Context-Aware Classrooms as Places for an Automated Analysis of Instructional Events

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Introduction

1.1 Pandemic Times: Emergency Remote Instruction

Fast and large-scale implementation of **remote instruction** hindering:

- students **learning** (Pearson 2022)
- students **engagement** (Walker & Koralesky 2021)
- students **mood** (Panadero et al. 2022)
- students **privacy** (Human Rights Watch 2022)

And questions on how to reach a "**new normal**" are now raised

📚 Houlden & Veletsianos 2022

1.2 Are Smart Classrooms a place to start with?

Smart Classrooms, or **Context-aware Classrooms** (CACs), equipped with cameras and mics to record and analyze instructional events can be a place allowing 1. **In presence, blended and distance learning** 2. A **finer analysis** of the instructional variables

But
- **no agreement** on what a CAC is (is a room with an intelligent white board intelligent?)
- a **few comprehensive reviews** exist (see however Kaur et al. 2022)
- **theoretical underpinnings** are seldom explored

1.3 Goals of this Presentation

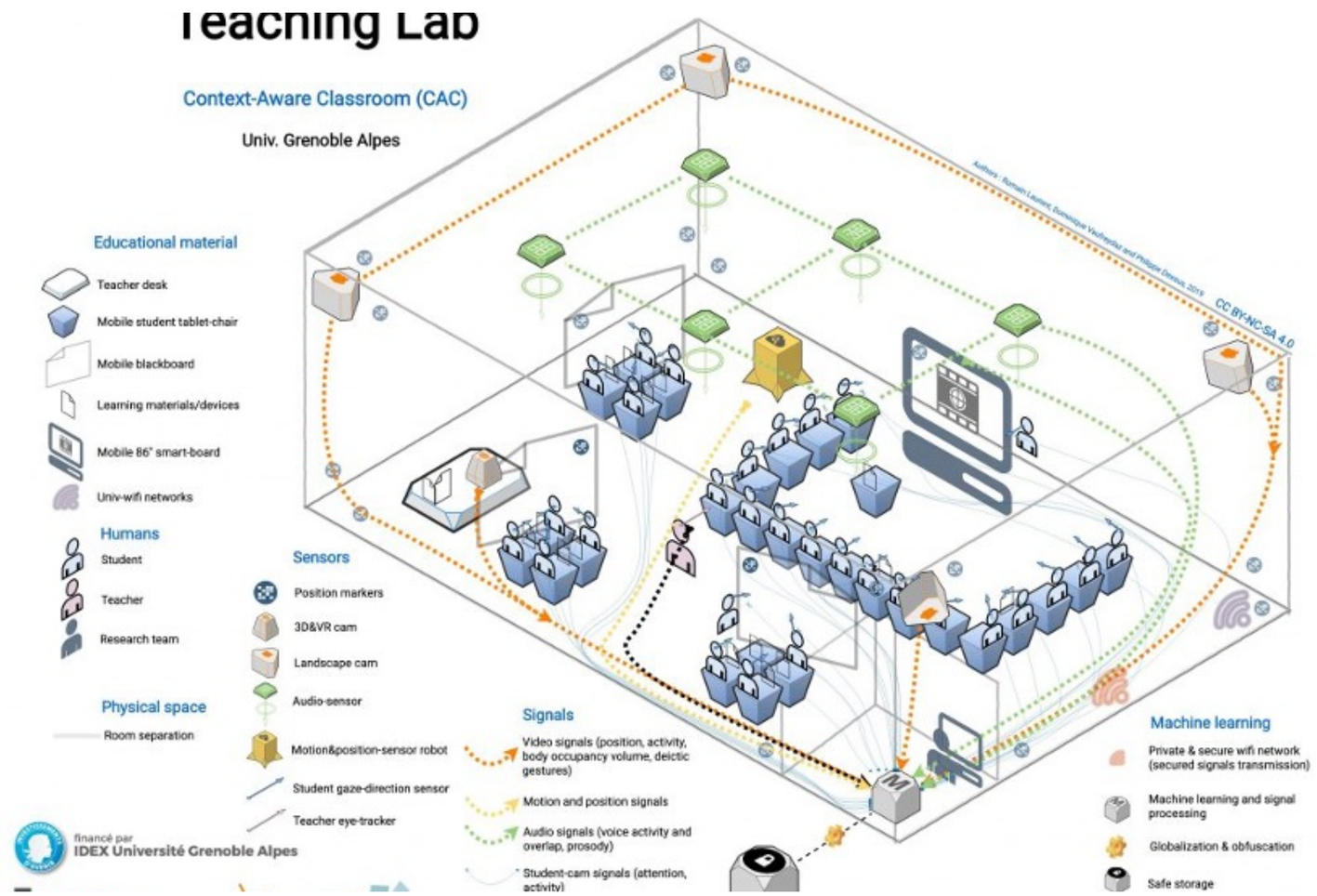
1. In post-pandemic times, what a Context-aware Classroom can help attain a “new normal”
2. What a **Context-aware Classroom** is…
3. … according to 3 main **approaches**…
4. … and what can be their **purposes**…
5. … seeking for which **research questions**?

2 Context-aware Classrooms

2.1 Context-aware Classrooms: a Definition

- any **physical environment** (most often, university rooms)
- in which instructional and learning **events** occur
- ways to **capture and analyze** these events are enabled in
- data capture and analysis are supported by **several digital devices, techniques and tools**: signal analysis and processing techniques, robotics, artificial intelligence, sensors, controllers, and effectors.
- a.k.a. ambient, ubiquitous, adaptive, intelligent, responsive, smart, or pervasive classroom

2.2 Teaching Lab Project, @ Univ. Grenoble Alpes



2.3 Context-aware Classrooms

- “**Meta-device**“, wide range of situations (hybrid, in presence or distant learning)
- to analyze a **large range of event features**: activities, emotions, performance, location, gaze, head direction, body posture, finger pointing…
- The first CACs were aware, **reactive to instructional events**
- More recently they allow the **supervision, monitoring, and assessment** of instructional situations

2.4 Rooms, but with Ears and Eyes!

- CACs have **ears and eyes**
- can “see, hear, record, and analyze“ a wide range of behaviors
  - for **all** students (and for teachers too)
  - at a **high frequency**
  - stored for an **indetermined time**
- ⚠ students can not easily **opt out** to be in the classroom
- ⚠ “**learnerism**” replaces learning and can foster behaviors like lurking or cheating (Macfarlane 2013)

3 Three Theoretical Accounts

3.1 Behavioral Approach

- Classroom = Place where individuals behave and react to stimuli
- **Main argument**: Isolated cues can be pre-determined, captured and automatically analyzed to trigger some classroom reactions (**centralized model**, Dron 2018)
- ⚠ behavior datafication ➡ behavior surveillance & normalization (Manolev et al. 2019)

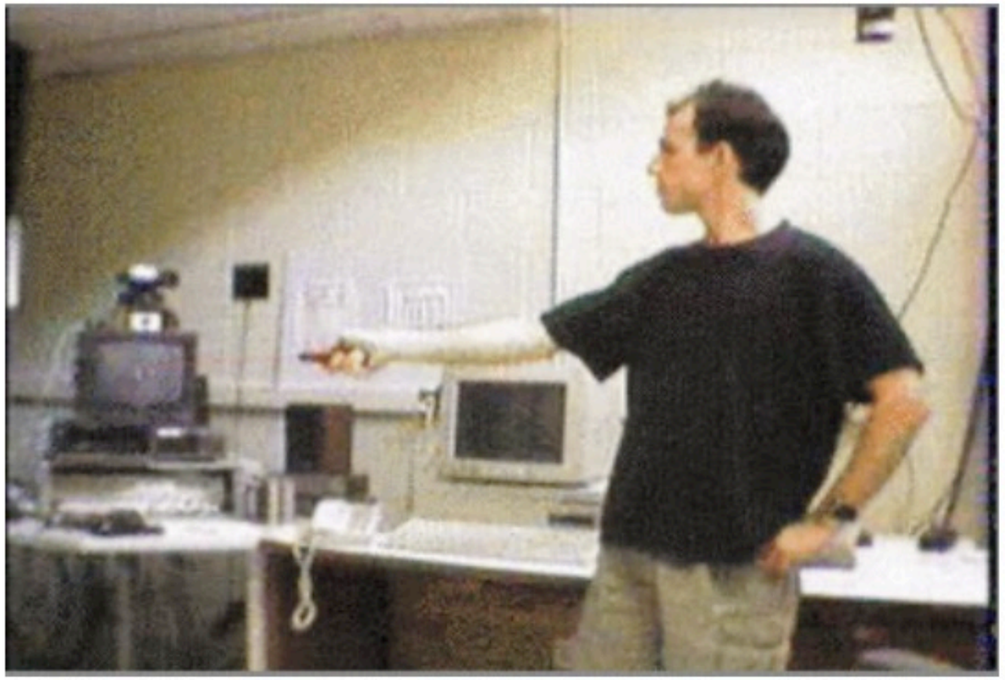
Students

- Positive and negative reinforcements
- Extinction/Punishment (for negative behaviors)

Teacher

- Intention and action recognition based on behaviors

3.3 Reactive Environments (Cooperstock et al. 1997)



The teacher selects a view for a remote student by pointing the laser at a seat

3.4 Ecological Approach

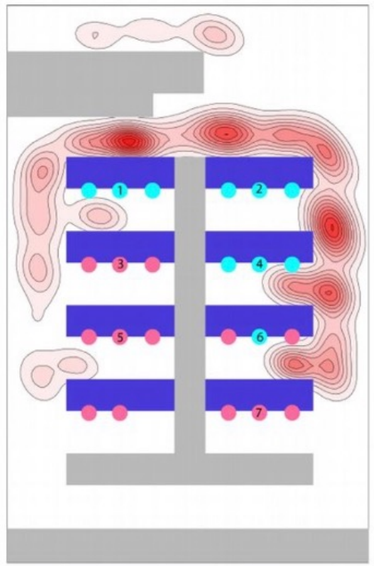
Classroom = environment in which (**distributed model**, Dron 2018):

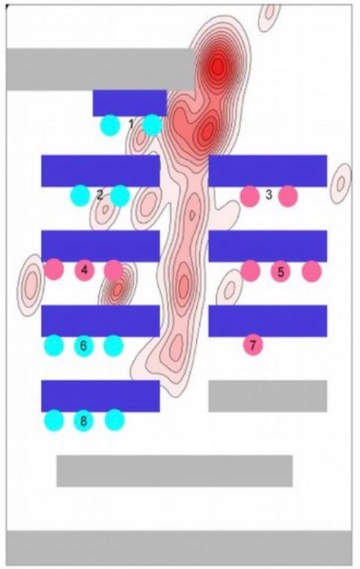
- Individuals are inserted in various **Perception—Action loops** within an environment…
- … likely mediated by devices
- The physical environment guides individuals' behaviors

Main argument: Observational cues are not predetermined and emerge from the interaction

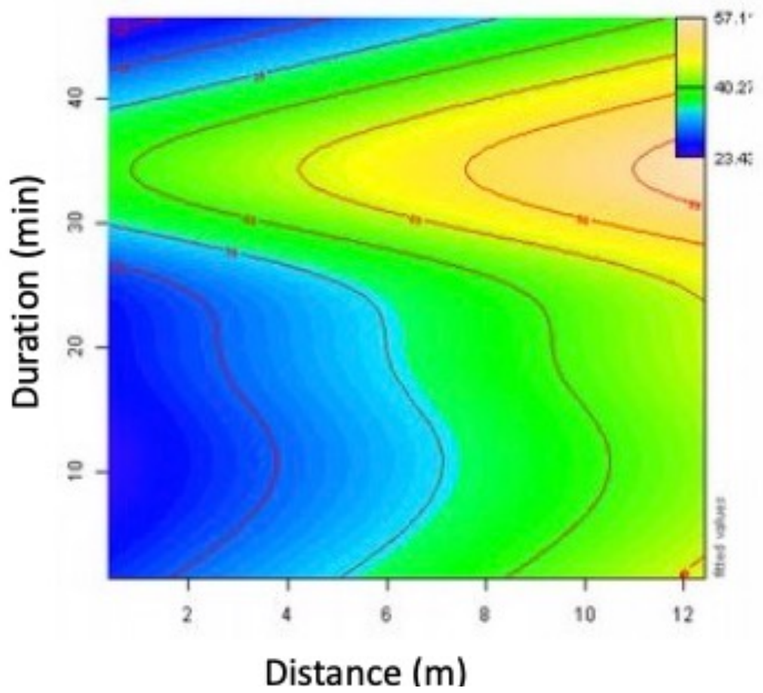
3.6 The Effect of Seats Arrangement in Classrooms (Lermigeaux-Sarrade 2018)

Infrared cameras; the teacher wearing a jacket with infrared spots





3.7 Off-task probability as a function of teacher proximity and time



📚 Lermigeaux-Sarrade, 2018, p. 215

3.8 Enactivist Approach

Classroom = environment in which (**emergent model**, Dron 2018):

- Individuals' experience a first-person view of “being here”
- Perception, cognition, and emotion are intertwined with action

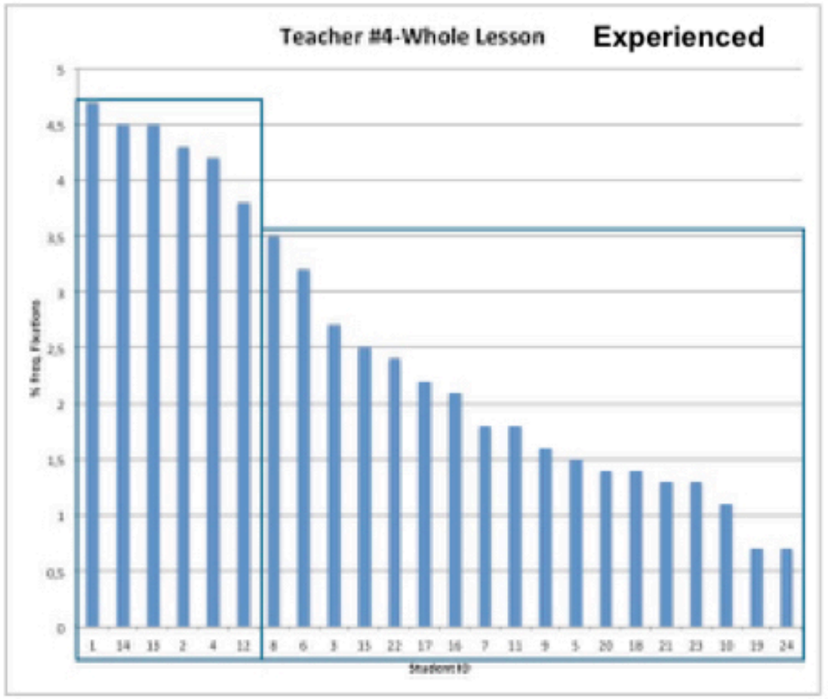
Main argument: What is to be a teacher? a student?

3.10 Novice vs. Expert Teacher's Gaze (1/3)

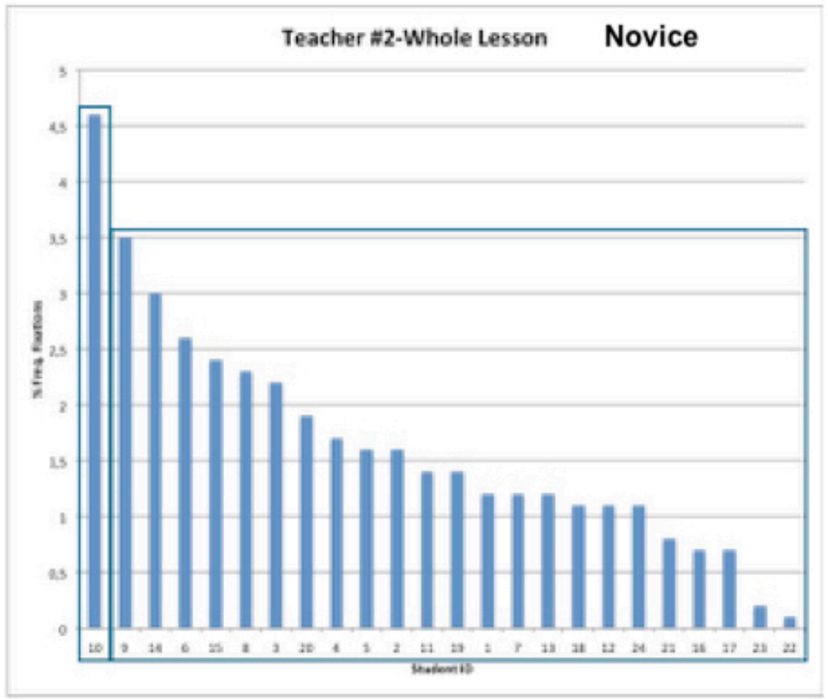
- C**ontext**: 4 elementary teachers (2 novices and 2 experienced) wore mobile eye trackers during maths lessons
- Report of which pupils are **most often gazed**, and which are their profile (in terms of **academic performance and behavior**)

📚 Dessus et al. 2016

3.11 Novice vs. Expert Teacher's % Gaze (2/3) on students

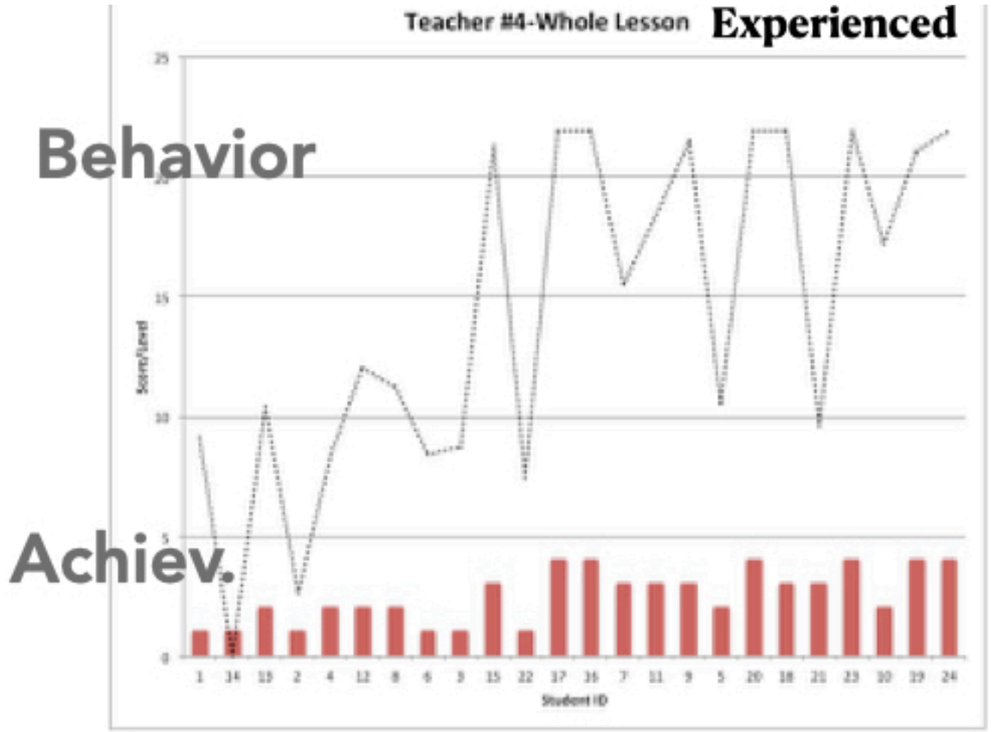


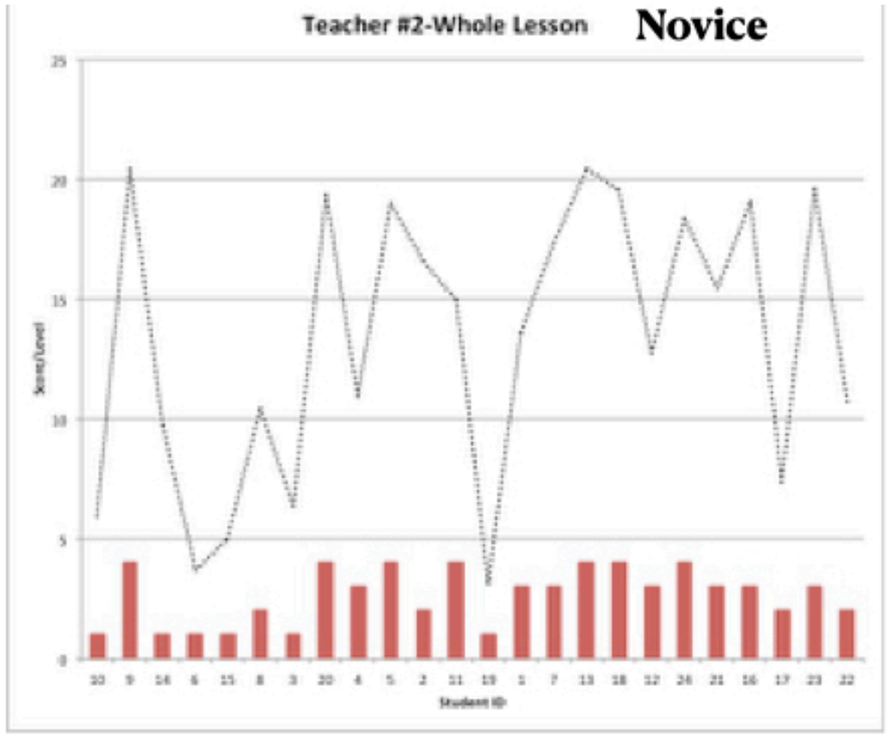
Students' IDs



Students' IDs

3.12 Novice vs. Expert Teacher's % Gaze (3/3) by Student Type





3.13 Towards Automated Classroom Observation

Multimodal Deep Learning models to predict Positive (PC) and Negative Climates (NC) of the **Classroom Assessment Scoring System**

- both image and auditory features are analyzed
- correlations with human scores: PC = .58 ; NC = .66

📚 Pianta et al. 2008; Ramakrishan et al. 2020

4️⃣ What CACs can do for you?

4.1 Behavior-centered CACs: *Demoing*

- Main assumptions:
  - Teachers cannot **pay attention** to all the students' behaviors
  - Some facilities can be embarked to help teachers
  - The classroom “**follows**” attendees' action
- Result:
  - Specific Events trigger CACs **reaction or analysis** (**low frequency**)
- Implementation problem:
  - Unexpected behaviors aren't taken into account

4.2 Ecological CACs: *Monitoring*

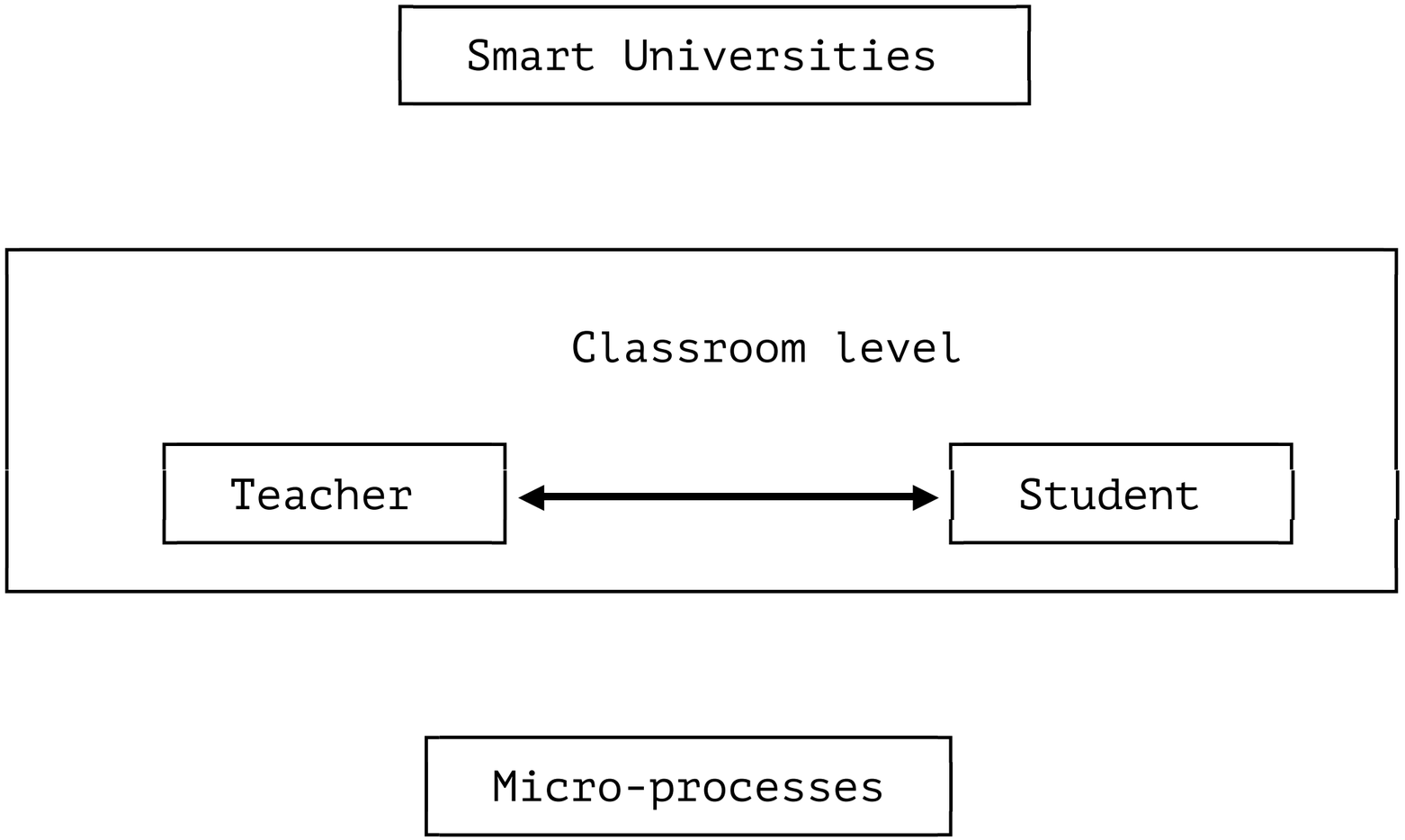
- Main assumptions:
  - Teacher's and students' behaviors are **contingent to each other** within the environment
  - The CAC is **where** attendees' actions take place
- Result:
  - More complex events are analyzed to characterize the attendees' relationships, and compared to humans' coding (**mid frequency**)
- Implementation problem:
  - Scrutinizing every movement = surveillance

4.3 Enactivist CACs: *Assess the Whole (or personal) Picture*

- Main assumptions:
  - Multimodality including physical measures helps analyze attendees 1st person view in classrooms
  - The CAC **is part of** attendee's action
  - Less clear-cut boundaries
- Result:
  - (Parts of) classroom climate can be measured (**high frequency**)
- Implementation problem:
  - **Multimodality** requires a large variety of devices and demanding analyzes

5️⃣ Some Research Questions

5.1 Global View



5.2 A step closer: How to (not) Capture Students' Inner World?

- So far, automated recognition of students' engagement, interest, emotions (inner states):
  - **is far below human's performance** (Dupré et al. 2020), but CAC-captured context can help in this recognition, Feldman Barrett 2017)
  - doesn't account for the question of **gaming, or cheating** (very difficult to automatically detect, see the problems with proctoring, Burgess et al. 2022)
- In the domain of written assessment, teachers have **to adapt themselves to students' practices** (i.e., the use generative deep learning like GPT-3) (Sharples 2022)

5.3 A Step Higher: How to Scale CACs up?

- **CACs aren't Russian dolls**: a university cannot be smart in the sense a classroom does, at least because far more complex social processes are at stake (territoriality, crowding, see Gifford et al. 2011)
- Even weather can be considered as personal data (Purtova 2018) because weather is “datified” and, when crossed with other (more) personal data (sound sensors, WiFi signatures), **weather can be used to identify persons** (information in purpose)
- Classroom-level data ➡ owned by teachers/students ; university-level data ➡ owned by university

5.4 A Step towards Teachers

CACs can be used to

- arrange flexible places for **hybrid teaching sessions**
- assess the effect of **specific space arrangement** on students' achievement
- more objectively study **old concepts in teacher cognition** (i.e., steering group, Kounin 1970)
- propose **classroom videos** for professional development purposes

5.5 A Step towards Students

CAC data capture and analysis are **hidden to students**, and even if visible, not understandable

- **Acceptability** of CACs to students (and to teachers as well, see Cojean & Martin 2022)?
- **Explainability** of machine learning processes?
- Develop **role play sessions** to help them understand (pretend this room is equipped of cams… what would it change in your behavior?; why?)

5.6 Wait a minute! How to use Processing Power for Privacy Purposes?

5.7 Deep Learning to Obfuscate Videos

- A recent research path is to use the processing power to **obfuscate images and sound** and then delete the source information
- **Don't store personal data**: Extract locations (see Slides #3.6 & #3.7), and use deep learning to generate skeletons, head directions arrows, and general “mood”

📚 Ajuha et al. 2019; DALL-E mini ; Petrova et al. 2020

5.8 Pedagogy vs. Technology in CACs?

- Developing CACs without reflecting on their pedagogical use is pointless
- Pedagogy and technology are entangled, **no one “drives“ the other** (Fawns 2022)
  - neither technology nor pedagogy comes first
  - new tools require teachers to rethink teaching

6 Discussion

6.1 Recap

- CACs are commonly used at **behavioral** and **ecological** levels
- **Enactivist** CACs (will) allow multimodal and high-frequency measures of classroom climate
- CACs allow to **explore ethics and limits of AI**, and people have to adapt their practice to this new “meta-device” (Sharples 2022)
- However, so far, **no effect** of CAC **on learning** has been proven (Kwet & Prinsloo 2020)

6.2 Some Ethical Principles

1. There is **no value-free** CAC
2. **No metrics** captures the classroom climate as a whole, so don't marginalize what cannot be automatically captured and measured
3. **Respect** for persons (treating them as autonomous and respecting their wishes)
4. **Beneficence** (the benefits outweigh the risks)
5. **Justice** (compensation for less abled or minority attendees)
6. **Transparency** (explain research goals, methods and results)

📚 Salganik 2018

6.3 A CAC Research Manifesto

1. **Anonymize** (obfuscate) data as soon as possible (but not too soon because info is lost) throughout the workflow
2. **Globalize** the representation of individual behaviors at a classroom level
3. Provide **delayed feedback** instead of on-line to avoid supervision effects and cognitive load
4. Use CACs for **empowering teachers**, not for taking high-stake decisions

📚 Laurent et al. 2020

6.4 Which “New Normal” to Build?

- Account for more **ecologically-sound places** that allow various instructional situations
- Allow more **flexible devices** to develop blended learning sessions
- Develop more **context-aware** software to help students learn
- Allow **in-depth teachers’ reflection** on their practice (what's like to be a teacher?)

6.5 Thanks for your Attention! Questions?

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- **Slides**: download here: http://pdessus.fr/talk/slerd-22.pdf
- See also my chapter in the SLERD'22 Conf. proceedings
- **Thanks to** Olivier Cosnefroy, Romain Laurent, Vanda Luengo, Anastasia Petrova, and Dominique Vaufreydaz for co-authoring research cited in this presentation
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- 📚 **References** at the end of the presentation

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