approach to learning and the development of the LOGO programming language.

Piaget's theory of cognitive development emphasized the idea that children are active learners who construct their understanding of the world through interactions with it. He introduced concepts like assimilation, accommodation, and stages of cognitive development. Piaget believed that children learn by actively exploring and manipulating their environment.

Papert was inspired by these ideas and extended them into the realm of technology and education. He co-created the LOGO programming language, which was designed specifically for children. LOGO was based on the idea of constructionism, a theory that suggests learning is most effective when individuals are actively engaged in constructing something meaningful, especially with tools that allow for creative expression.

Papert used LOGO as a tool to facilitate learning by enabling children to create

How can I use it in my teaching?

- Generate examples
- Generate questions
- Generate feedback
- Generate lesson plans
- …

uld you make the quizz more difficult

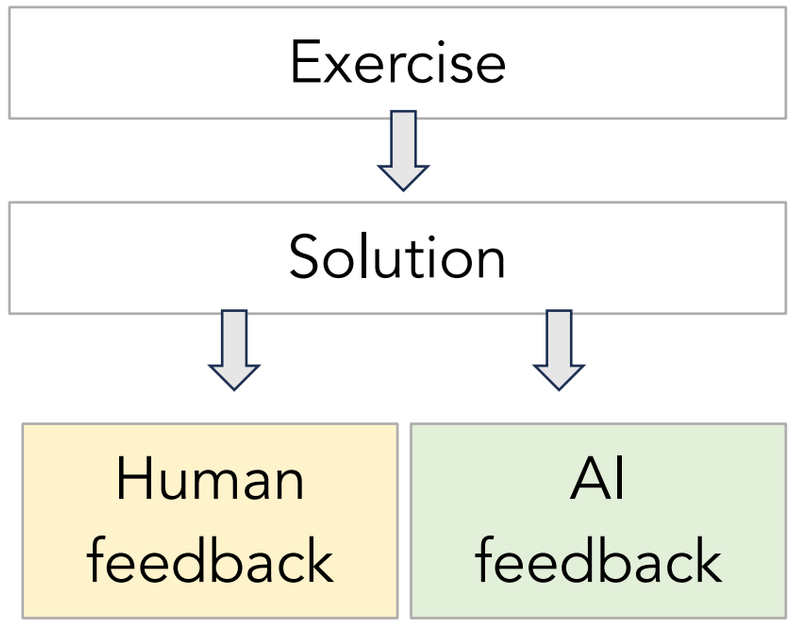
Certainly! Here's an even more challenging quiz on advanced topics in hotel marketing:

Expert Hotel Marketing Quiz

1. **Explain the concept of "channel optimization" in hotel distribution strategy. What are the key considerations for hotels aiming to optimize their distribution channels?
2. **Discuss the role of blockchain technology in the hotel industry's marketing and operations. How can blockchain enhance guest experiences and streamline hotel operations?
3. **Elaborate on the concept of "hyper-localization" in hotel marketing. Provide examples of how hotels can effectively implement hyper-localization to attract guests.

Teachers: How can I use it in my teaching?

- Generate examples
- Generate questions
- Generate feedback
- Generate lesson plans
- …



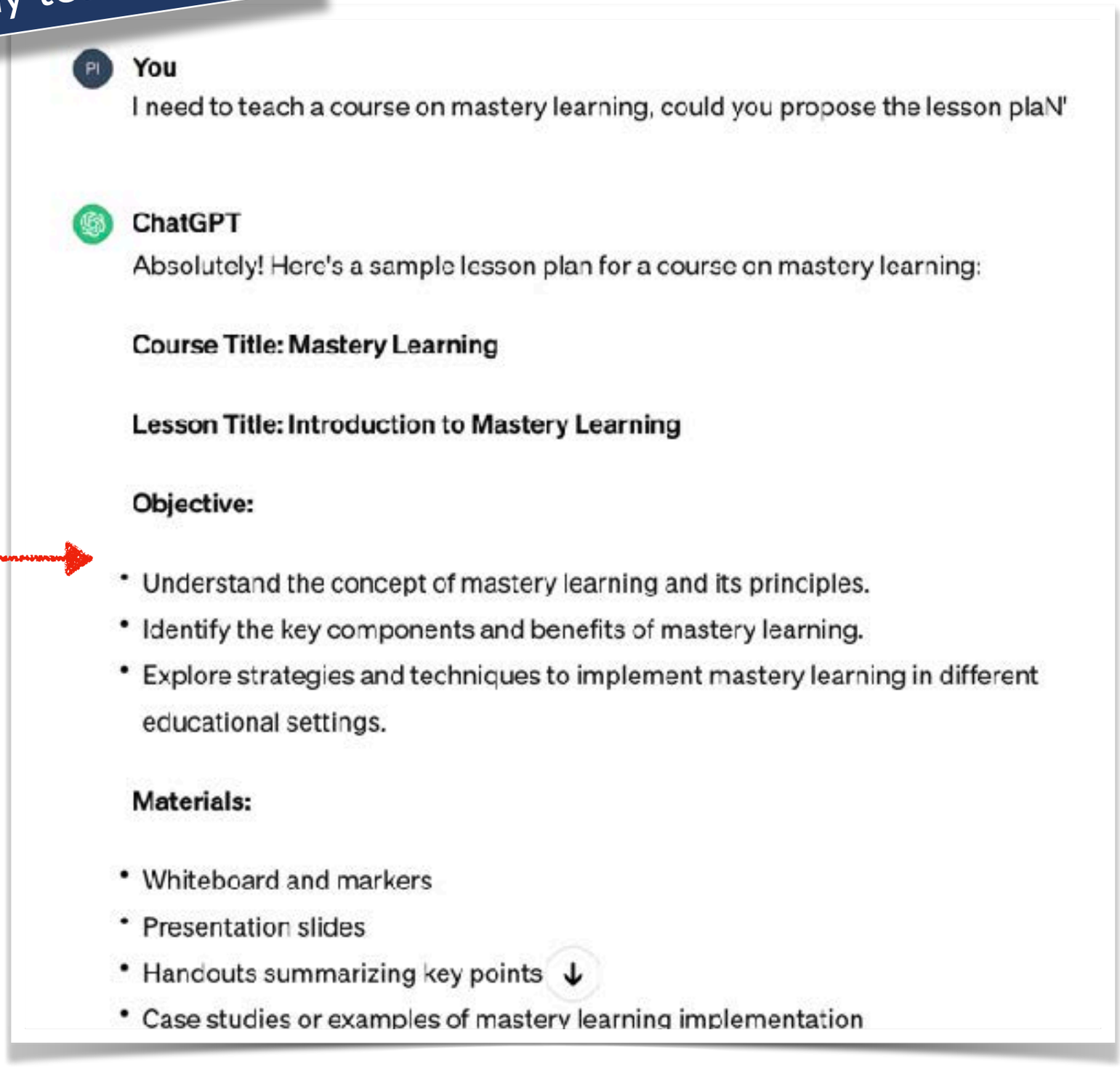
Which one has been generated by a human ?
How do you know ?

Which one has been more useful ?
Why ?

Prof. Tanja Käser, EPFL

Teachers: How can I use it in my teaching?

- Generate examples
- Generate questions
- Generate feedback
- Generate lesson plans
- …



PI **You**

I need to teach a course on mastery learning, could you propose the lesson plaN'

ChatGPT

Absolutely! Here's a sample lesson plan for a course on mastery learning:

Course Title: Mastery Learning

Lesson Title: Introduction to Mastery Learning

Objective:

- Understand the concept of mastery learning and its principles.
- Identify the key components and benefits of mastery learning.
- Explore strategies and techniques to implement mastery learning in different educational settings.

Materials:

- Whiteboard and markers
- Presentation slides
- Handouts summarizing key points
- Case studies or examples of mastery learning implementation

Lesson Outline:

I. Introduction (15 minutes)

- Welcome students and introduce the concept of mastery learning.
- Discuss the objectives for the session and the importance of mastery learning in education.
- Ask students about their familiarity or previous experience with mastery learning.

II. Understanding Mastery Learning (20 minutes)

- Define mastery learning: Explain how it differs from traditional teaching methods, emphasizing the focus on individual student mastery of content.
- Discuss the principles of mastery learning, including self-pacing, personalized instruction, and assessment based on mastery.
- Use examples or case studies to illustrate the concepts.

III. Components of Mastery Learning (25 minutes)

- Break down the key components:
- Clear learning objectives
- Diagnostic pre-assessment
- Varied instructional strategies
- Ongoing formative assessment
- Flexible pacing and time for remediation
- Discuss each component in detail, highlighting its significance in the mastery learning process.

IV. Benefits of Mastery Learning (15 minutes)

- Explore the advantages of mastery learning for students, such as increased retention, deeper understanding, and self-directed learning.
- Discuss how mastery learning can support diverse learners and address individual needs effectively.

V. Implementing Mastery Learning (20 minutes)

- Discuss practical strategies for implementing mastery learning in various educational settings.
- Present examples of successful implementation methods, including technology integration, individualized learning plans, and differentiated instruction.

VI. Application and Activity (20 minutes)

- Engage students in an activity or discussion where they apply the principles of mastery learning to a hypothetical scenario or real case studies.
- Encourage brainstorming on how mastery learning can be integrated into specific courses or subjects.

VII. Conclusion and Recap (10 minutes)

- Summarize the key points discussed during the lesson.
- Reiterate the benefits and potential challenges of implementing mastery learning.
- Encourage students to reflect on how they might apply mastery learning principles in their own teaching or learning environments.
-

You

How to learn recursion through productive failure?

ChatGPT

Learning recursion through productive failure involves creating an environment where students can experiment, make mistakes, and learn from them in a constructive way. Here's a potential approach:

1. Introduce the Concept:

- Begin with a simple explanation of recursion, using relatable examples like fractals, factorial calculation, or recursive algorithms.
- Highlight the basic structure of recursion: a function calling itself and approaching a base case.

2. Hands-On Exercises:

- Provide exercises with clear instructions for students to write recursive functions. Start with straightforward problems that gradually increase in complexity.
- Encourage students to attempt solutions independently or in small groups, allowing them to explore different approaches.

2. Hands-On Exercises:

- Provide exercises with clear instructions for students to write recursive functions. Start with straightforward problems that gradually increase in complexity.
- Encourage students to attempt solutions independently or in small groups, allowing them to explore different approaches.

3. Failure-Friendly Environment:

- Emphasize that making mistakes is a natural part of learning. Create a safe space where errors are expected and embraced as opportunities to learn.
- Foster a supportive classroom culture where students share and discuss their attempts openly.

4. Reflective Practice:

- After the initial attempts, hold a group discussion where students share their approaches and any challenges faced.
- Analyze common mistakes or misconceptions together and explore why certain solutions didn't work as expected.

5. Guided Problem Solving:

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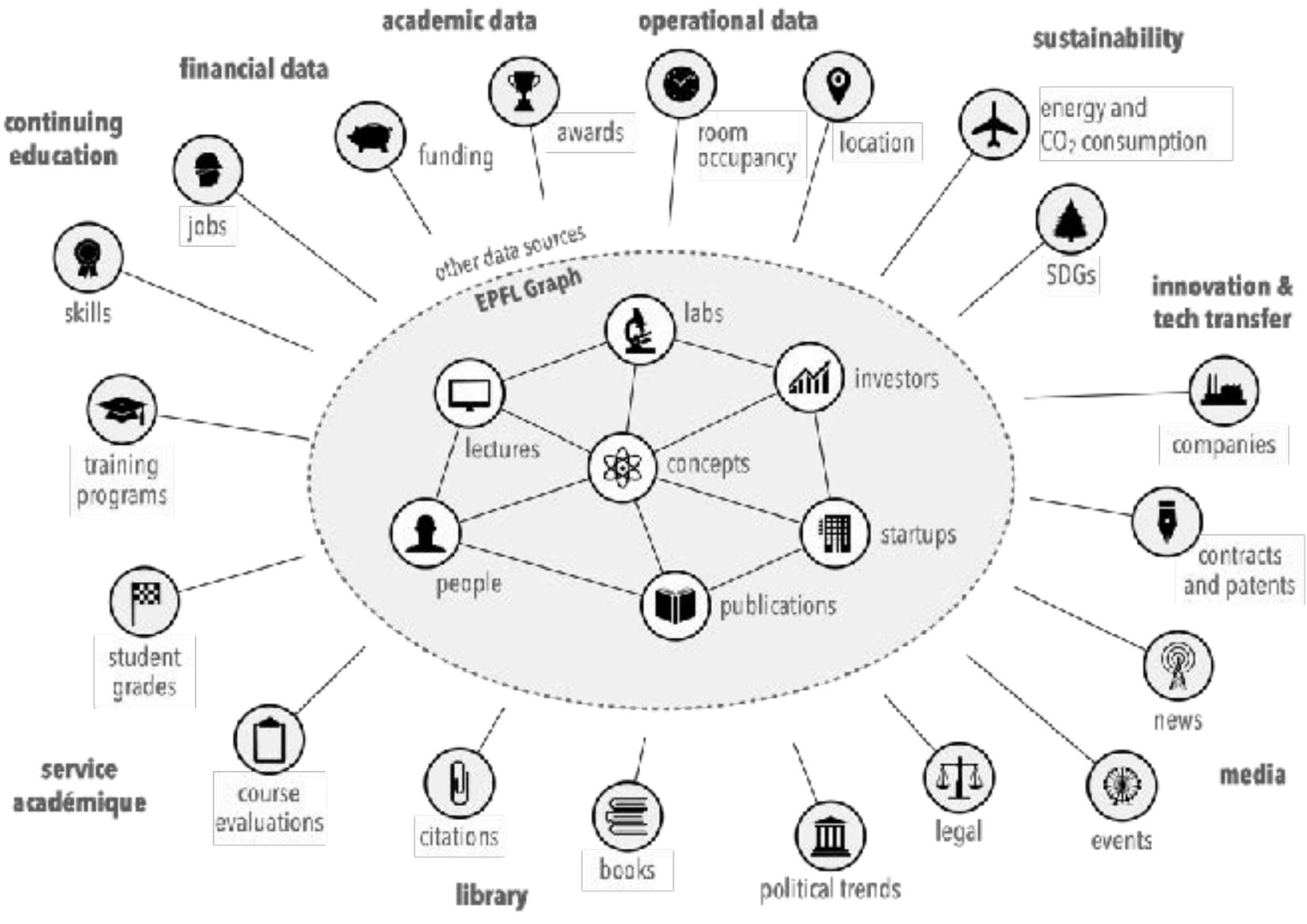
polytechnique
fédérale
de Lausanne

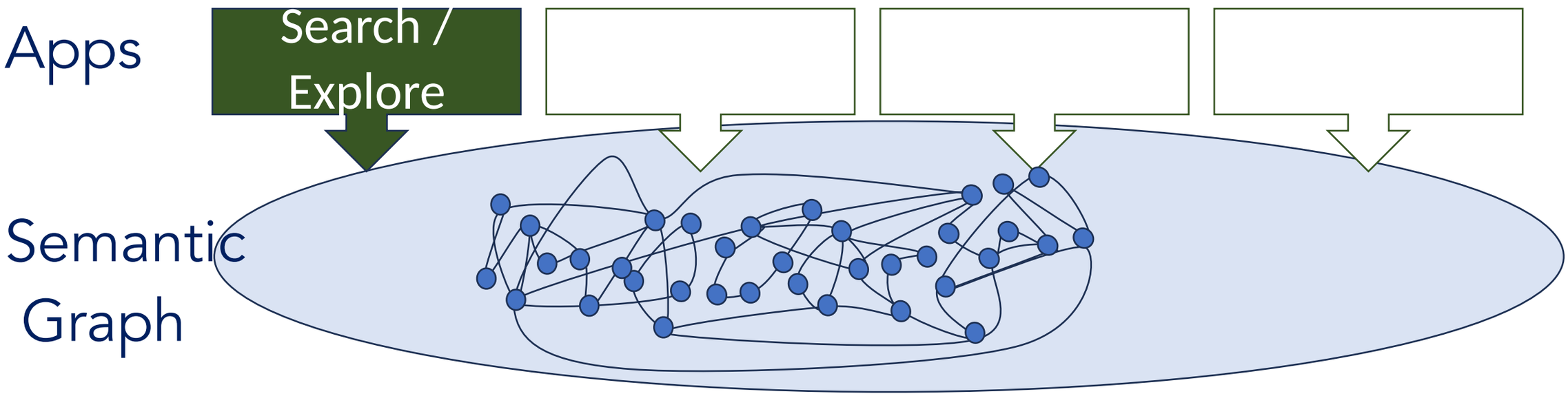
Data-driven decisions

using a combination (or *federation*) of academic, institutional, and operational data.



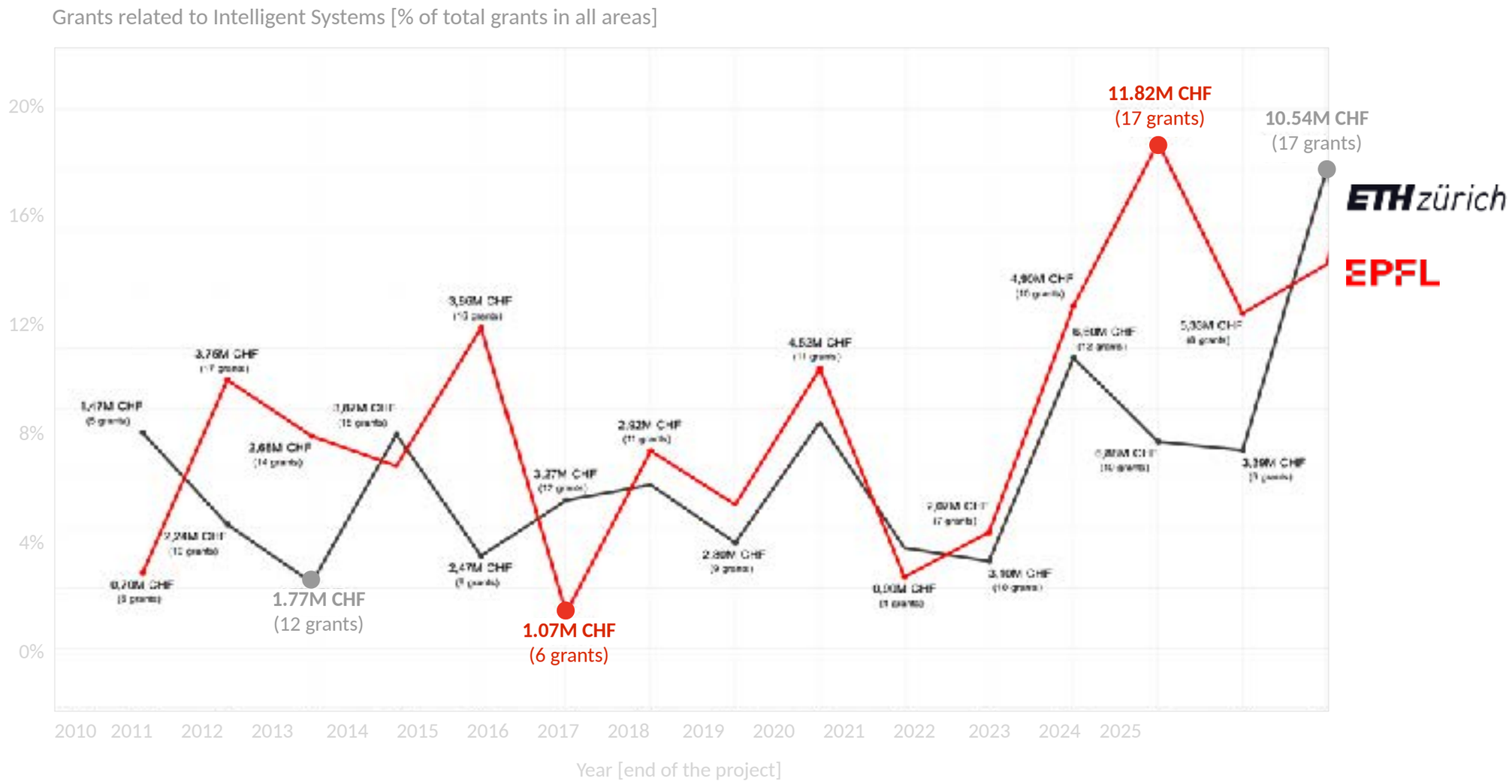
From global AI trends, hopes and fears

to local AI-powered services



Data-driven decisions

How has SNSF funding in "intelligent systems" evolved at EPFL and ETHZ?

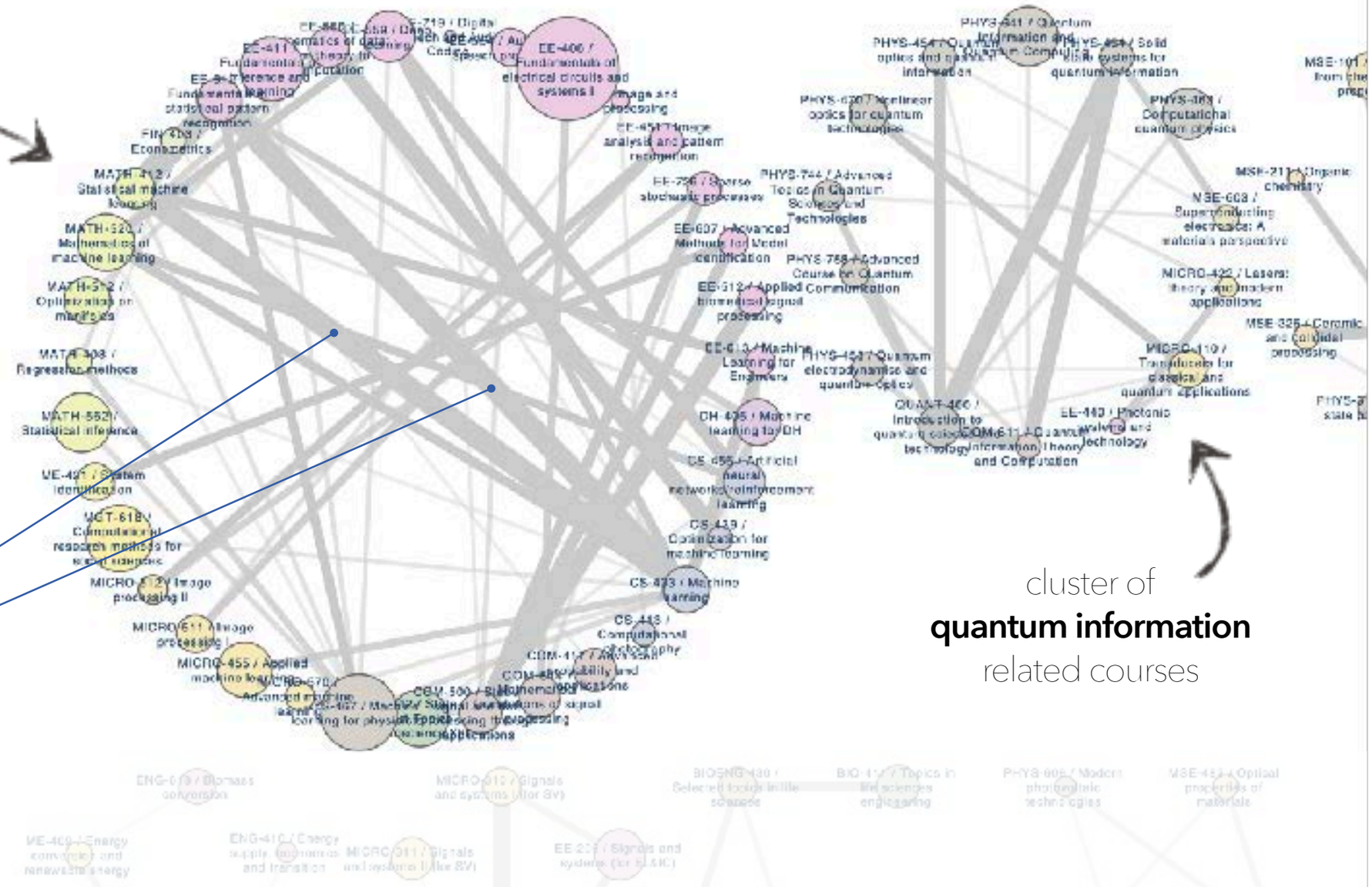


Data-driven decisions

Are some EPFL courses redundantly teaching the same subjects?

cluster of courses at EPFL teaching **machine learning**

these courses are potentially teaching the same subjects.

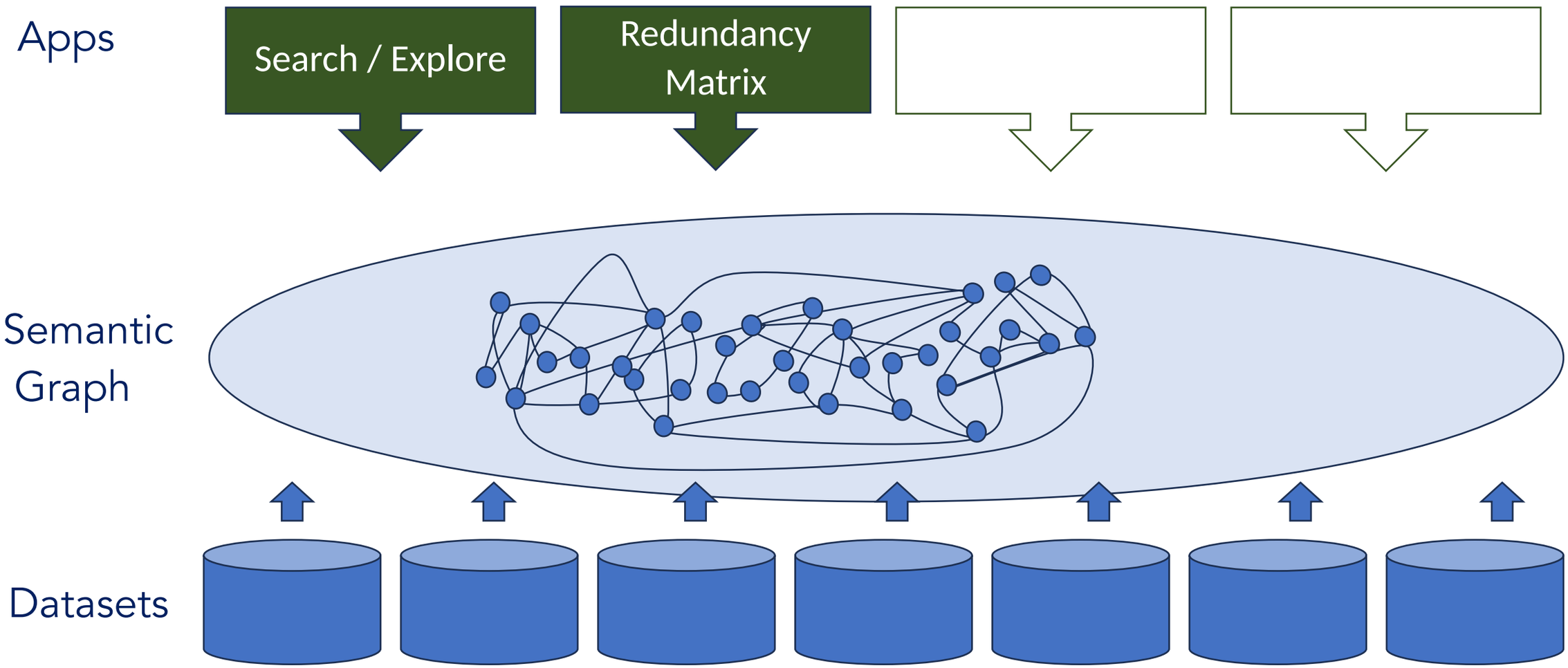


cluster of **quantum information** related courses

SourceCode	TargetCode	SourceName	TargetName
CH-160	MSE-101	Advanced general chemistry	Materials: from chemistry to properties
CH-313	BIO-212	Chemical biology	Biological chemistry I
CH-210	BIO-212	Biochemistry	Biological chemistry I
CH-160	PHYS-106	Advanced general chemistry	General physics : thermodynamics (English)
CH-160	MSE-422	Advanced general chemistry	Advanced metallurgy
CH-160	BIO-212	Advanced general chemistry	Biological chemistry I
CH-110	MSE-101	Advanced general chemistry I	Materials: from chemistry to properties
CH-411	BIO-212	Cellular signalling	Biological chemistry I
CH-633	MICRO-530	Advanced Solid State and Surface Characterization	Nanotechnology
CH-419	BIO-212	Protein mass spectrometry and proteomics	Biological chemistry I
CH-633	MSE-352	Advanced Solid State and Surface Characterization	Introduction to microscopy + Laboratory work

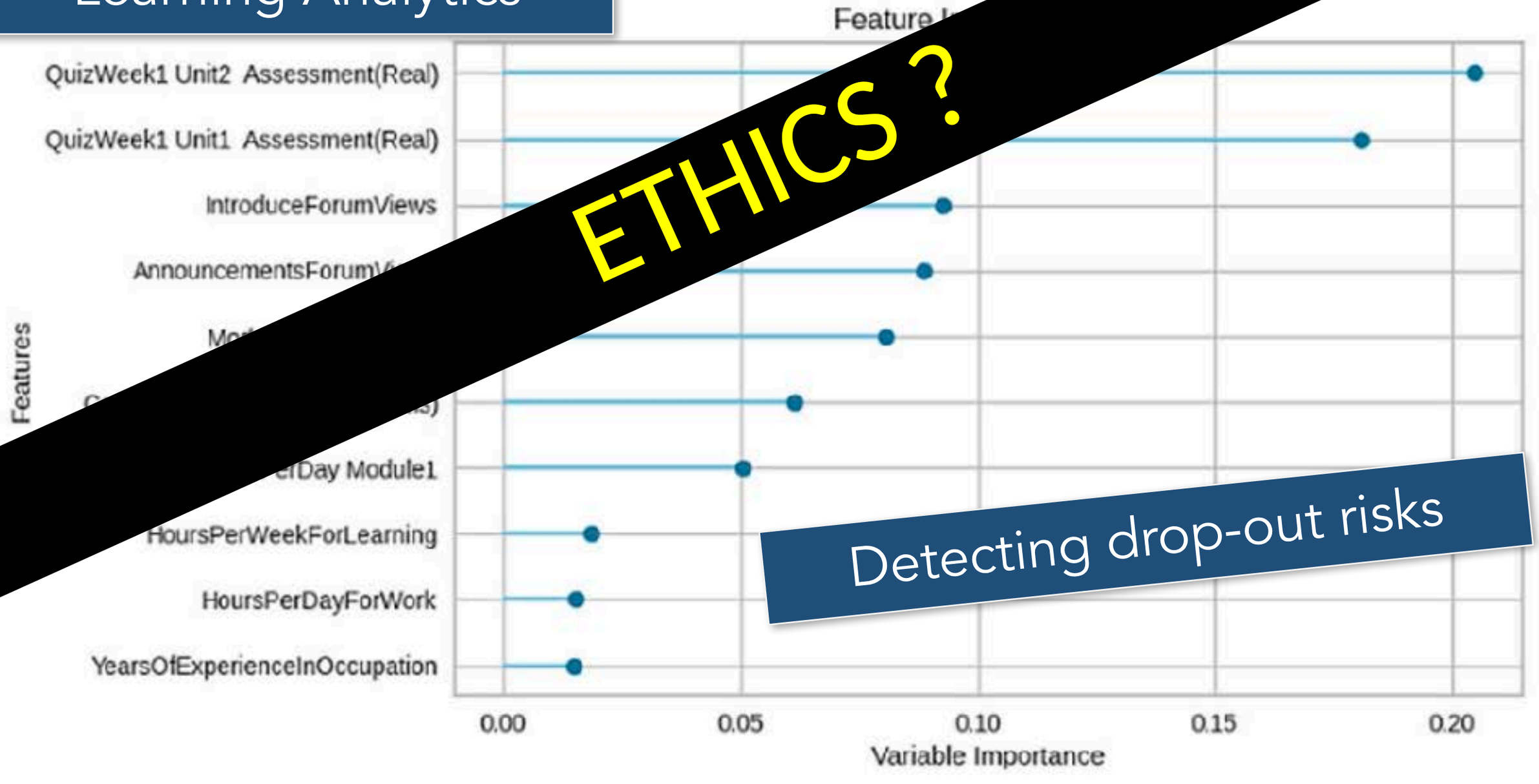
From global AI trends, hopes and fears

to local AI-powered services



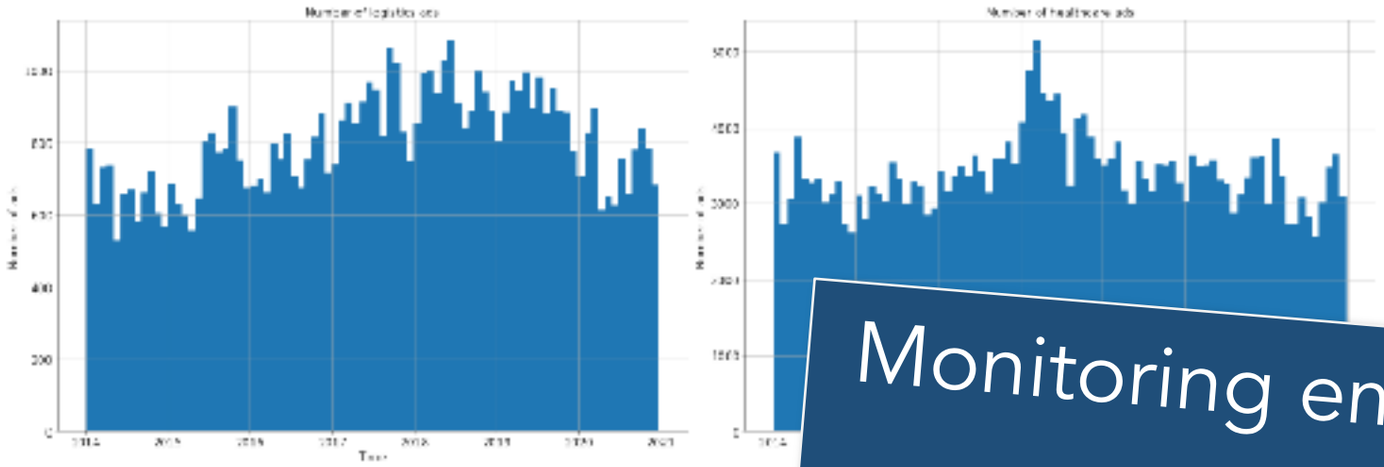
Learning Analytics

ETHICS ?



Detecting drop-out risks

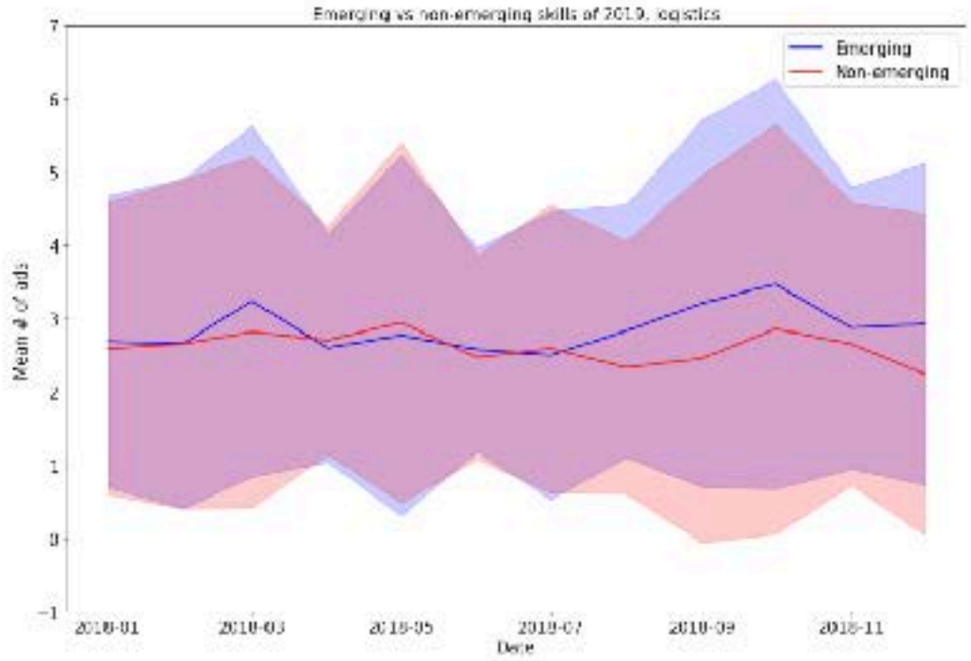
Panagiotakopoulos, T.; Kotsiantis, S.; Kostopoulos, G.; Iatrellis, O.; Kameas, A. Early Dropout Prediction in MOOCs through Supervised Learning and Hyperparameter Optimization. Electronics 2021, 10, 1701. https:// doi.org/10.3390/electronics1014

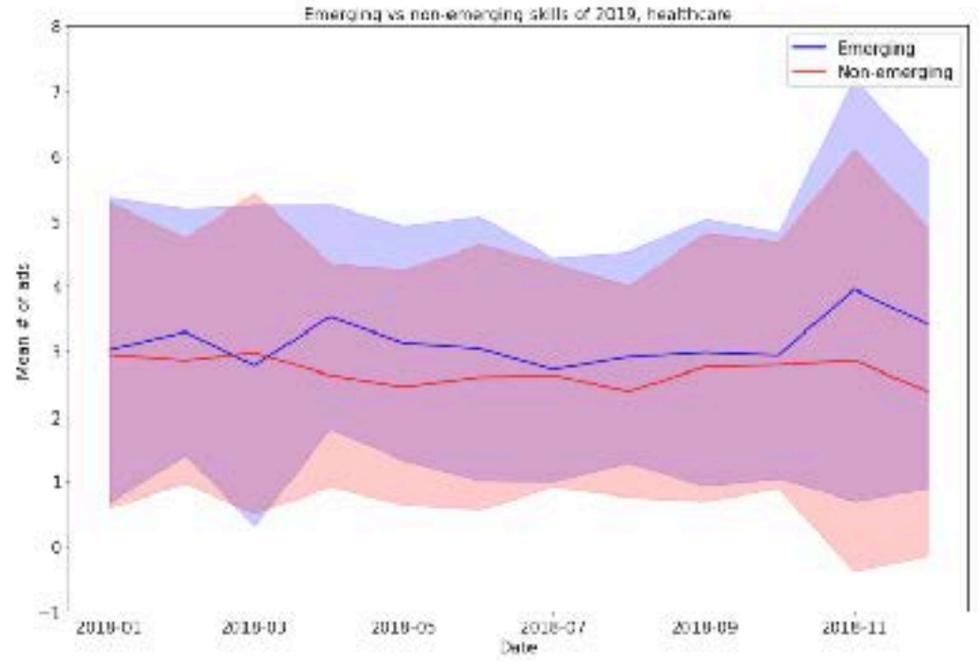


(a)

Figure 6.1 – The number of job ads per month in the JobCloud dataset in (a) logistics and (b) healthcare, 2014-2021.

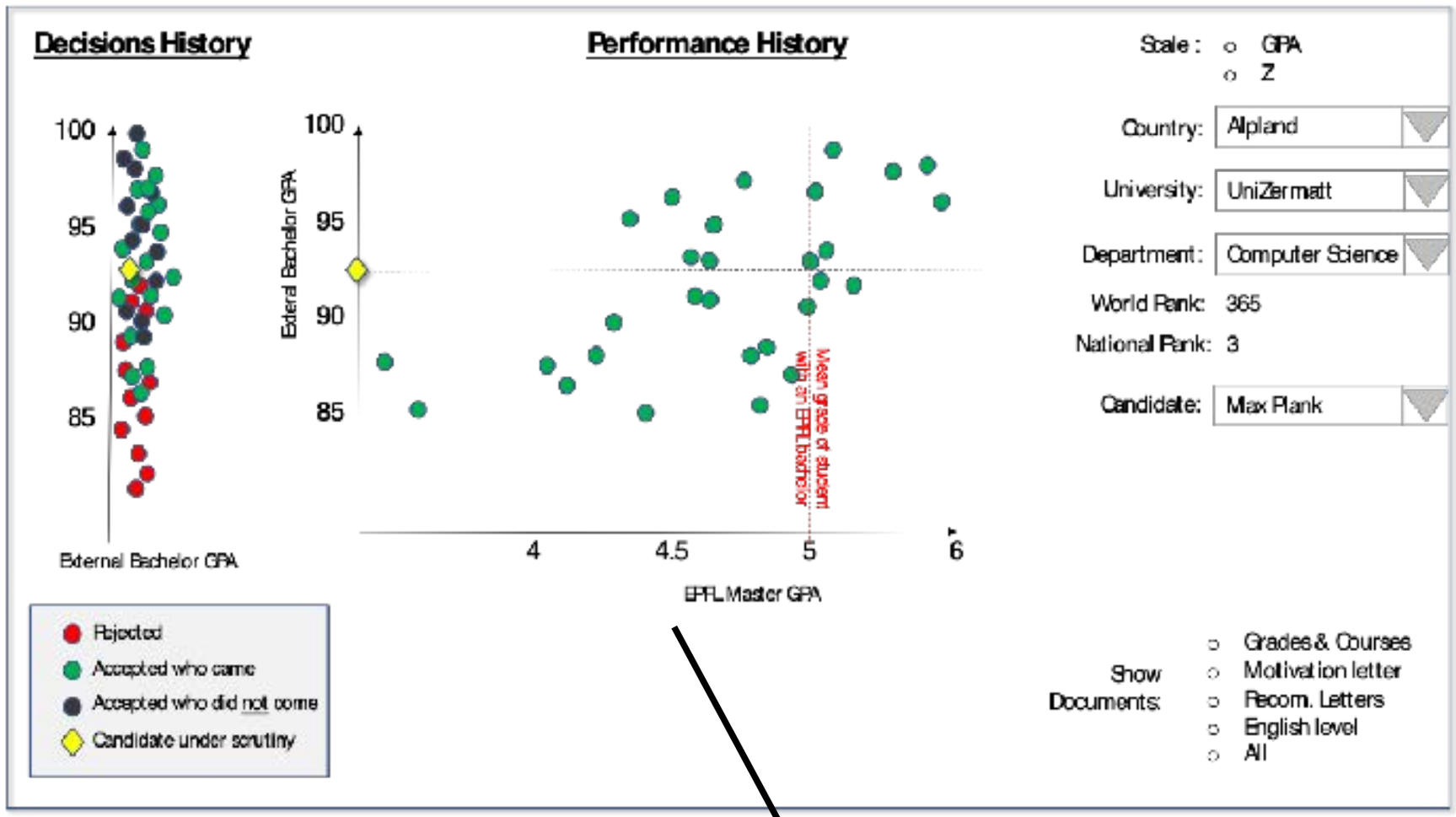
Monitoring emerging requirements from industry

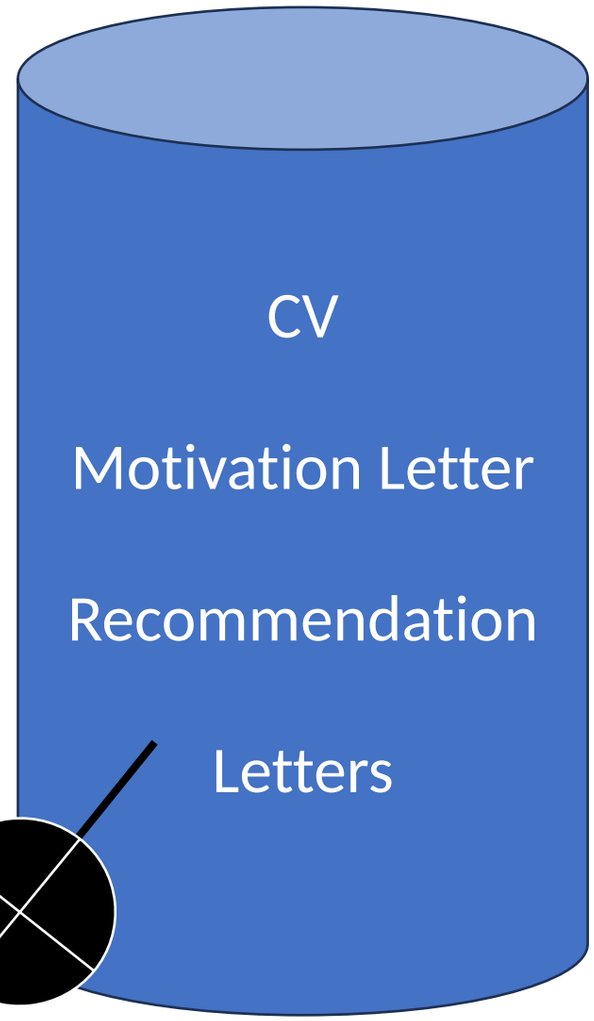




Ramtin Yazdanian

Master Admissions

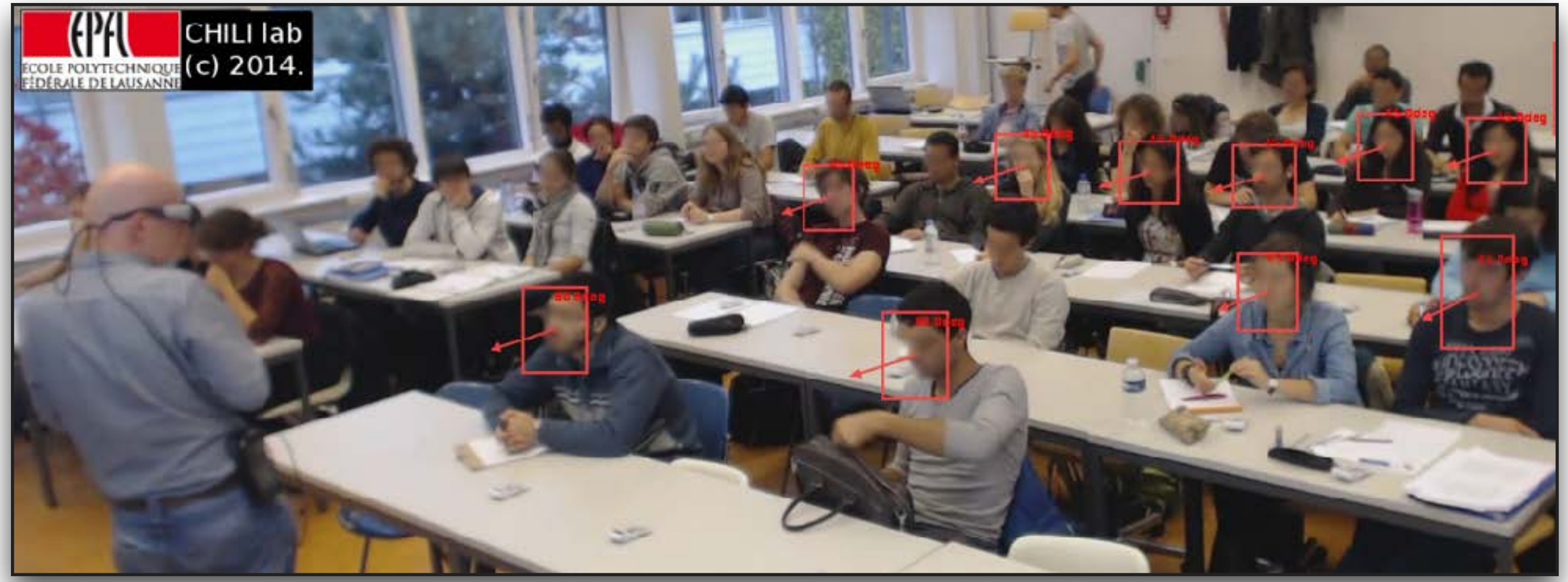




Keep a human in the loop ?

3. Classroom analytics

You passed below 5% attention



Raca, M., & Dillenbourg, P. (2013). System for assessing classroom attention. In *Proceedings of 3rd International Learning Analytics & Knowledge Conference*

Do you really want to put cameras in classes ?

NO

EPFL Exercises Session

assistant

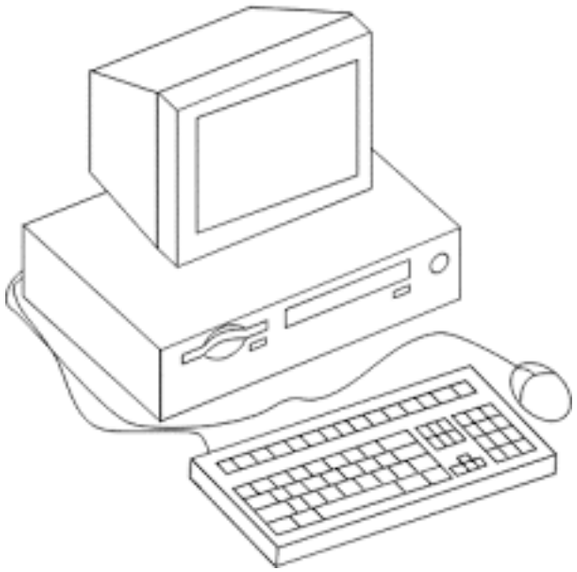
works

waits

"While Waiting Productivity" LOSS : 62% ➔ 6%

H. Alavi, O. Guédat

Classware: the classroom is a digital system



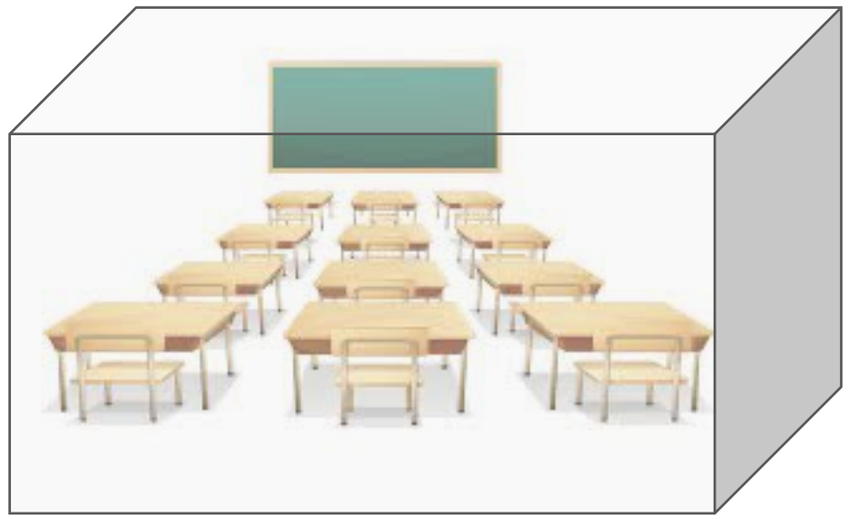
learning analytics

individual student

knowledge state

system decision

open student model



classroom analytics

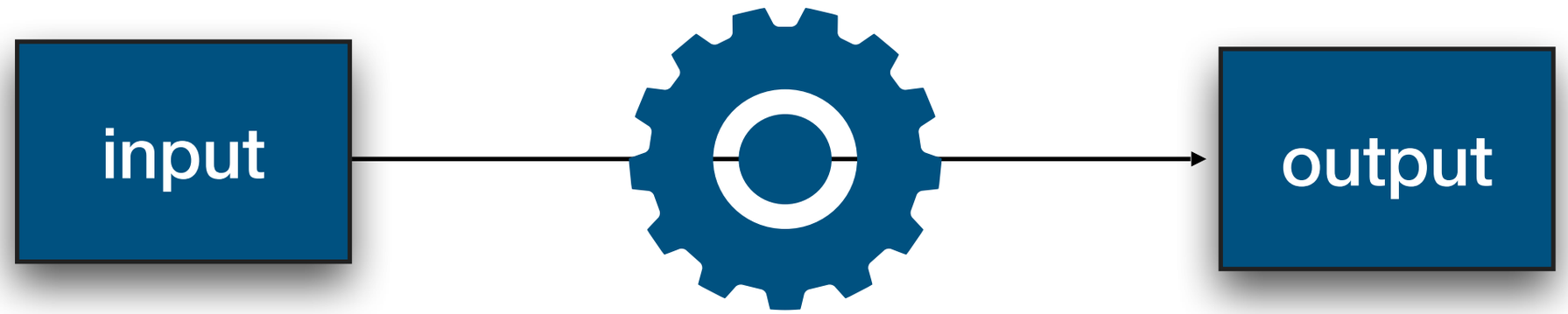
n students

activity state

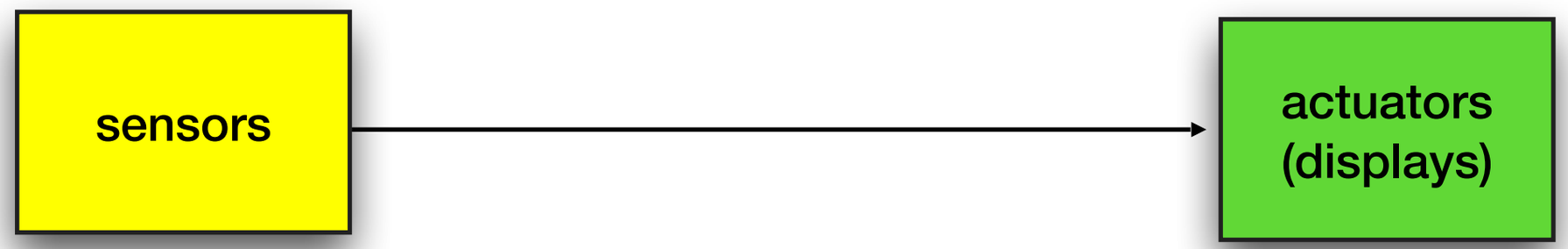
teacher decision

dashboards

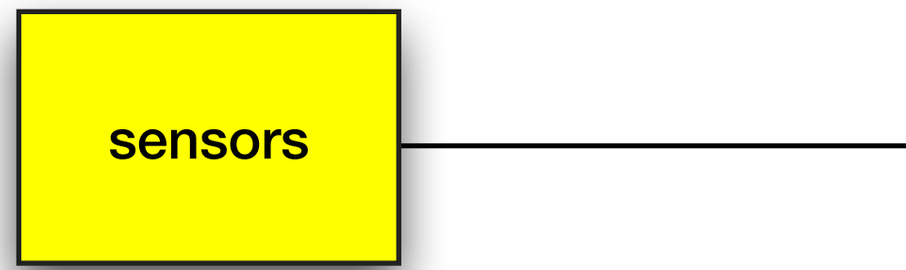
My (physical) classroom is a digital environment



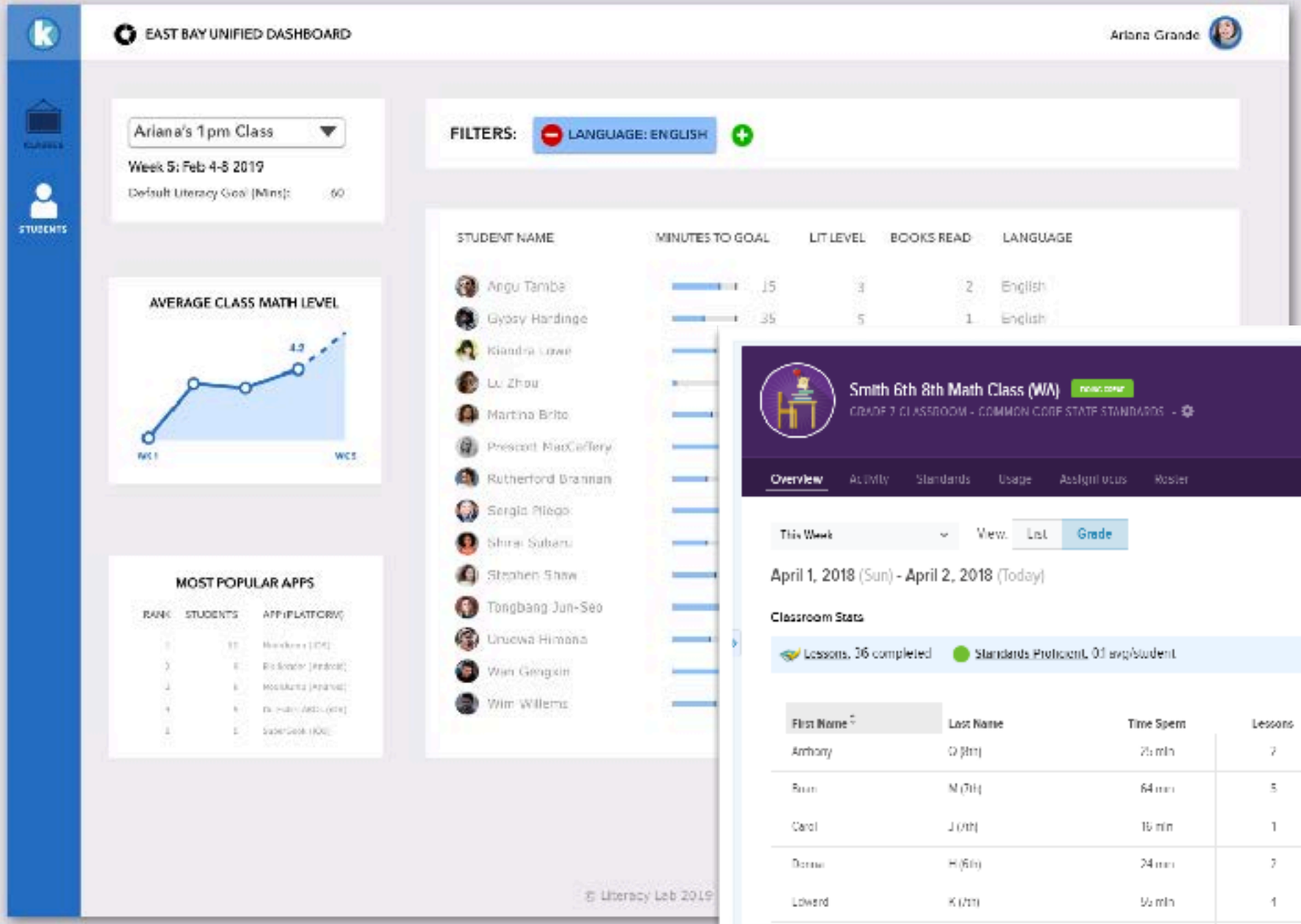
My (physical) classroom is a digital environment

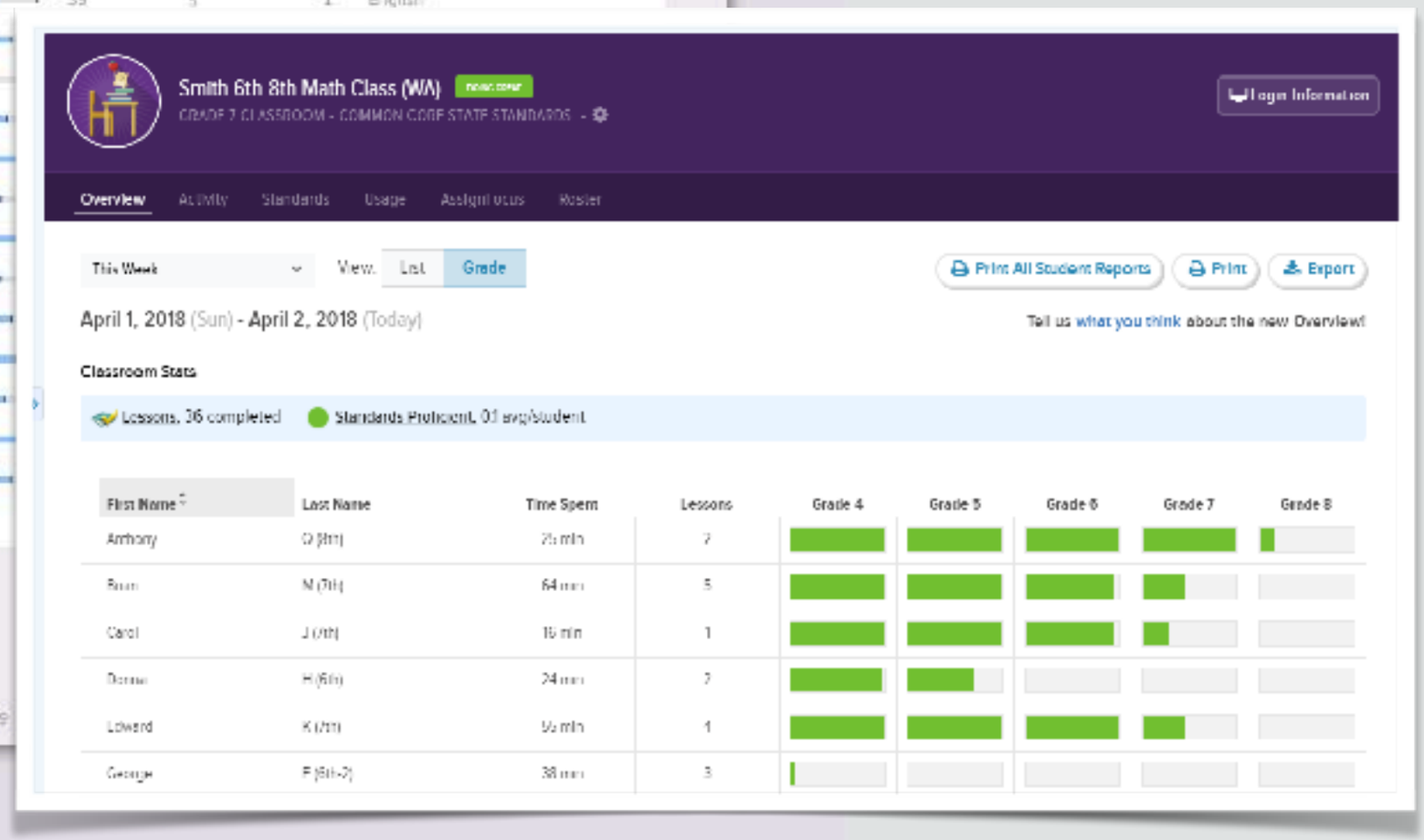


- **Accelerometer** that measures acceleration forces
- **Magnetometer** that measures magnetization/magnetic fields
- **Light sensor** that measures the strength of light
- **Gyroscope** that measures orientation
- **Hygrometer** that measures moisture in the atmosphere
- **Thermometer** that measures ambient temperature
- **Barometer** that measures atmospheric pressure
- **Proximeter** that detects when something is close



- **Precision Gas Sensor** - Test air quality, carbon monoxide levels
- **Reducing Gas Sensor** - Sense methane, propane, and natural gas leaks
- **Oxidizing Gas Sensor** - Ozone sensing and chlorine leaks
- **Non-Contact Thermometer** - Check food temperature, engine diagnostics, …
- **Humidity Sensor** - Check heat index, food storage conditions
- **Temperature Sensor** - Measure ambient temperature
- **Light Sensor** - For checking light intensity, sunlight monitoring,….
- **Color Sensors** - Use as a color meter, color matcher/analyzer, even pattern recognition
- **Pressure Sensor** - Blood pressure monitor
- **Proximity Sensor** - Use it as a stud finder or liquid level monitor
- **Expansion Connector** - Connecting other sensors like EKGs, Thermal Printers, and more





Kidapolis

Dreambox

Dashboard

actuators (displays)

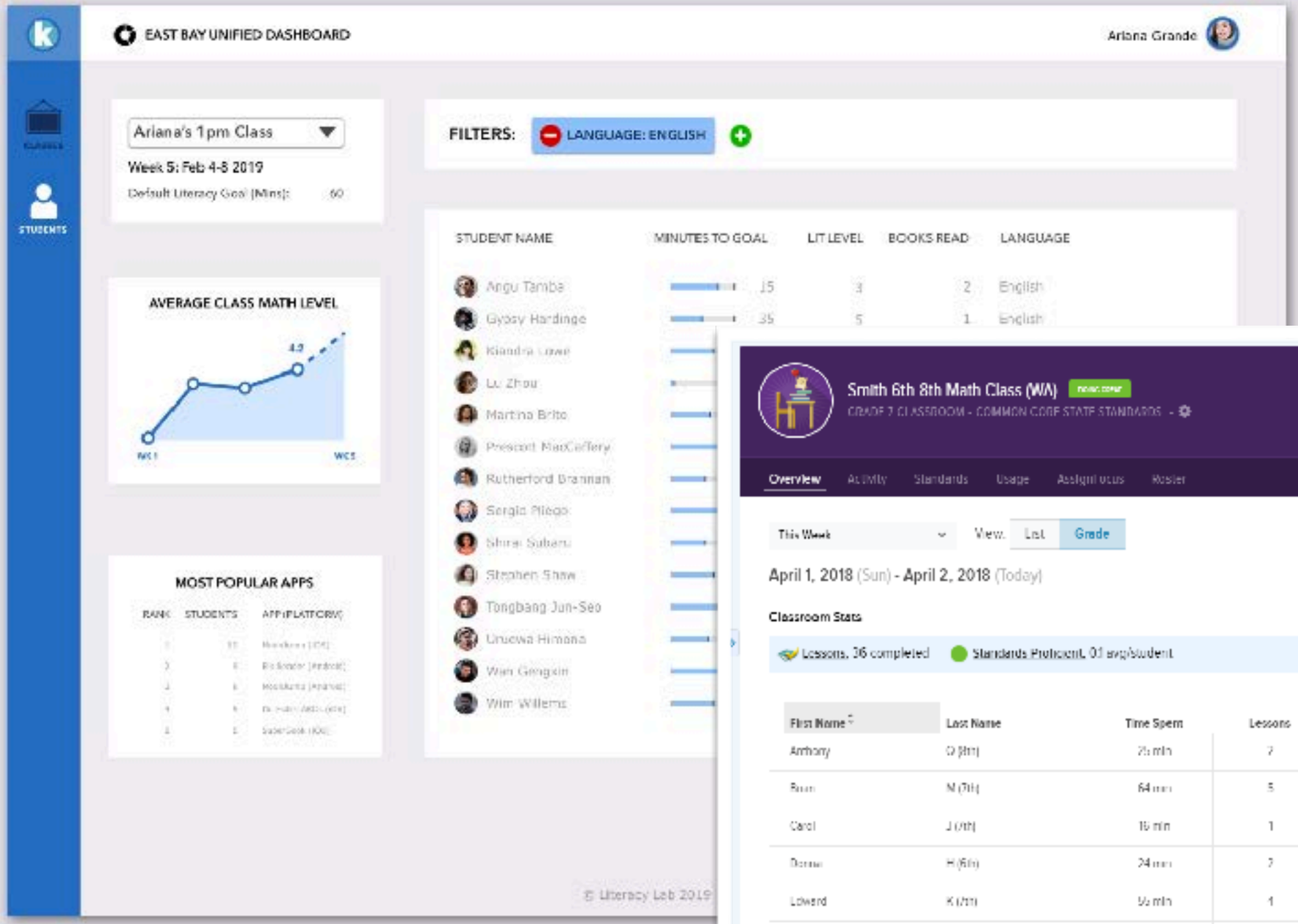
Kidapolis

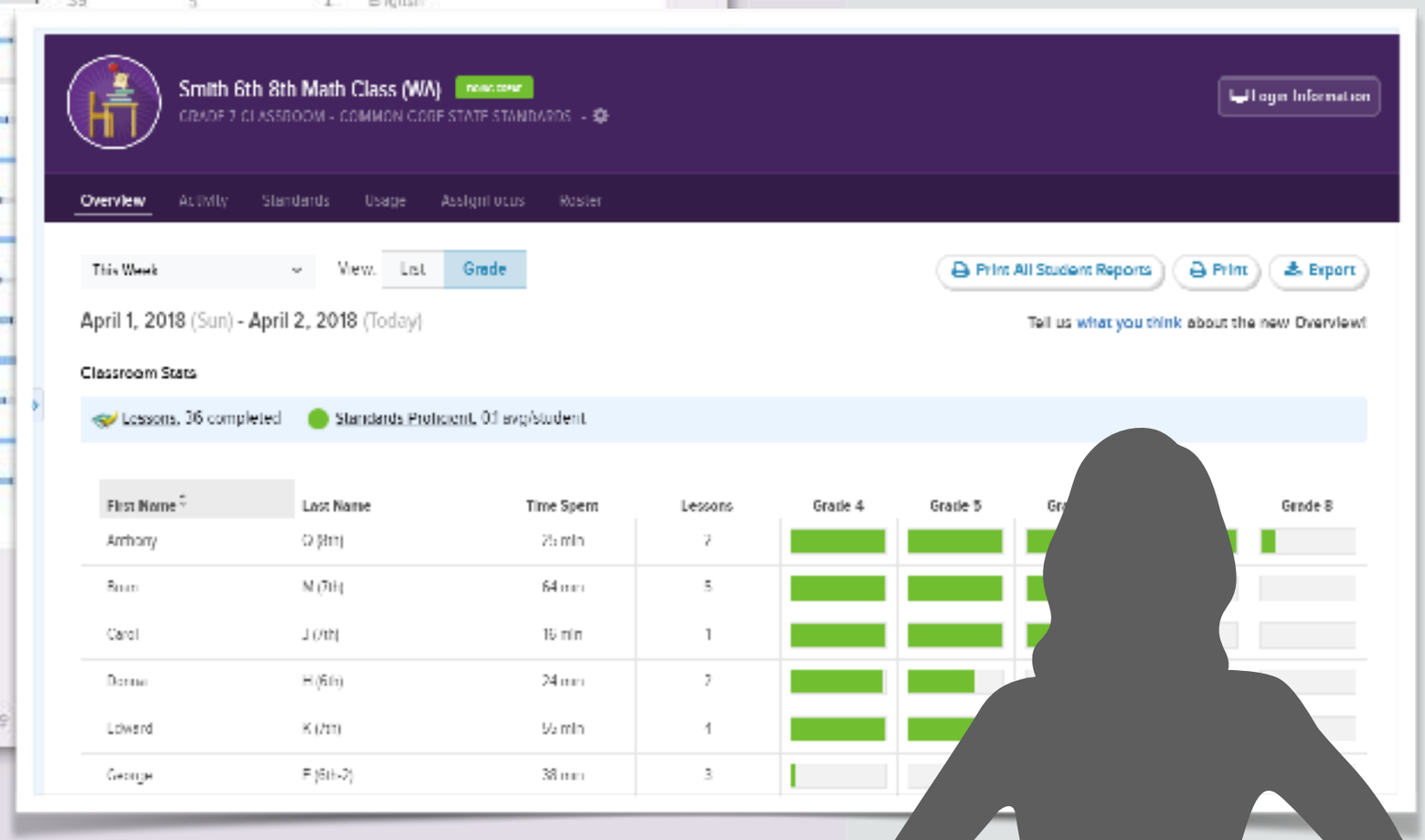
Dreambox

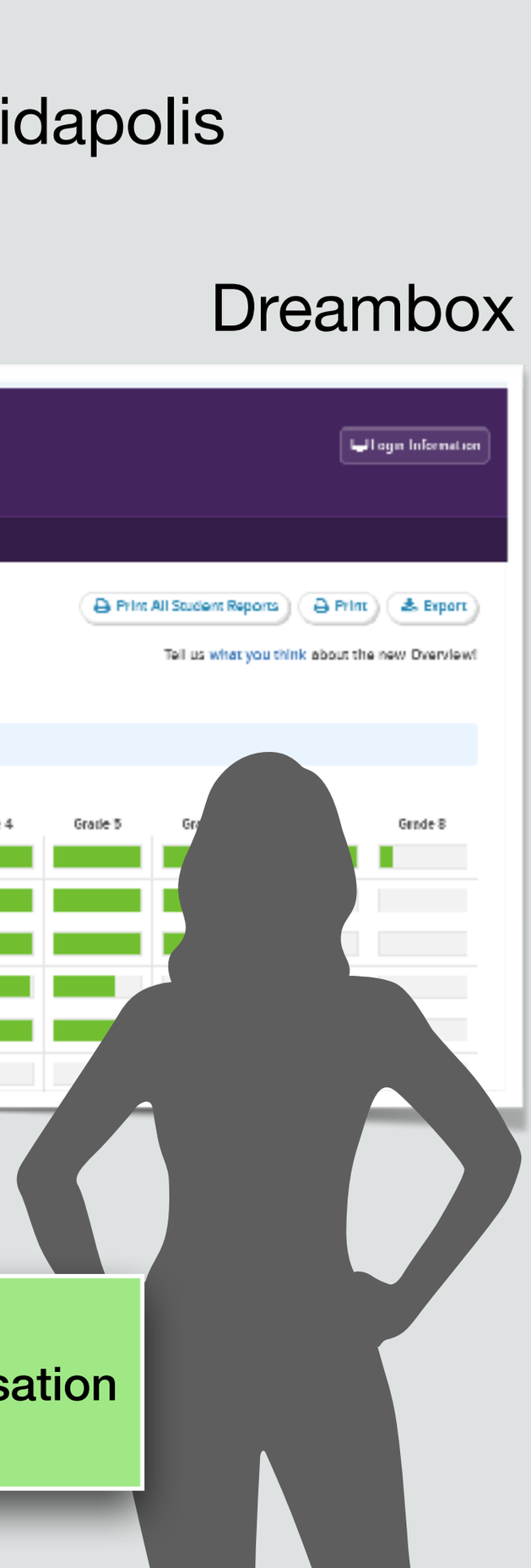
Dashboard

Classroom Data

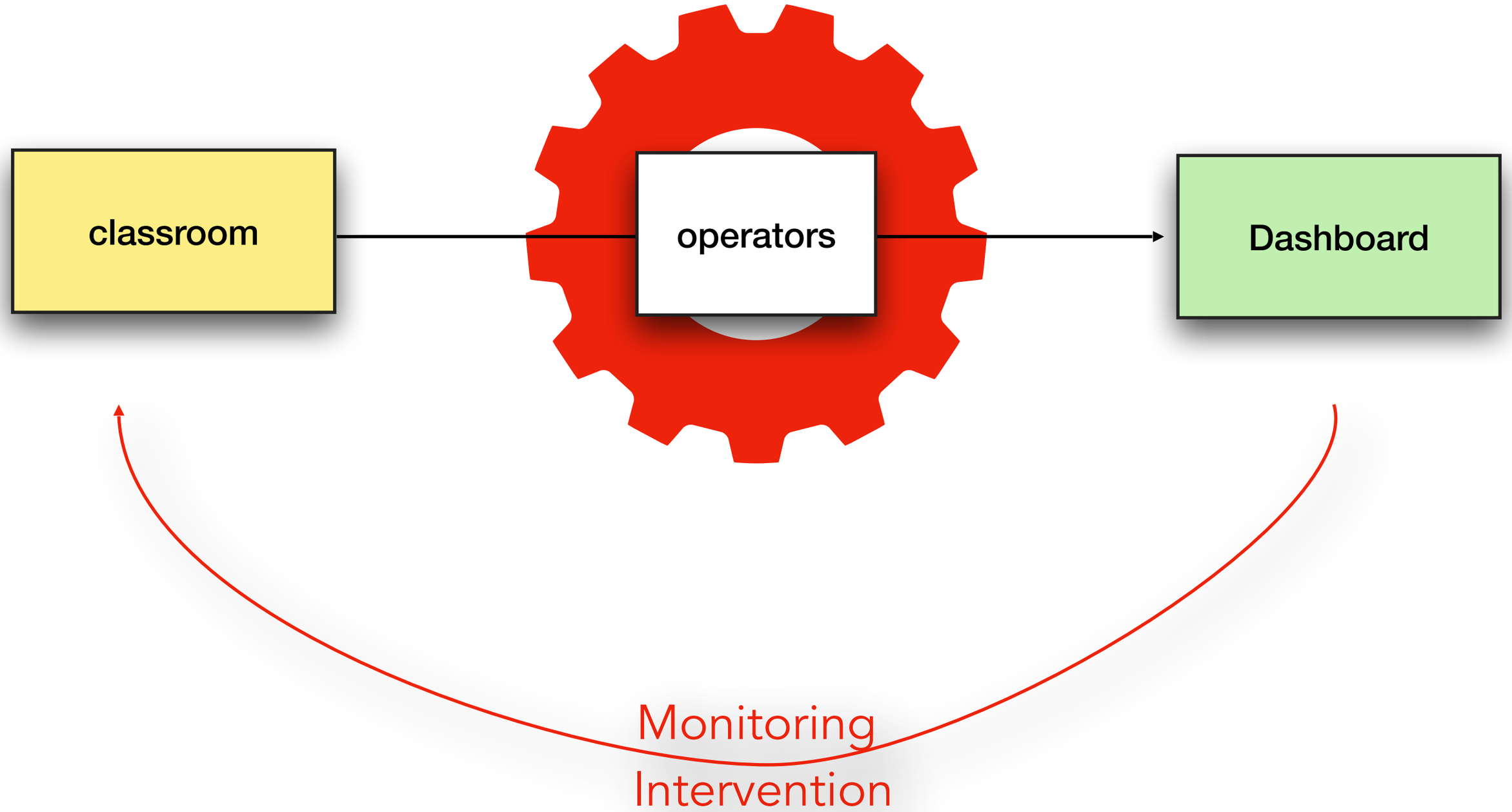
Visualisation







Aggregation, comparison, visualisation,….



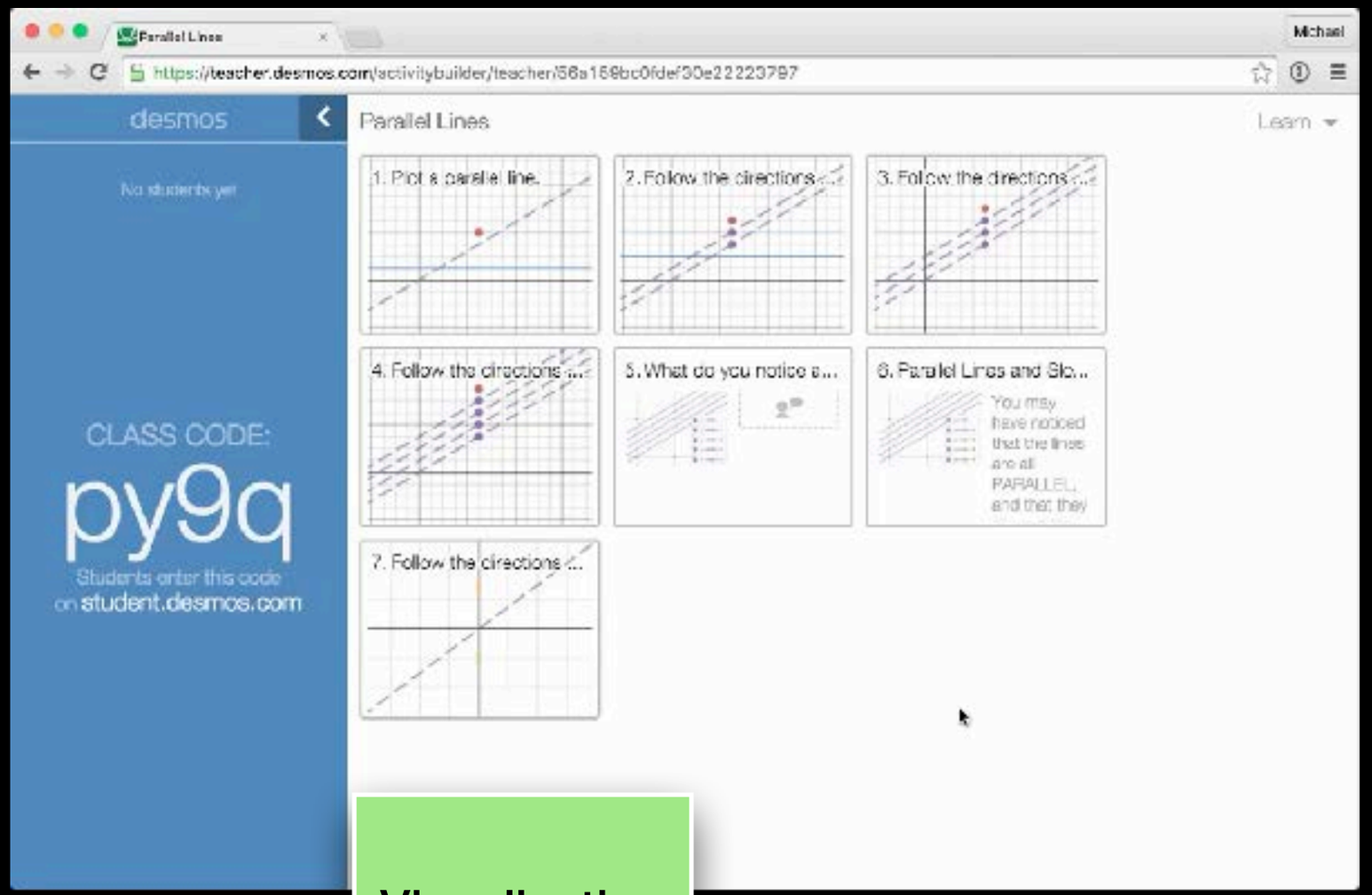
Distributed

Data

Visualisation

Centralized

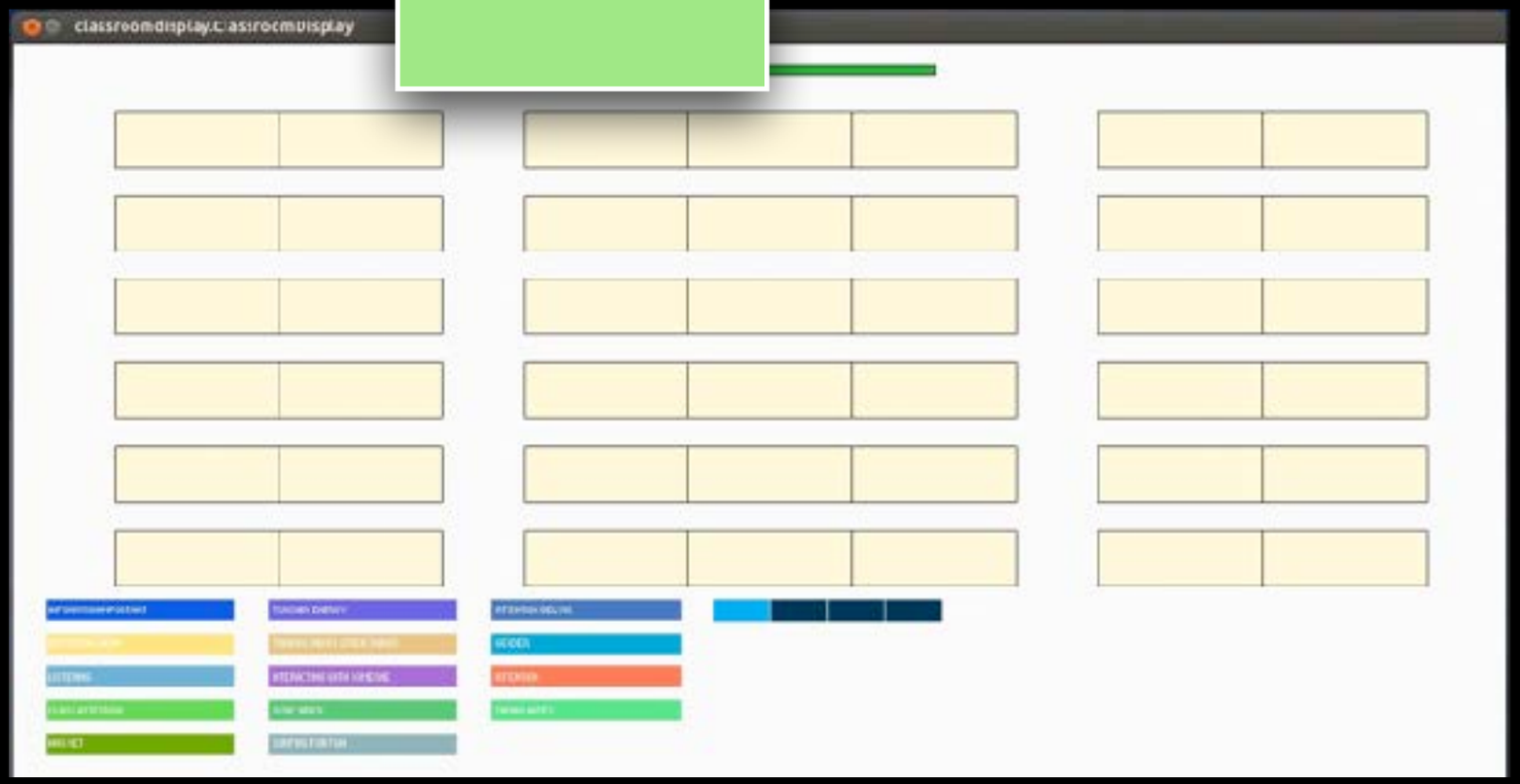
Realtime



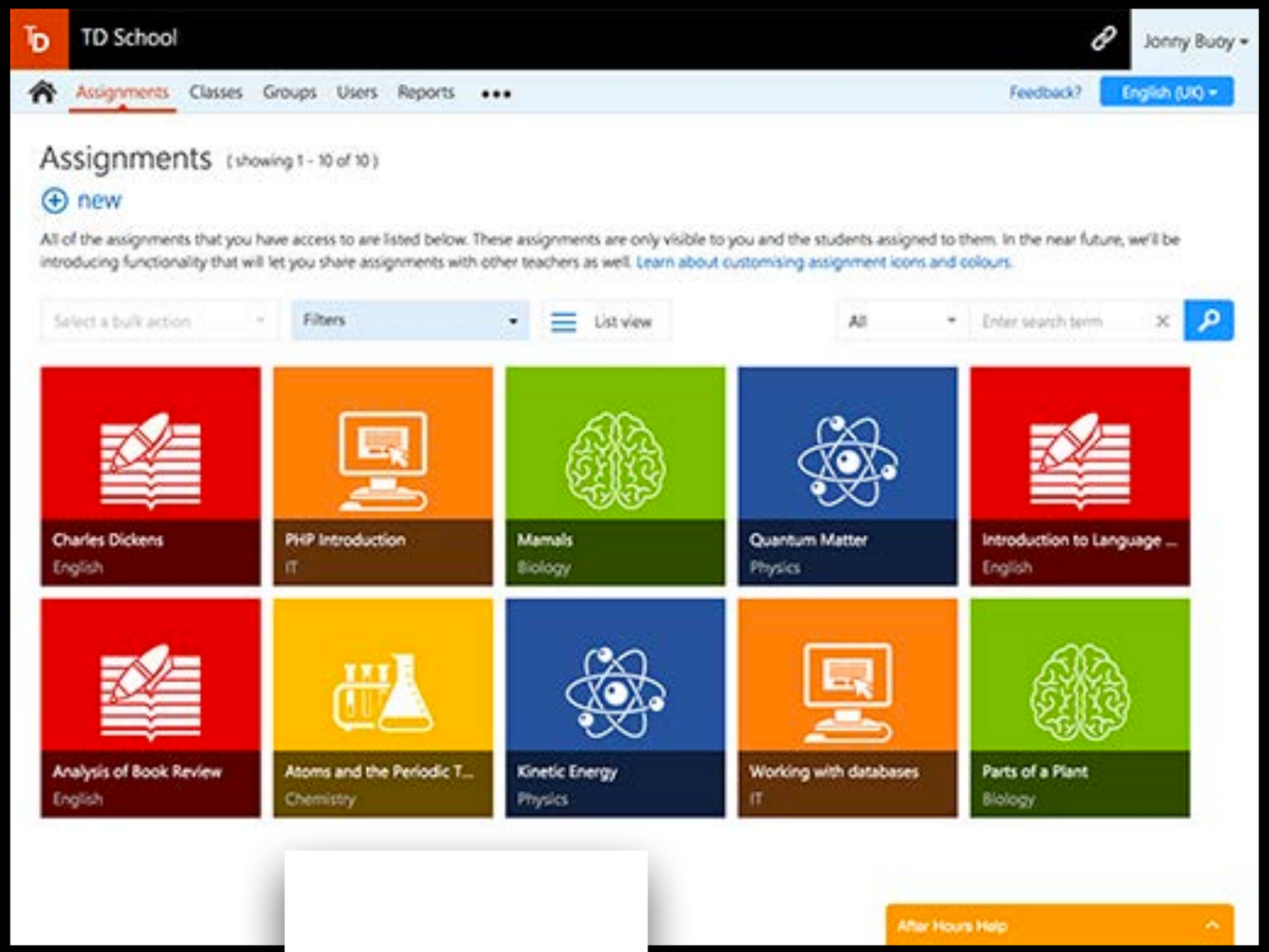
Data

Visualisation

Replay



Focal



Data

Visualisation

Peripheral
(ambient)

Public Dashboard

Data

Visualisation

Private Dashboard

https://www.brightfishlearning.com/reports/

LUMILO

real-time, continuous assessment for K-12 teachers

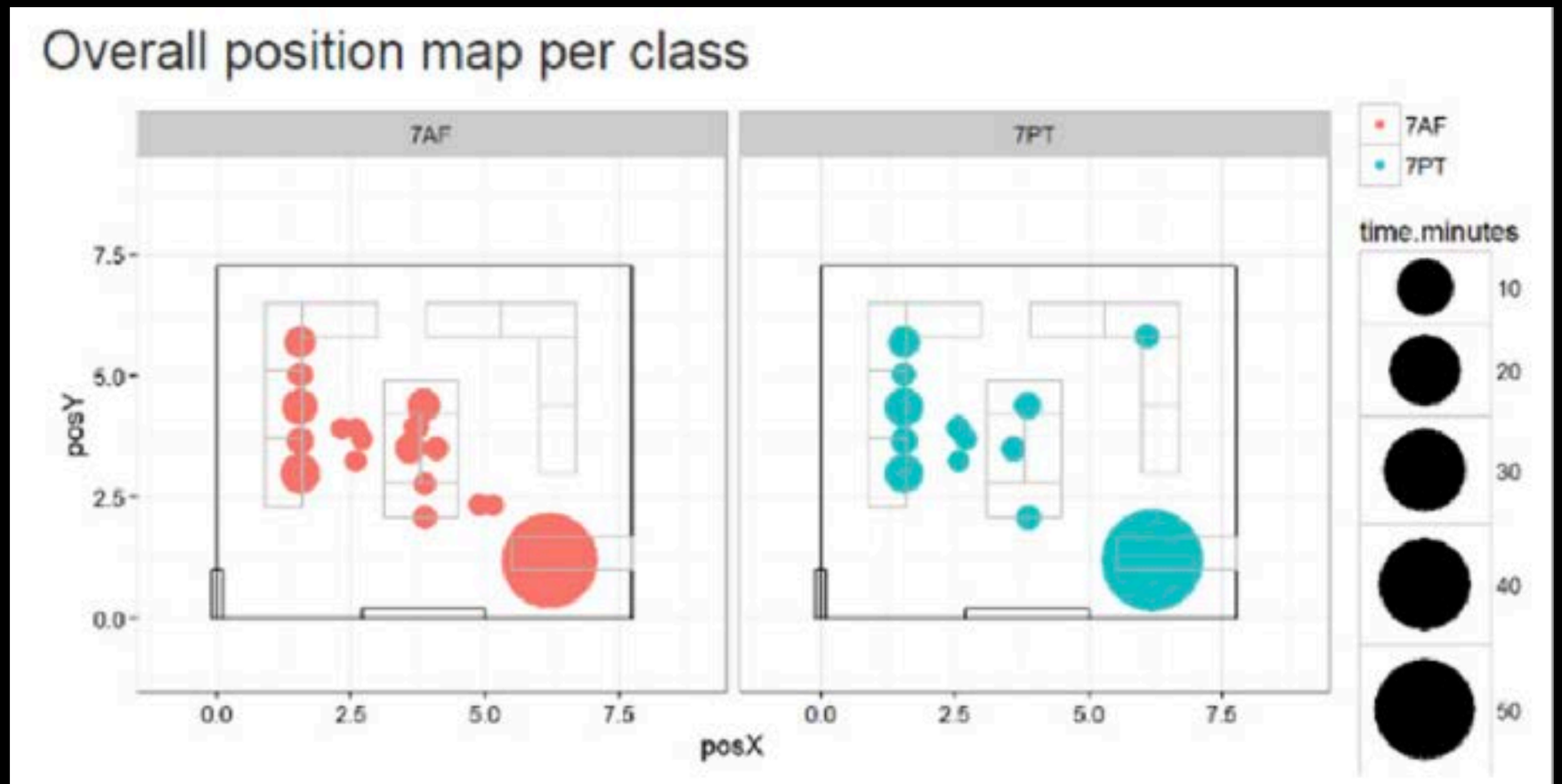
47% « out of the loop »

K. Hostein, V. Aleven & N. Rummel

Teachers'
Data

Visualisation

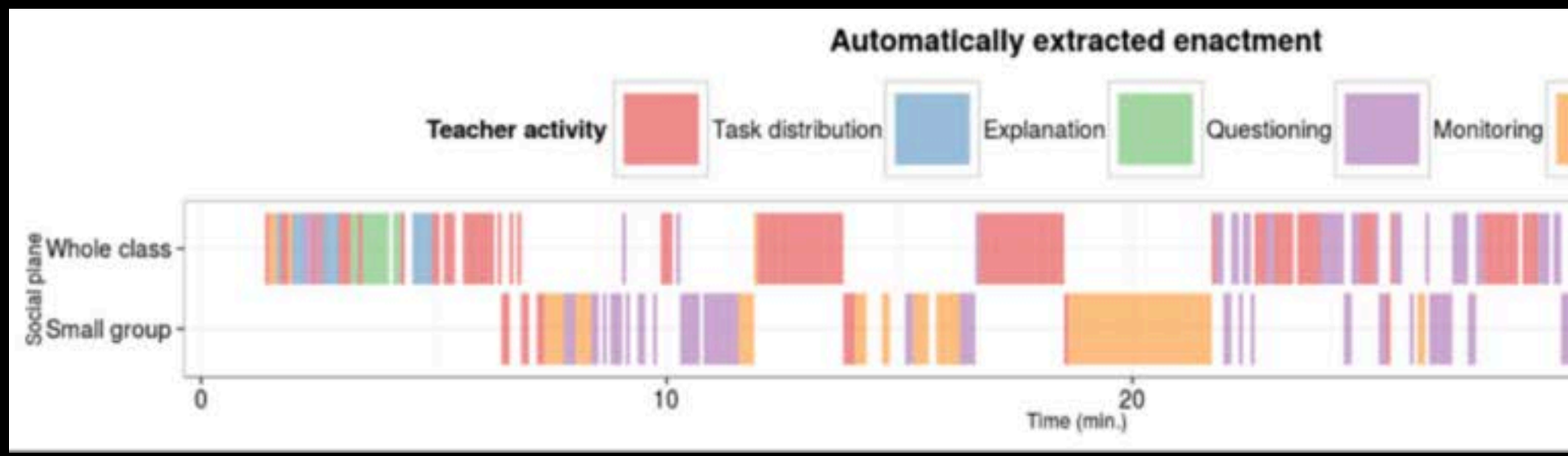
Sarrade Isabelle, EPFL



Prieto et al

Teachers' Data

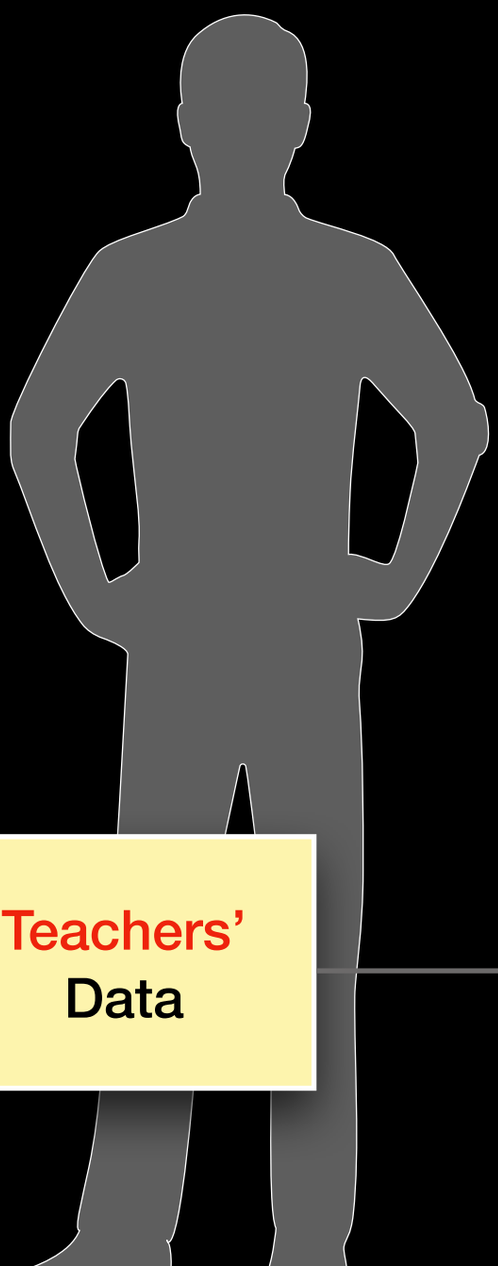
Visualisation



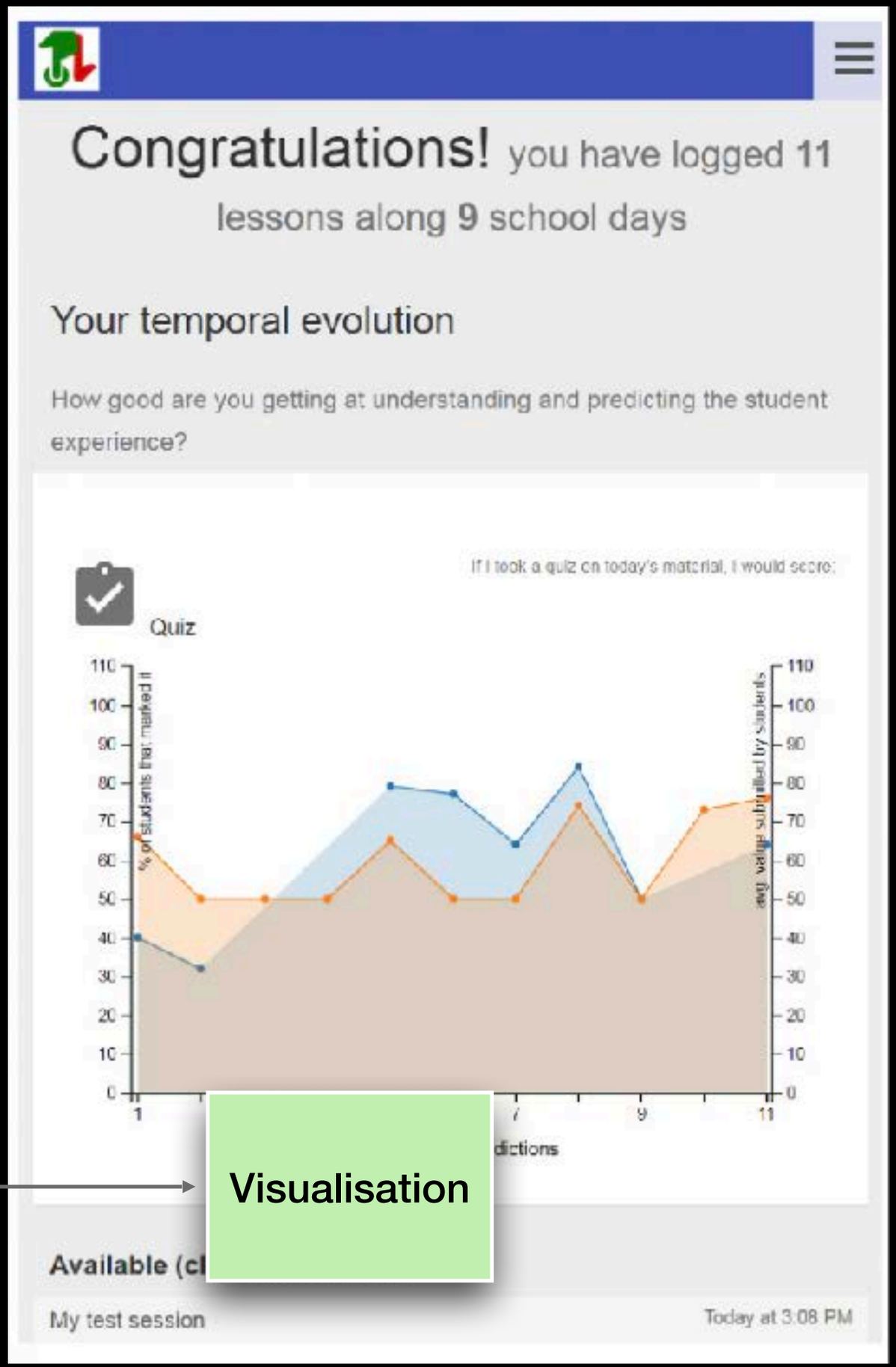
Teachers' Data

Visualisation

Prieto, L. P., Magnuson, P., Dillenbourg, P., & Saar, M. (2020). Reflection for action: Designing tools to support teacher reflection on everyday evidence. *Technology, Pedagogy and Education*, *29*(3), 279-295.

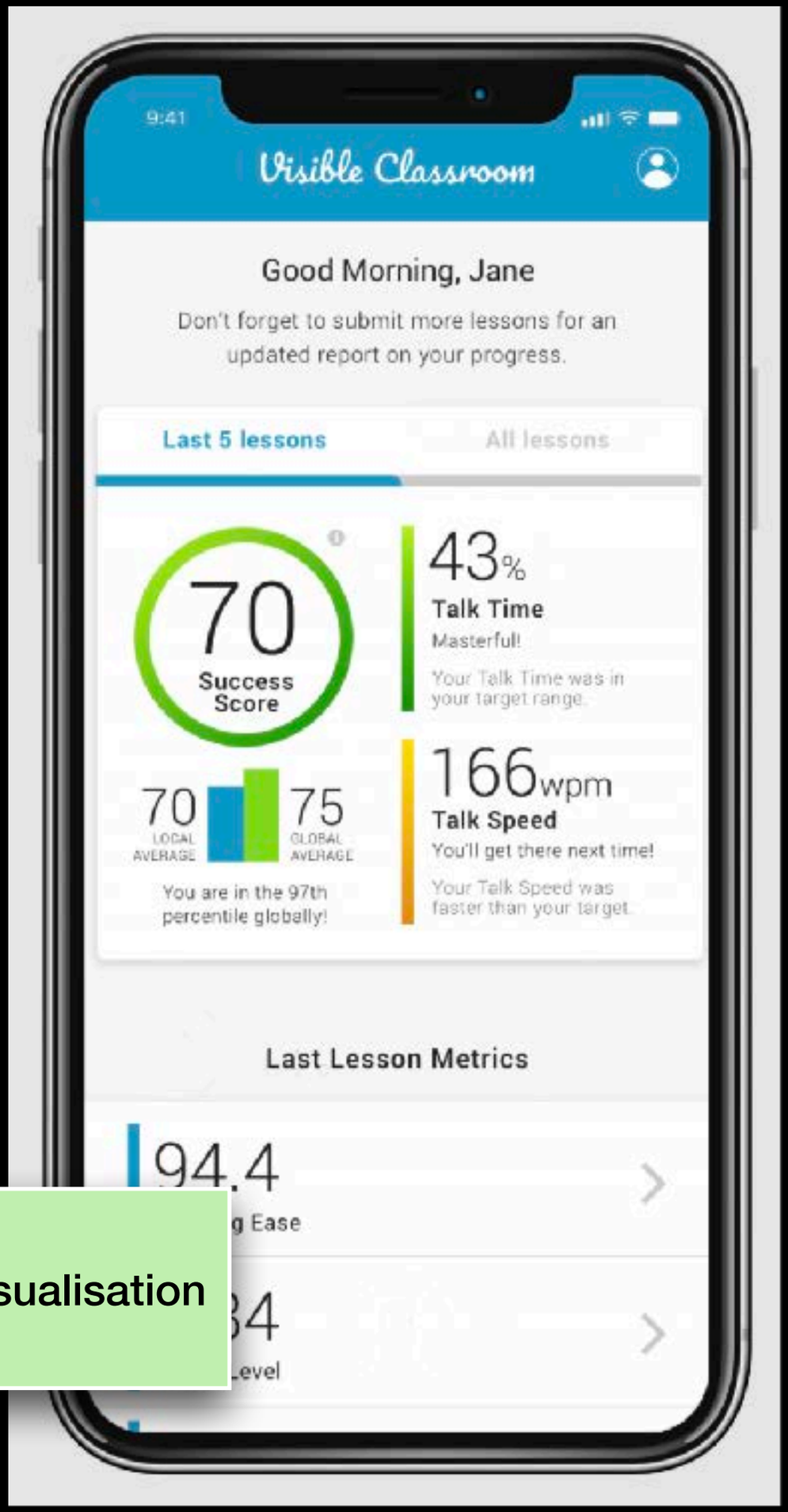


Teachers'
Data

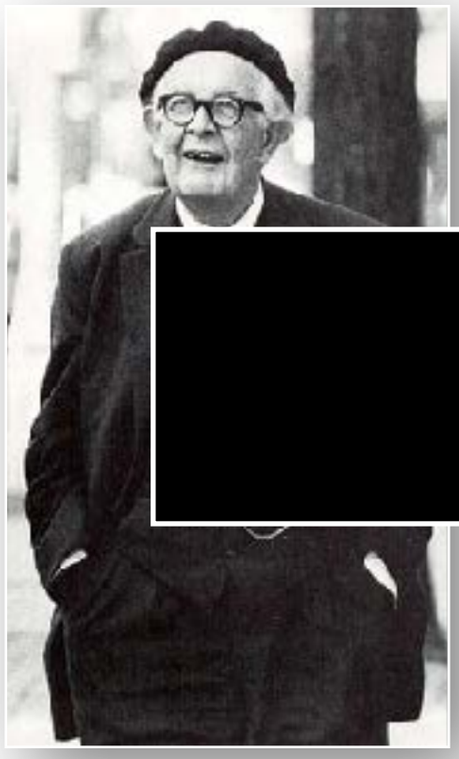


Teachers'
Data

Visualisation

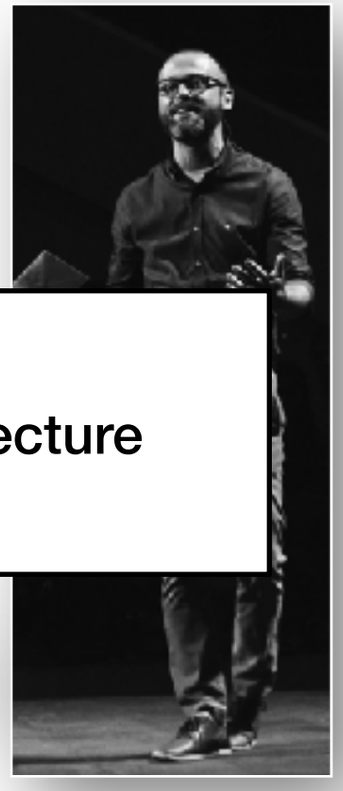


There is a time for telling



Problem Solving

Lecture

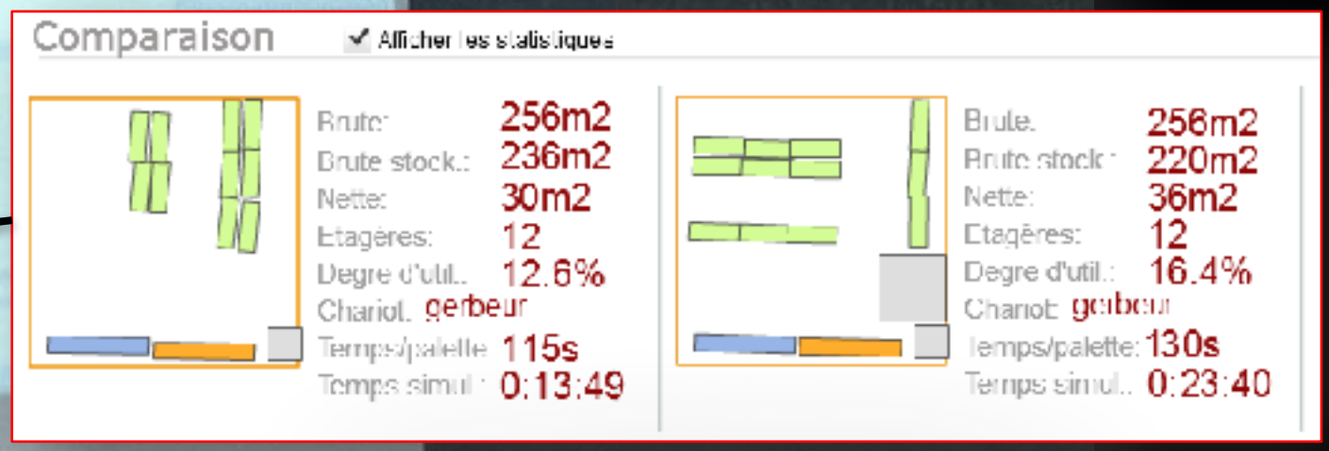


Collecting for debriefing


KOSMOS
200
MADE IN CHINA


Simpliquity

(1) monitoring



(2) debriefing

Problem Solving

Lecture

Question

Please order a standard return 2nd clas

Enter command

from Lausanne to Davos standard C2|re

Question

Please order a young return 2nd class ticket from Basel to Geneve without bike.

Your Ticket

From	To
Basel	Geneve

Travel	Fare
Return	

Class	Bike

City

Basel	Davos	Fribourg
Geneve	Lausanne	Neuchatel
	Zurich	

Travel

One-way	Return

Fare

Standard	Young	Half-fare

Class

Bike

Question

Please order a standard return 2nd class ti

From:
Fribourg

To:
Zurich

Travel:
Return

Fare:
Standard

Class:
2nd

Bike:
No

:24

Question

Please order a standard return 2nd class ticket from Basel to Zurich with a bike.

From
Basel

To
Zurich

Travel

- One-way
- Return

Fare

- Standard
- Young
- Half-fare

Class

- 1st
- 2nd

Bike

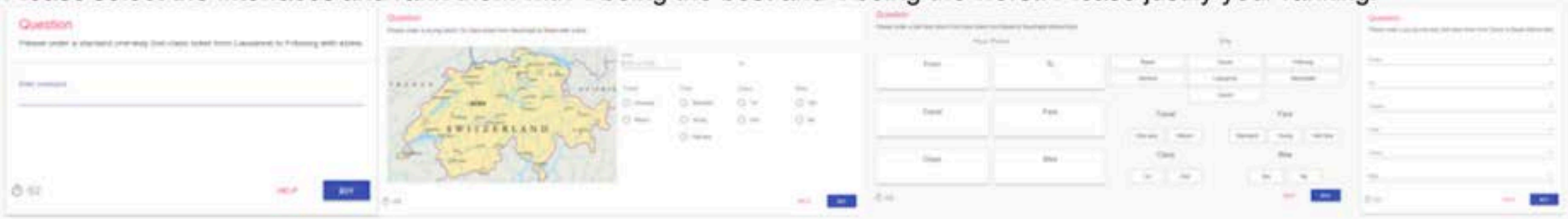
- Yes
- No

:36

HELP

BUY

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. **Drag and Drop**
2. **Command**
3. **Form**
4. **Map**

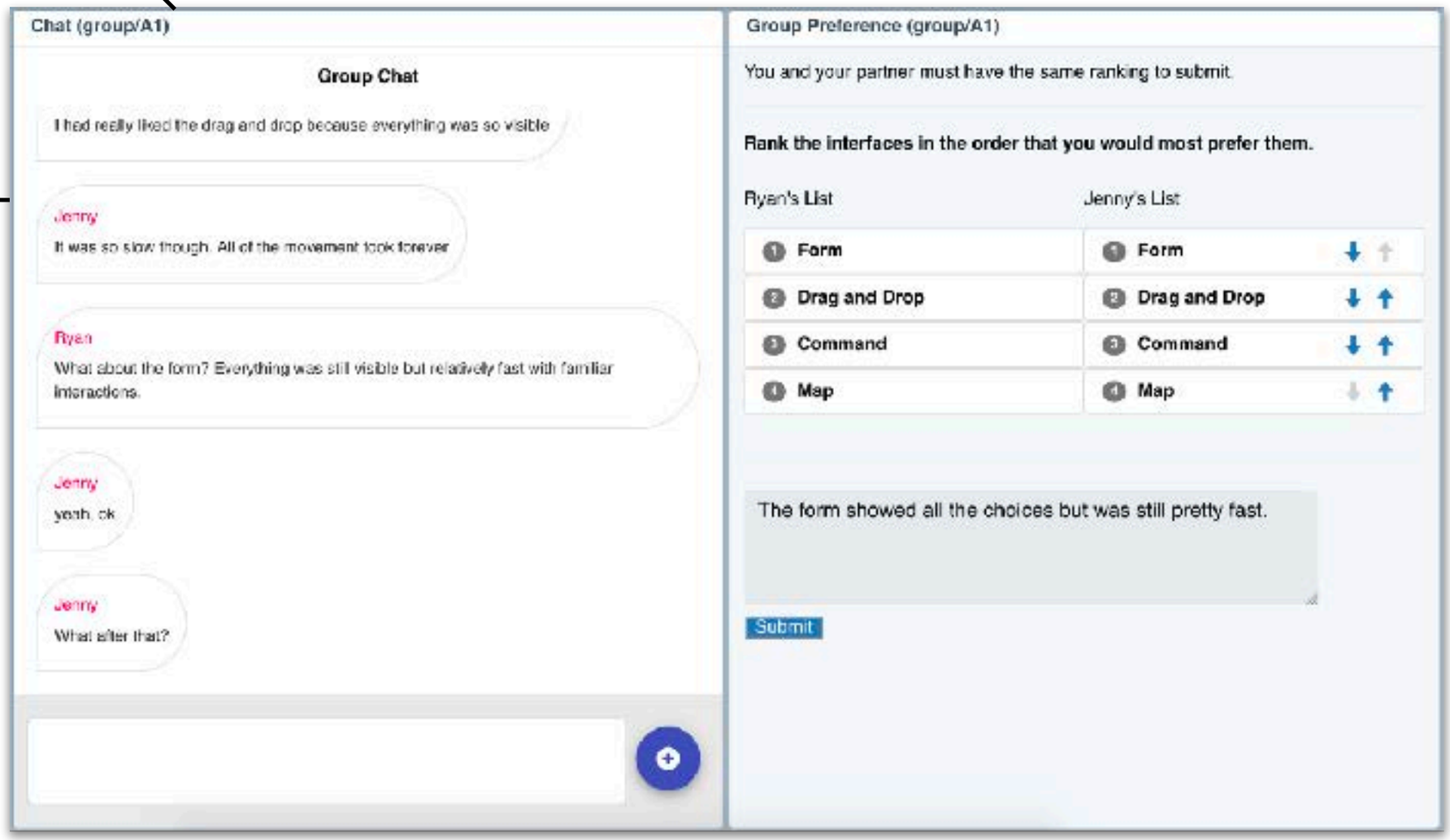
The drag and drop is easiest to see all of the options.

Submit

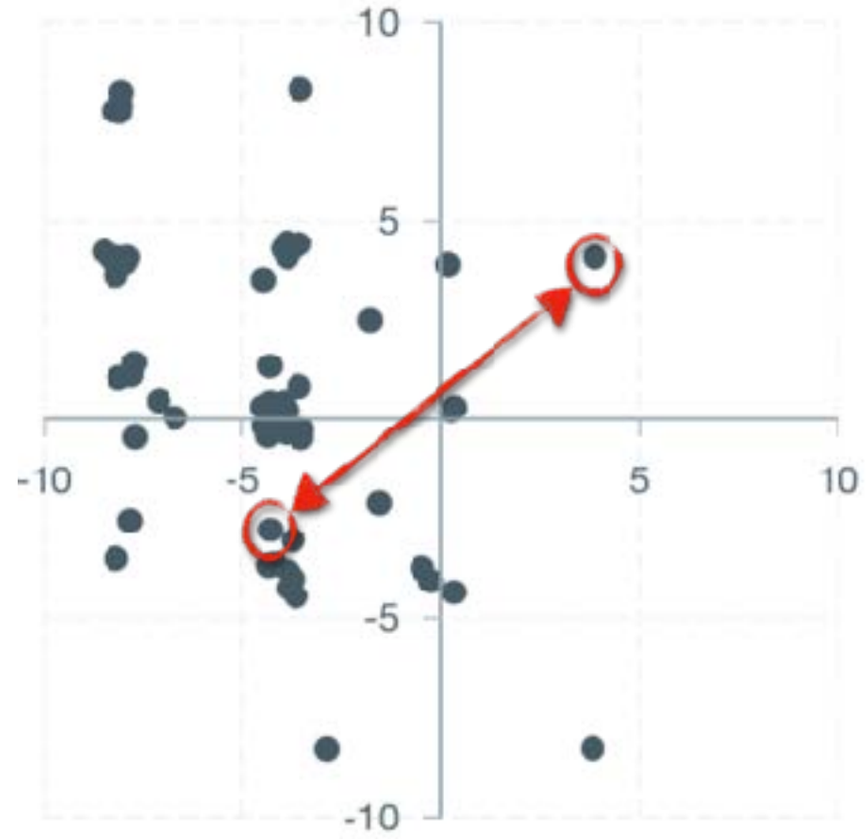
Class

Team

Solo



Socio-cognitive conflict

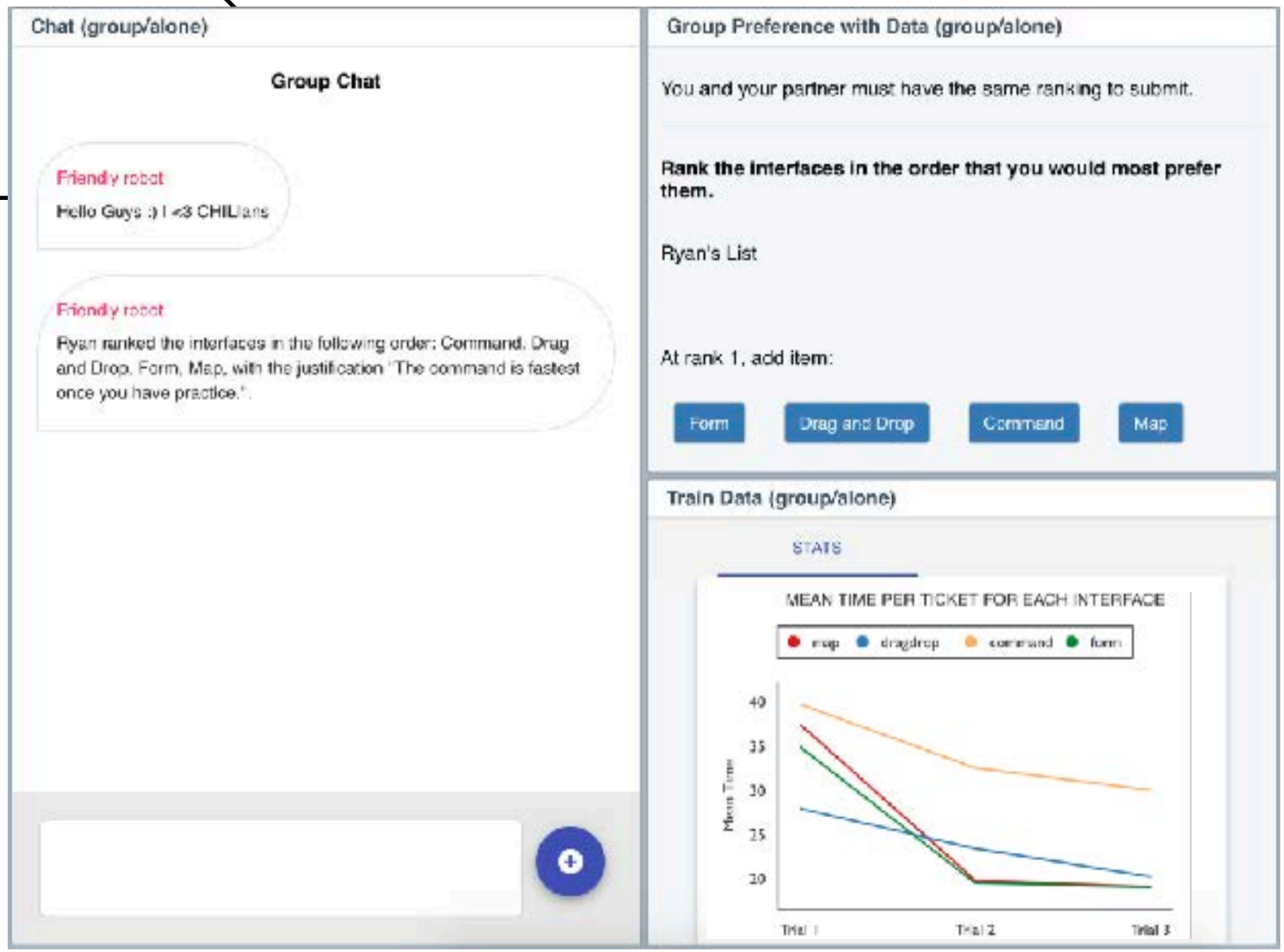

10
5
-10
-5
5
10
-5
-10

Class

Team

Solo

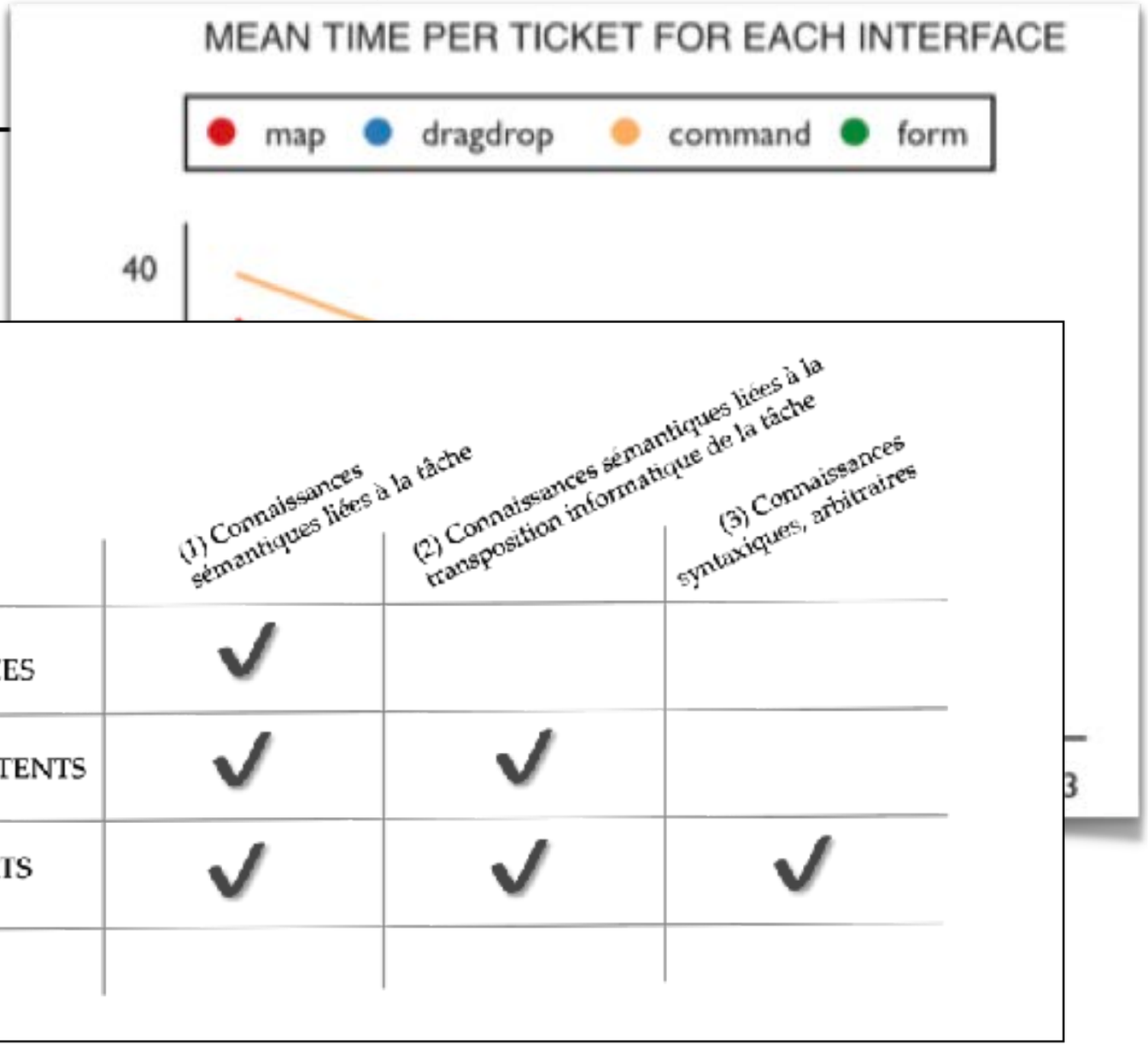
Arguing with data



Class

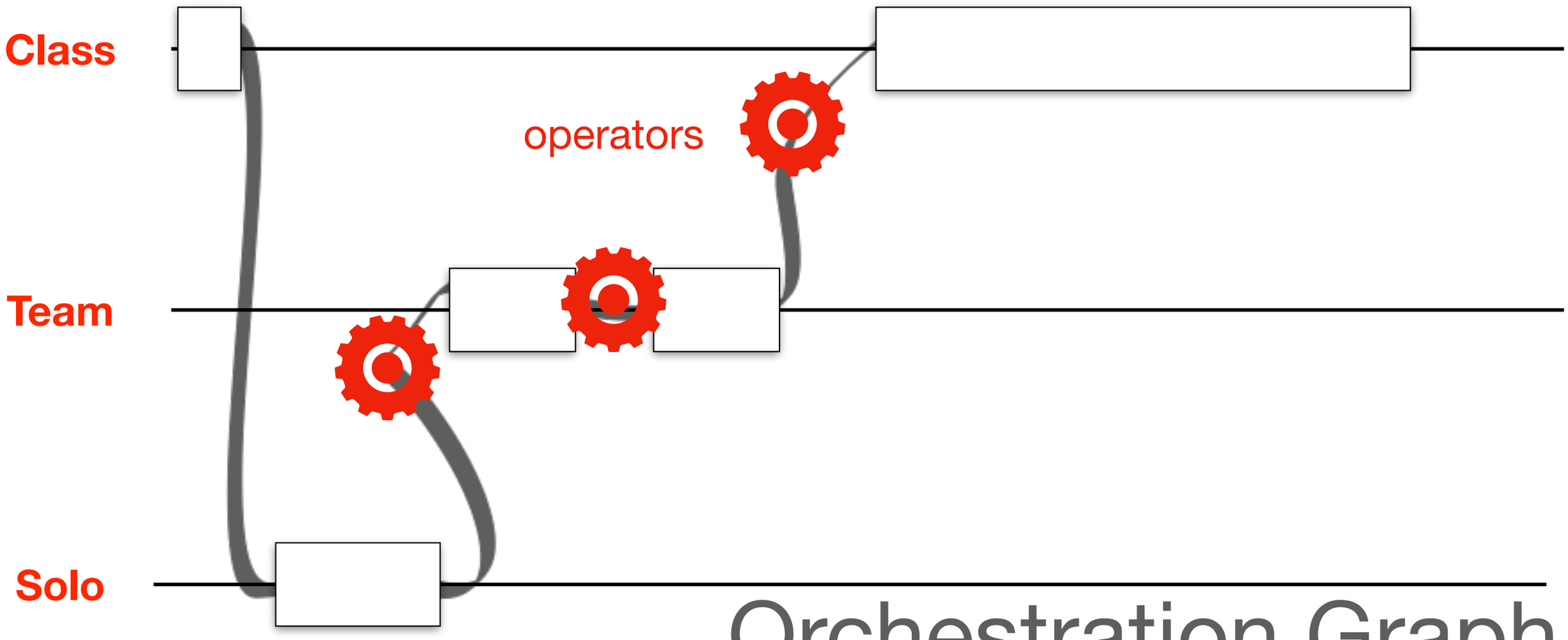
Team

Solo



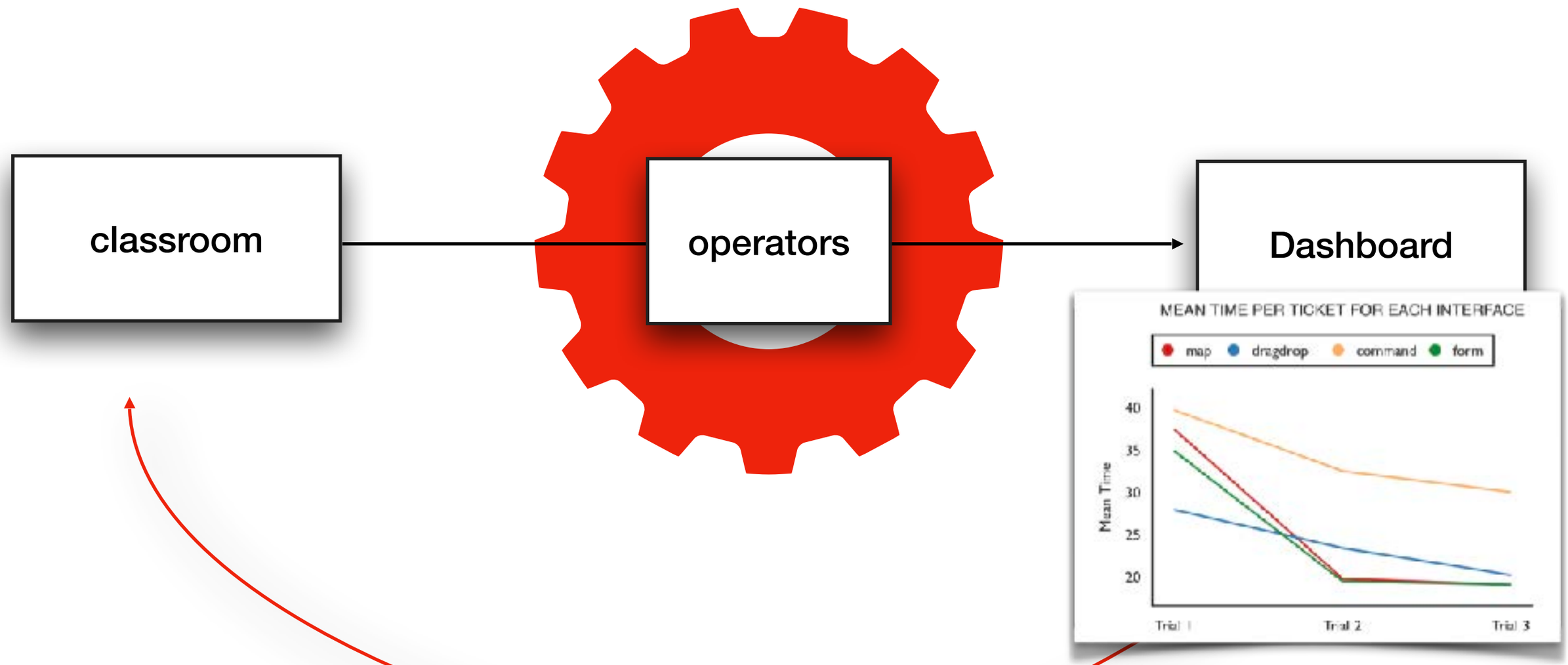
	(1) Connaissances sémantiques liées à la tâche	(2) Connaissances sémantiques liées à la transposition informatique de la tâche	(3) Connaissances syntaxiques, arbitraires
NOVICES	✓		
INTERMITTENTS	✓	✓	
EXPERTS	✓	✓	✓

Debriefing



Orchestration Graph

Aggregation, comparison, visualisation,….

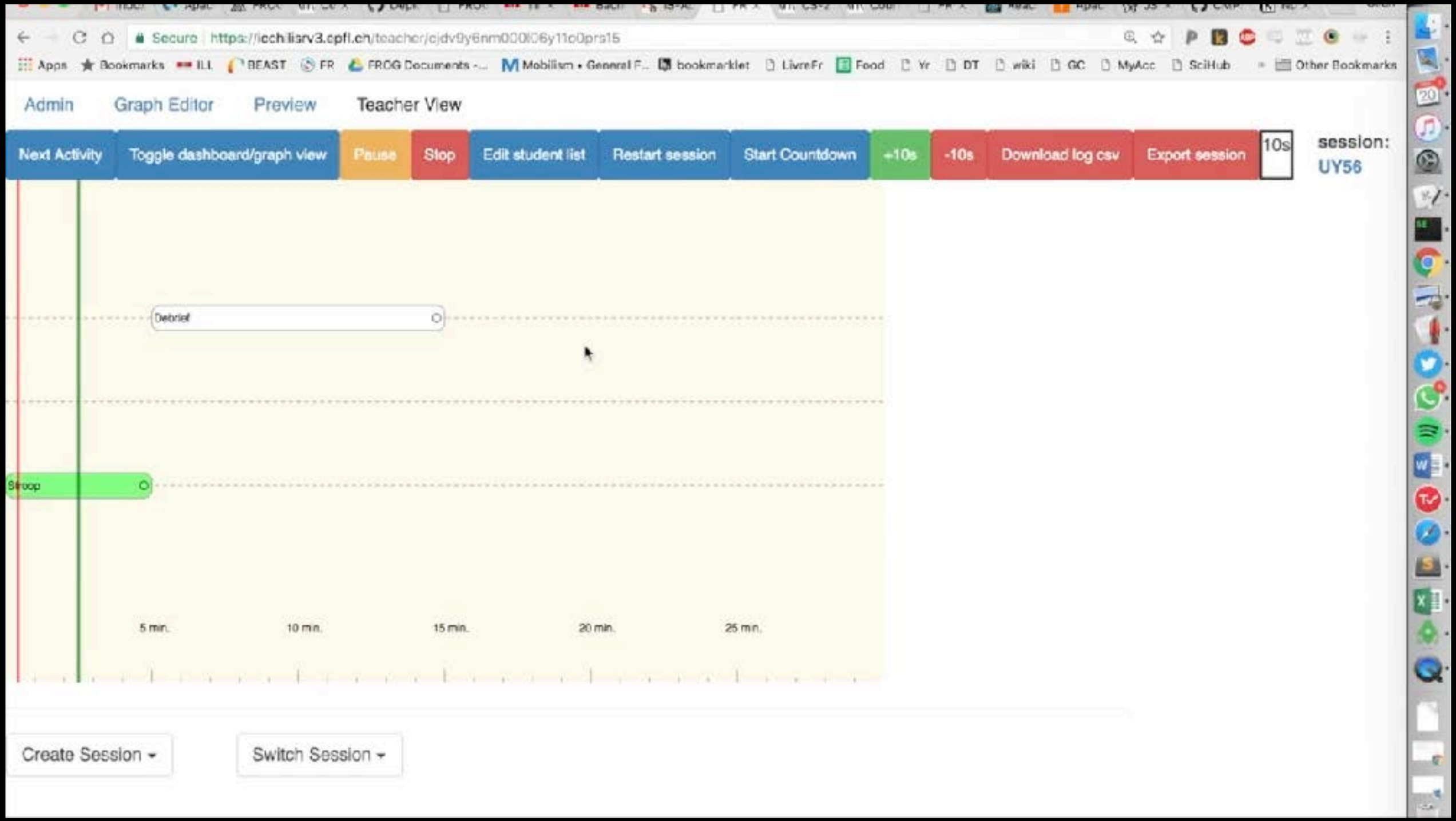


Monitoring

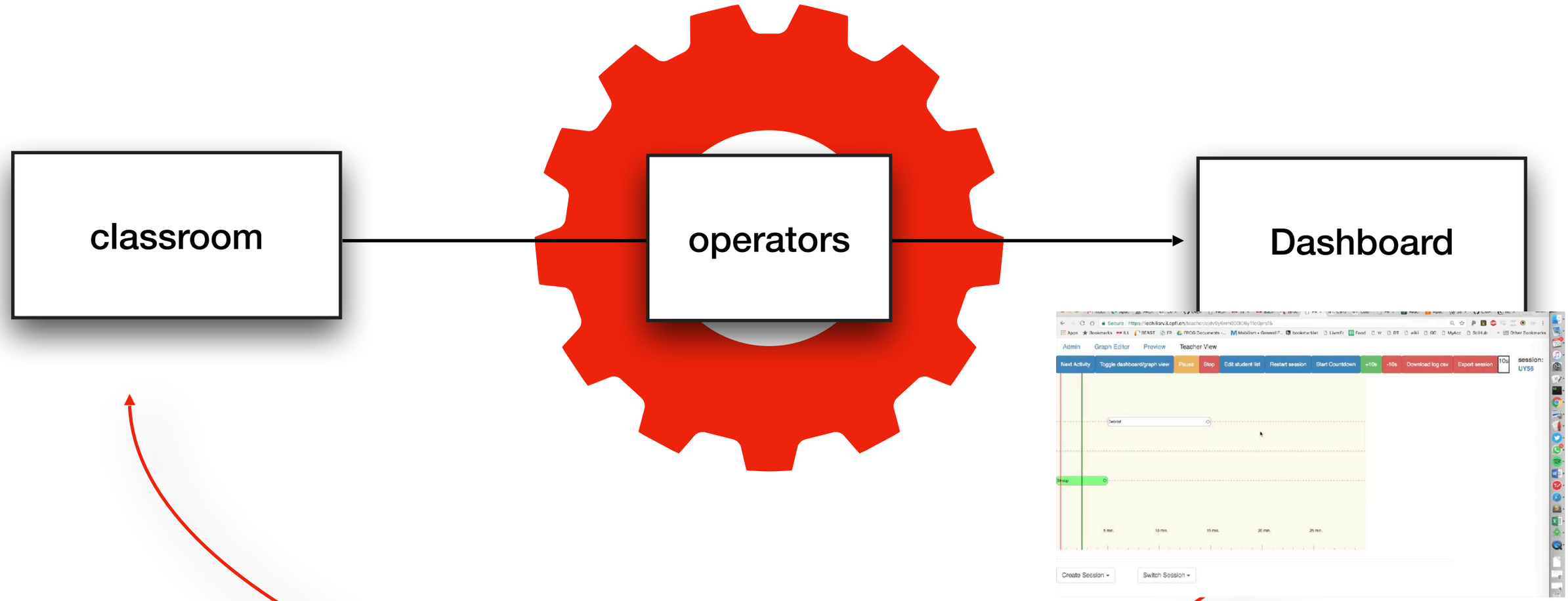
Intervention

+ Debriefing

Timing


Secure https://icchiiarv3.epfl.ch/teacher/cjdv9y6nm000l06y11o0prs15
Apps Bookmarks ILL BEAST FR FROG Documents -... Mobilism • General F... bookmarklet LivreFr Food Yr DT wiki GC MyAcc SciHub Other Bookmarks
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
Stroop
5 min.
10 min.
15 min.
20 min.
25 min.
Create Session
Switch Session

Aggregation, comparison, visualisation,….



Monitoring

Intervention

+ Debriefing

+ Timing

Classroom analytics for smooth classroom orchestration

Monitoring

Intervention

Debriefing

Timing

Chapter 11:
GenAI & Education

1. Learner modeling (for exam)
2. Generative AI (not for exam)
3. Classroom Analytics (not for exam)