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The Multimodal Matrix as a Quantitative Ethnography Methodology

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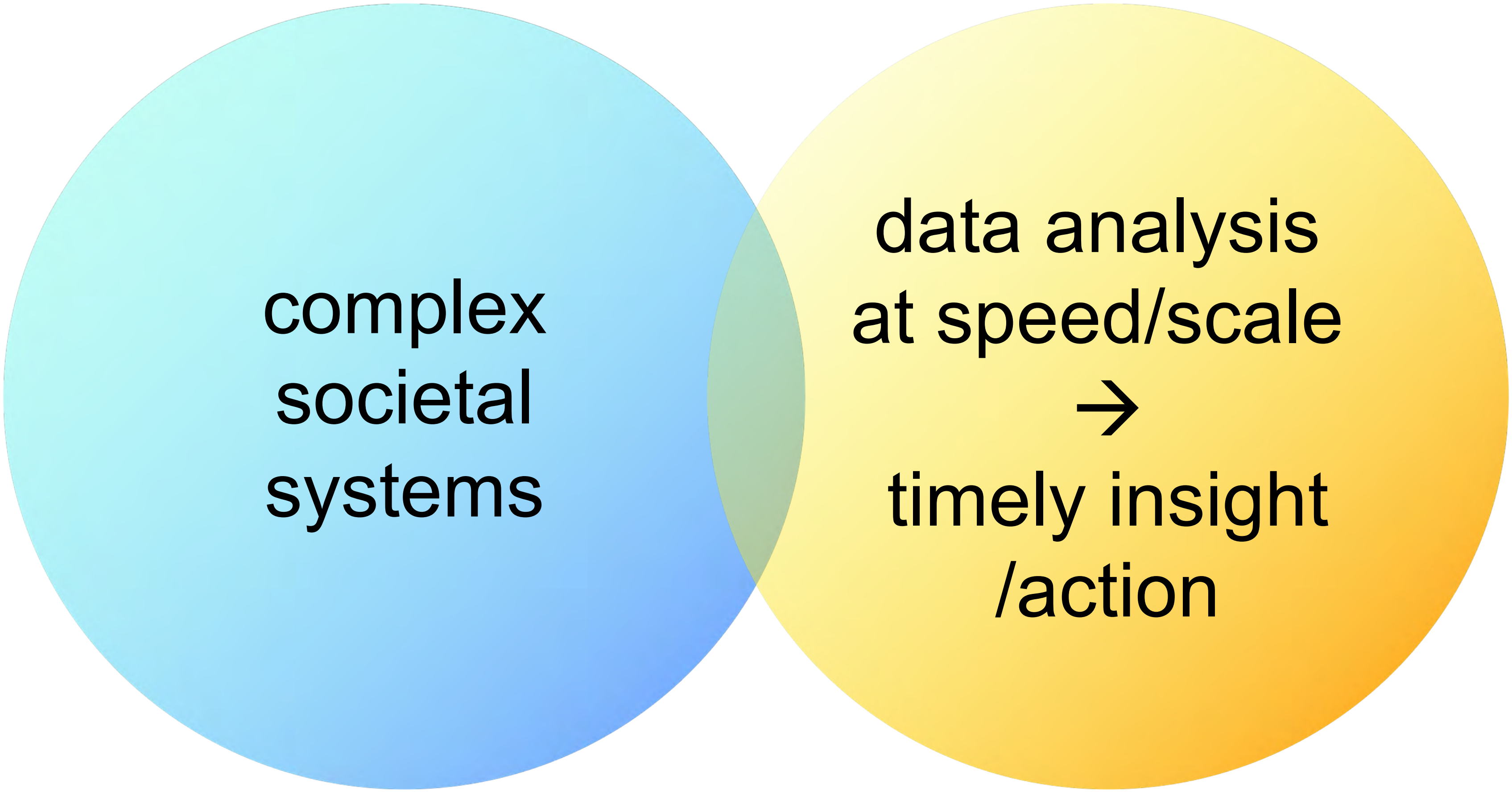
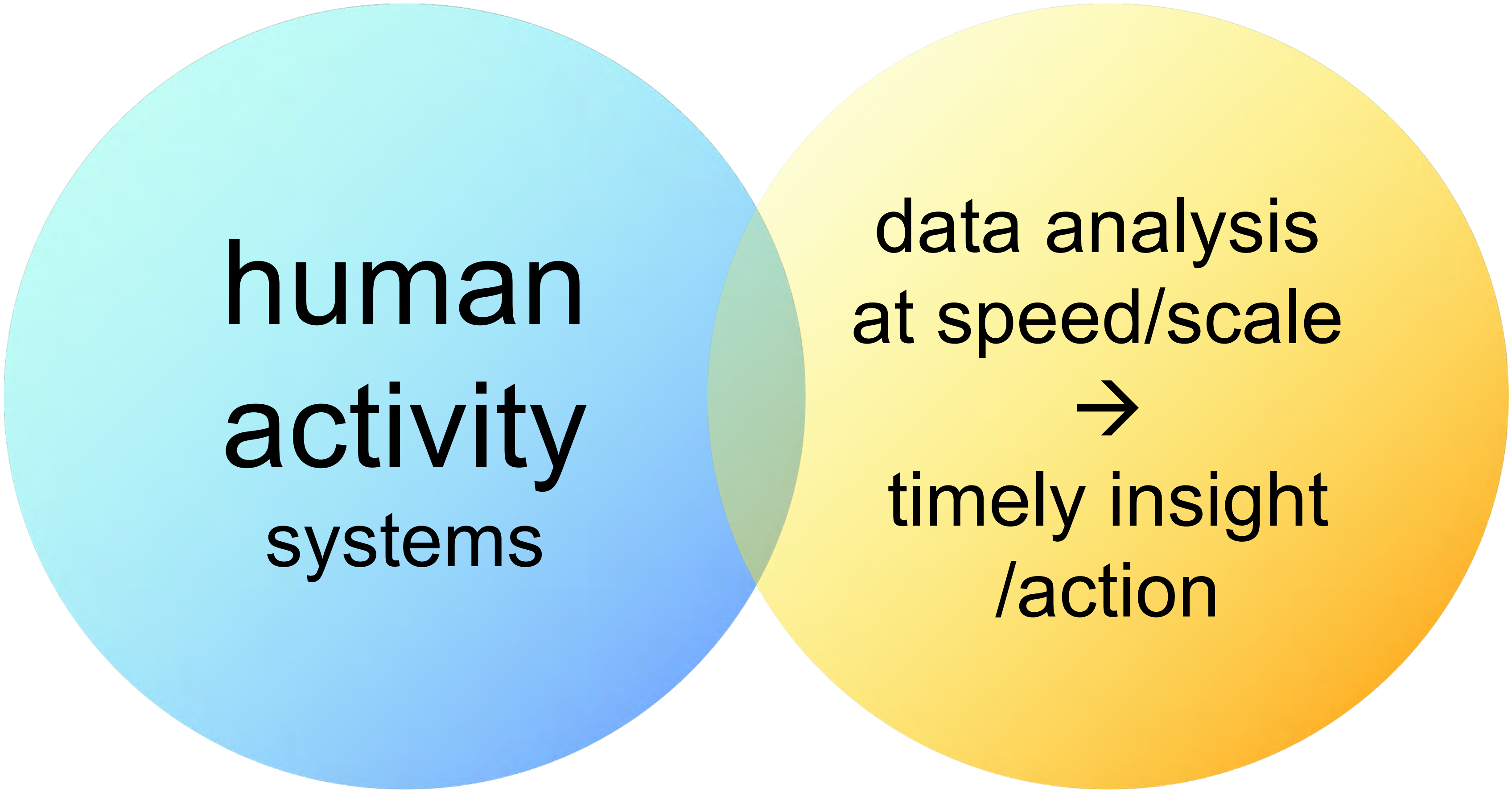
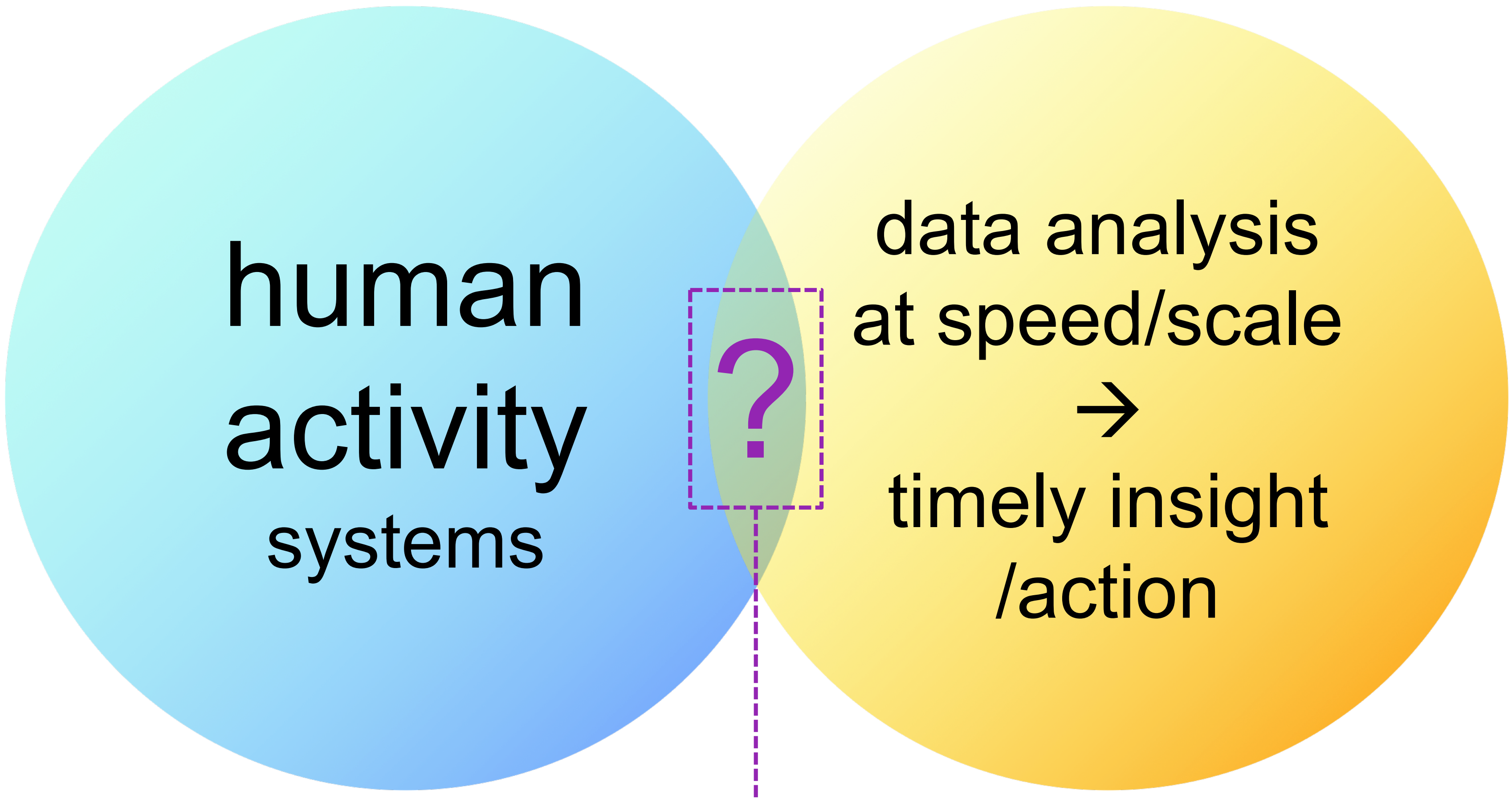
The promise of “Big Data”…



The particular systems we're all interested in…

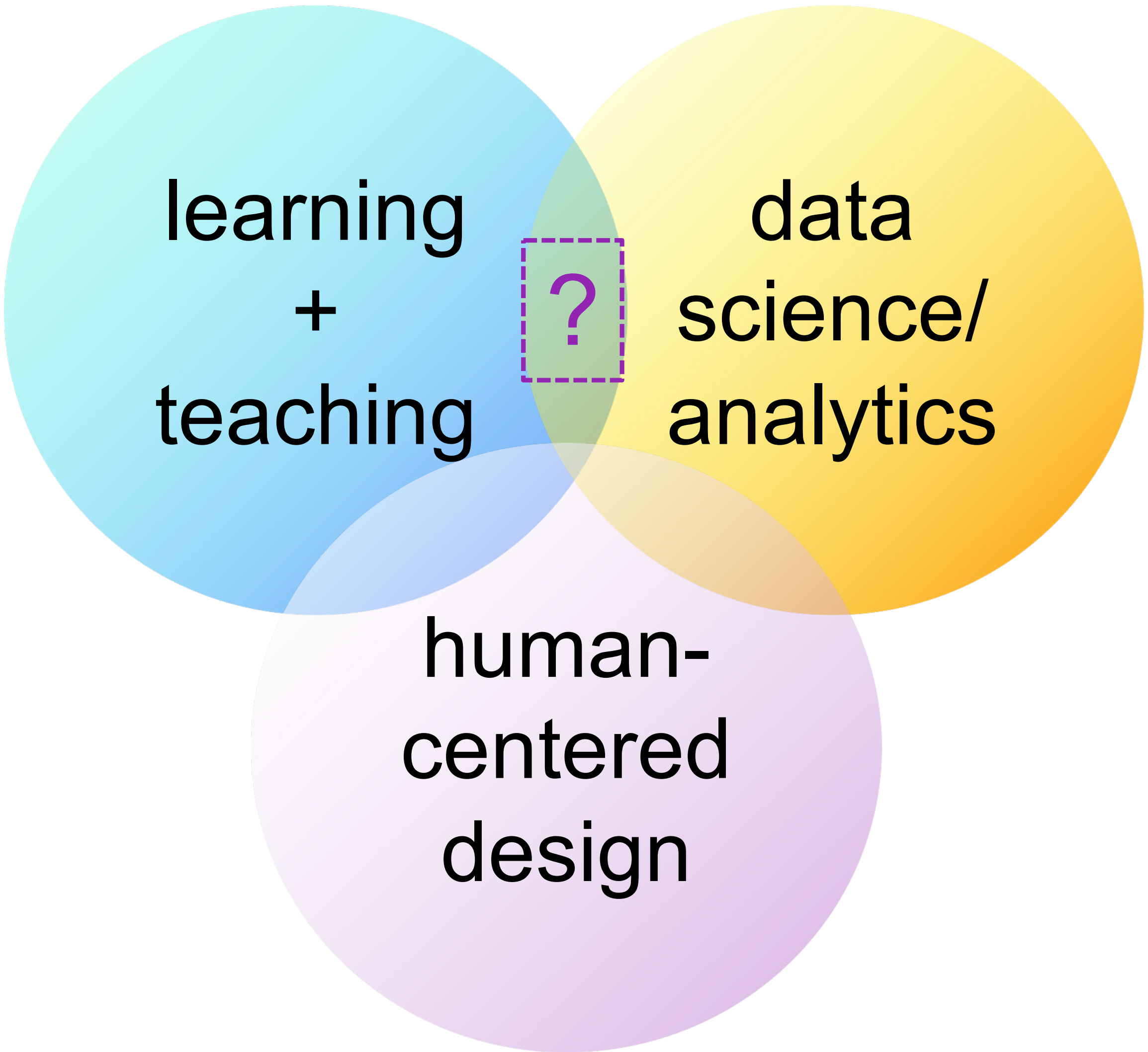


→ Raising the key methodological challenge…

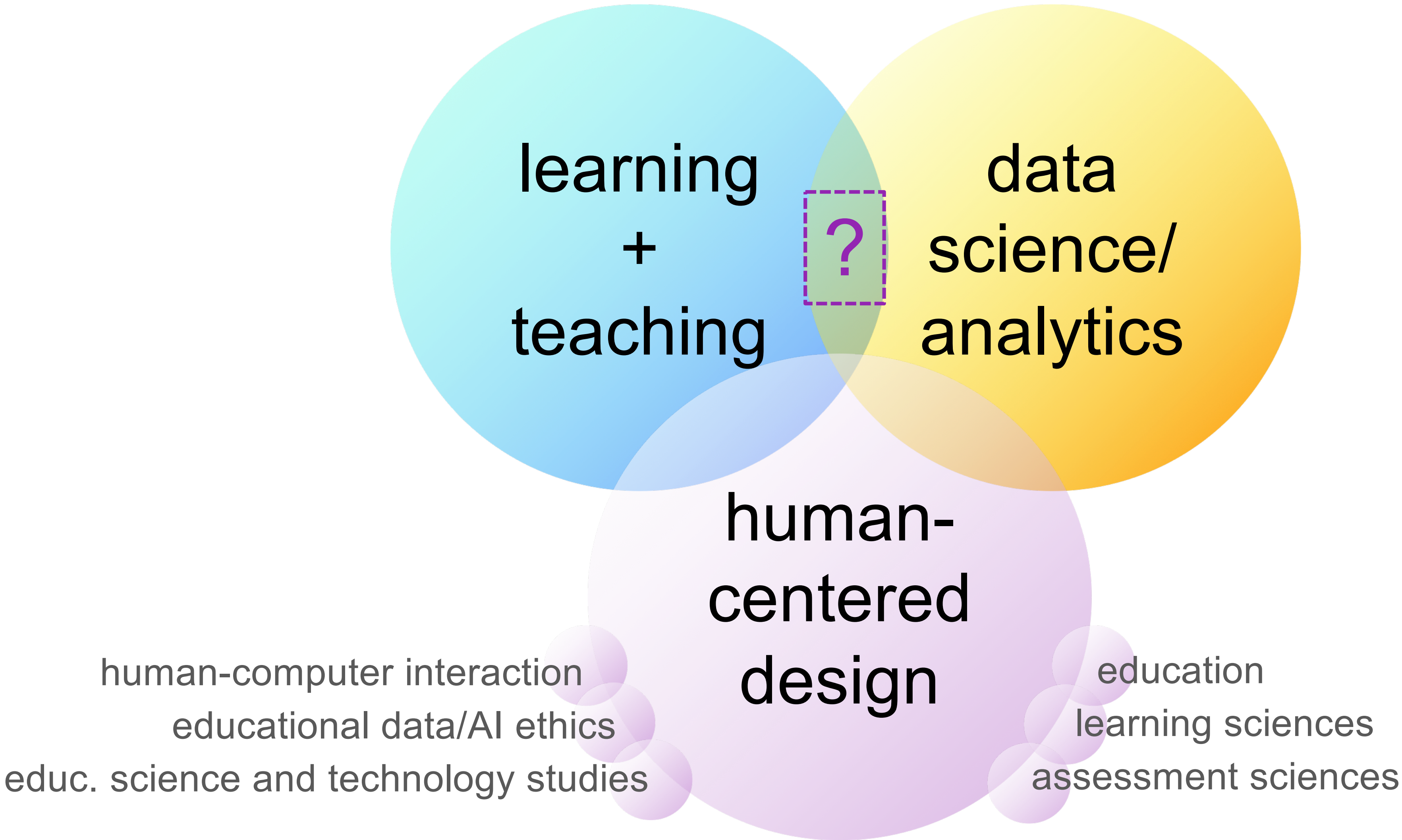


How to handle this intersection with integrity?

→ The particular context in which we're working…



→ The particular context in which we're working…



Training nurses to work respond as a team to a critical change in a patient's condition

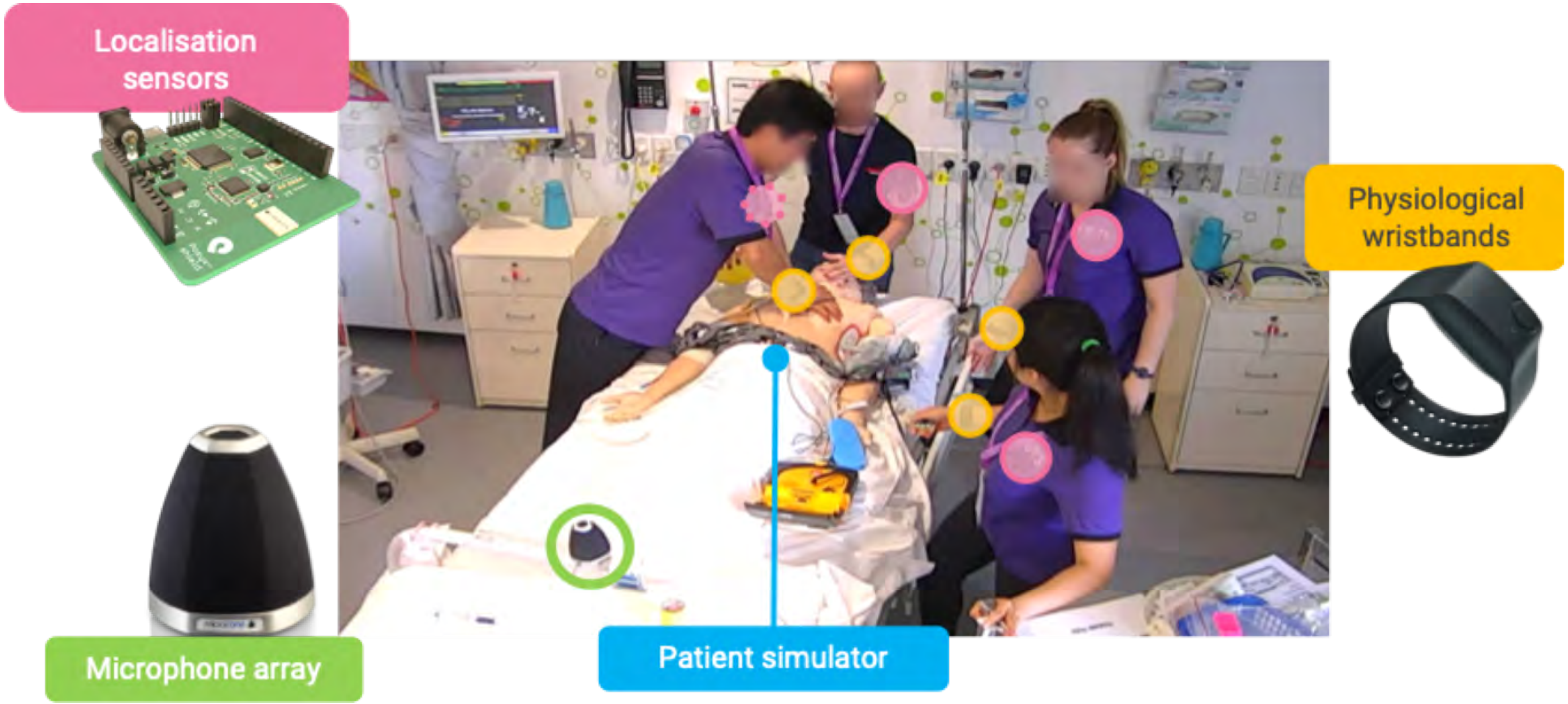
Simulation wards are used widely in universities and hospitals

At UTS, 5-6 teams in action at once

1 instructor coordinating

Intuition: scope to augment feedback to teachers and students using multimodal sensors and analytics?

While capturing collocated teamwork is certainly an **interesting multimodal analytics opportunity**…



…the multimodal data deluge begs the question:

how to make sense of this, and in close to real time?

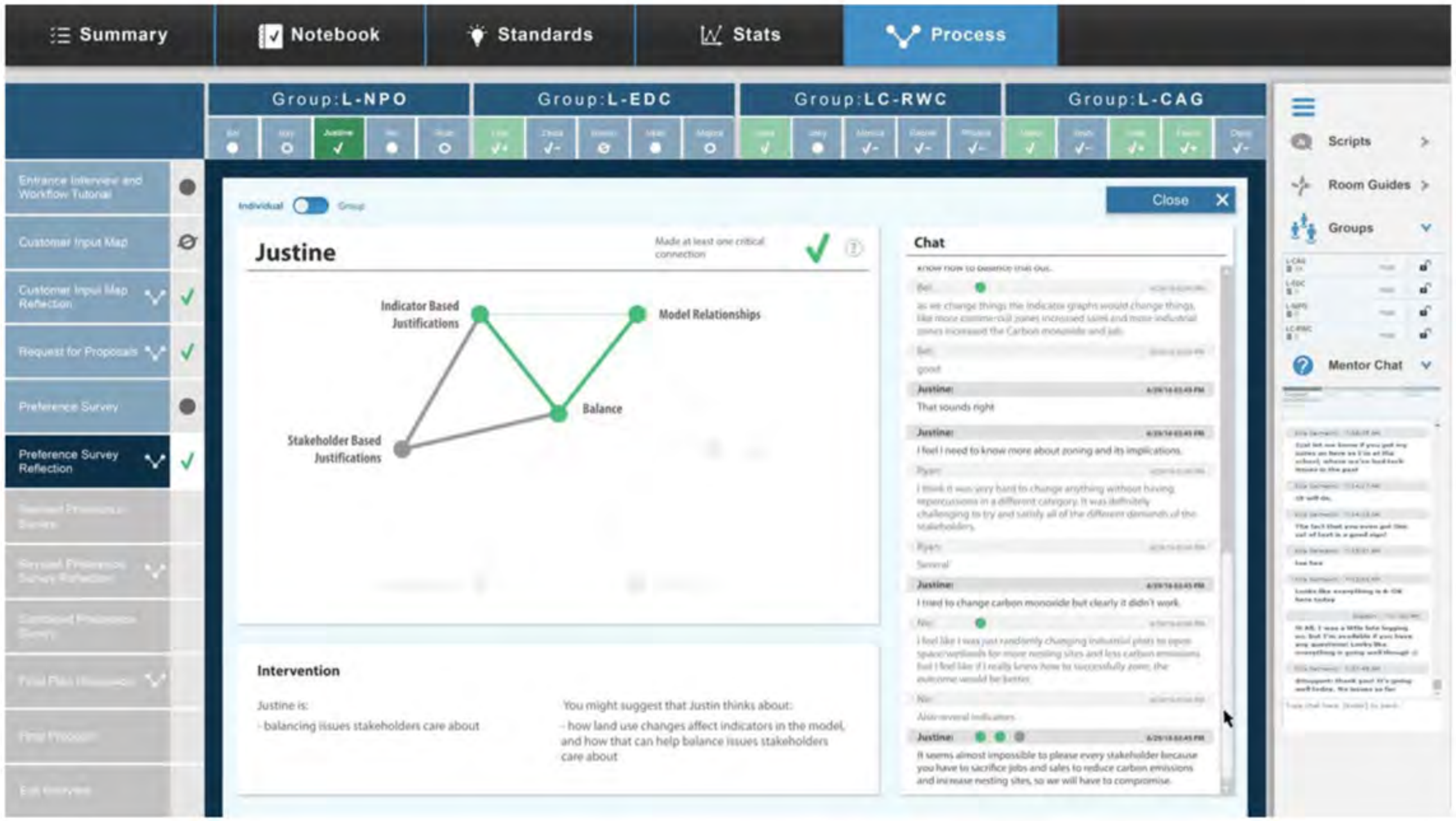
What contributions can Q.E. make?

“Meaningful Feedback”

Can this work make contributions back to Q.E.?

Real-time ENA for teachers from online teamwork is possible.

QE-enabled feedback for collocated teamwork?



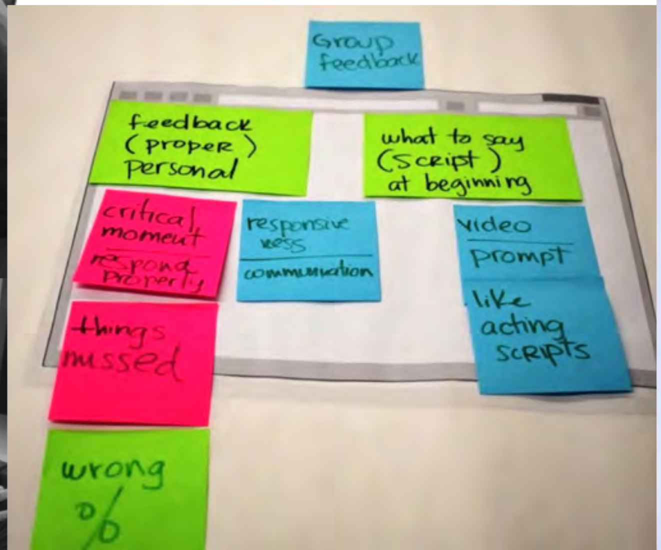
Herder, T. *et al.* (2018). Supporting teachers' interventions in students' virtual collaboration using a network based model. In *LAK'18: International Conference on Learning Analytics and Knowledge,* March 7–9, 2018, Sydney, NSW, Australia. ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3170358.3170394

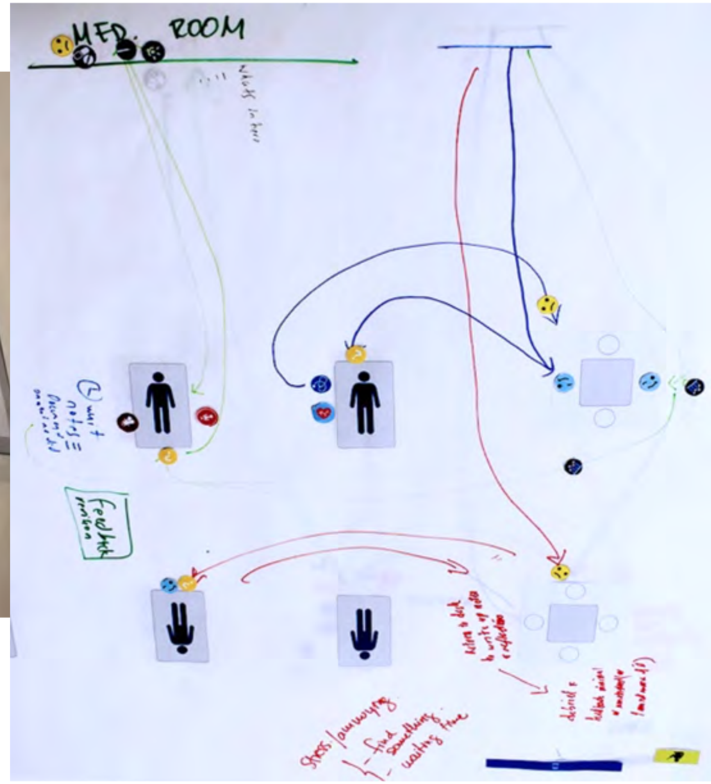
Understanding the human activity system

- Conceptual insights from CSCL
- Conceptual insights from assessment research
- Observation of simulations as they currently run
- Educator interviews
- Co-design sessions with educators and students

Co-design techniques to elicit student and educator perspectives

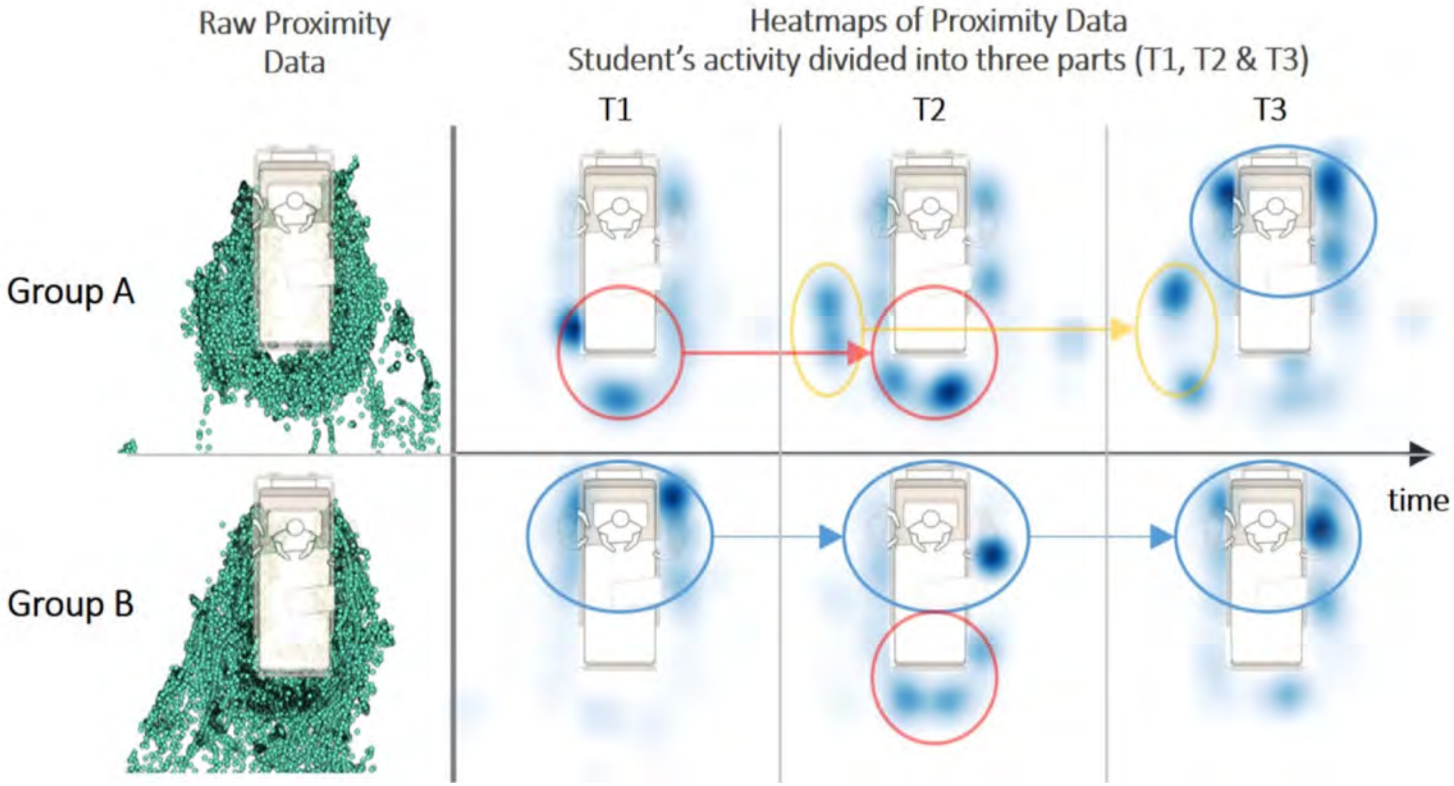
(e.g. “Teacher Superpowers”, and “Learning/Data Journey mapping” *)





* Prieto-Alvarez, C. G., Anderson, T., Martinez-Maldonado, R., and Buckingham Shum, S. (2018). Mapping Learner/Data Journeys: Evolution of a Visual Co-Design Tool. *Proc. Australian Conference on Human-Computer Interaction*, Melbourne, (ACM, NY), pp.205-214. https://doi.org/10.1145/3292147.3292168

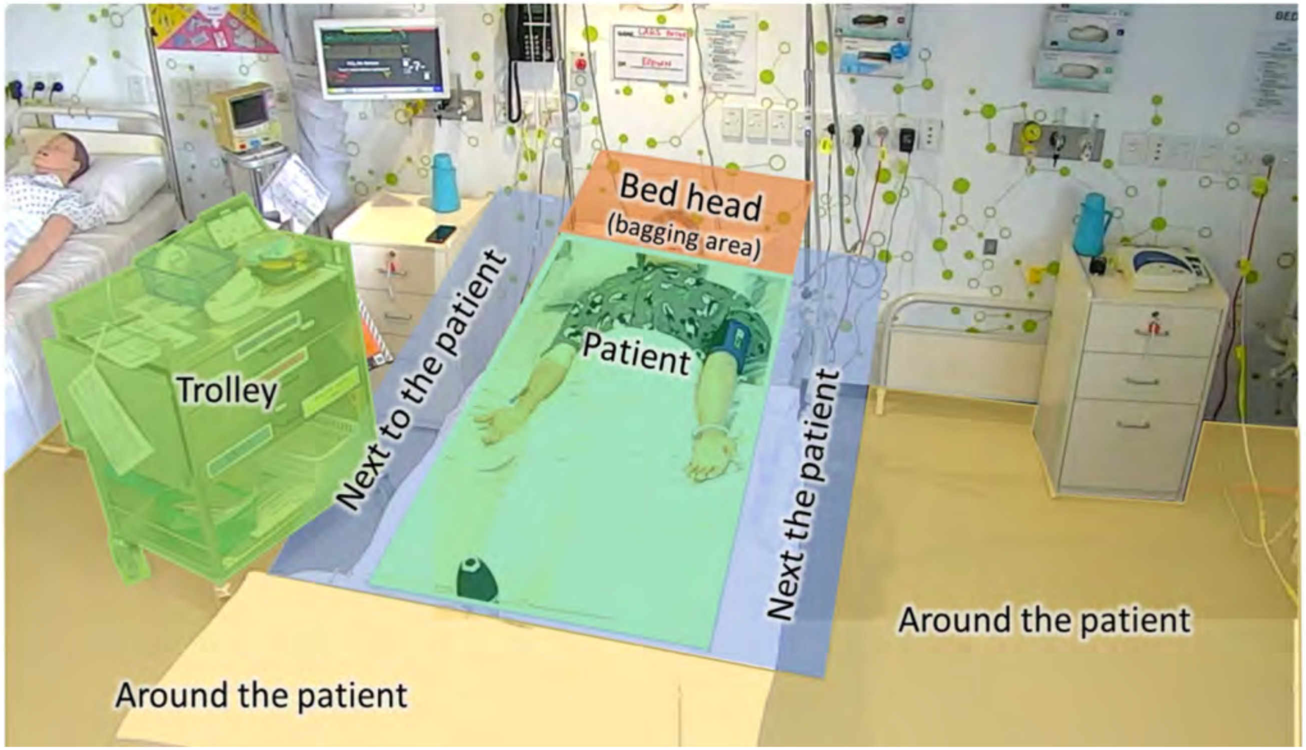
Starting from raw positional data of nurses' movements → temporally segmented heatmaps → …



Martinez-Maldonado, R., Yacef, K., Santos, A., Buckingham Shum, S., Echeverria, V., Santos, O. C., and Pechenizkiy, M. (2017) Towards Proximity Tracking and Sensemaking for Supporting Teamwork and Learning. *IEEE International Conference on Advanced Learning Technologies, ICALT 2017, 89-91.*

→ Understanding meaningful zones (= qualitative Codes)

Consultation with nursing educators clarified that there are 5 meaningful zones for nurses to understand (in these simulations)



i) the patient's bed for cases where nurses are located on top of or very close to the patient

ii) next to patient for cases where nurses are either side of bed

iii) around the patient for cases where nurses are 1.5 to 3 metres away

iv) bed head where nurses commonly stand to clear the airway during CPR

v) trolley area where nurses access medication or equipment

Theoretical lens: key features of collocated collaboration

ACAD: Activity-Centred Analysis & Design framework

- The SET — physical and digital space and objects; input devices, screens, software, material tools, furniture
- The EPISTEMIC TASKS — implicit and explicit knowledge oriented elements that shape the participants' tasks and working methods
- The SOCIAL SITUATION — the variety of ways in which people might be grouped together (e.g. dyads, trios); scripted or emerging roles; and divisions of labour
- AFFECTIVE RESPONSES — an extension to ACAD, building on evidence from healthcare simulation research

Martinez-Maldonado, R., Goodyear, P., Kay, J., Thompson, K., and Carvalho, L. (2016) An Actionable Approach to Understand Group Experience in Complex, Multi-surface Spaces. *SIGCHI Conference: Human Factors in Computing Systems, CHI 2016, 2062-2074.* https://doi.org/10.1145/2858036.2858213

From multimodal logs (data) → higher-order constructs (codes) as proxies → meaningful feedback on "patient-centred care" (Codes)

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Curriculum outcomes

1 **Patient-centred care**

&

2 **Teamwork**

From multimodal logs (data) → higher-order constructs (codes) as proxies → meaningful feedback on "patient-centred care" (Codes)

Curriculum outcomes

Constructs for collaborative activity (from ACAD Framework)

1 **Patient-centred care**
&
2 **Teamwork**

- Physical
- Epistemic
- Social
- Affective

From multimodal logs (data) → higher-order constructs (codes) as proxies → meaningful feedback on "patient-centred care" (Codes)

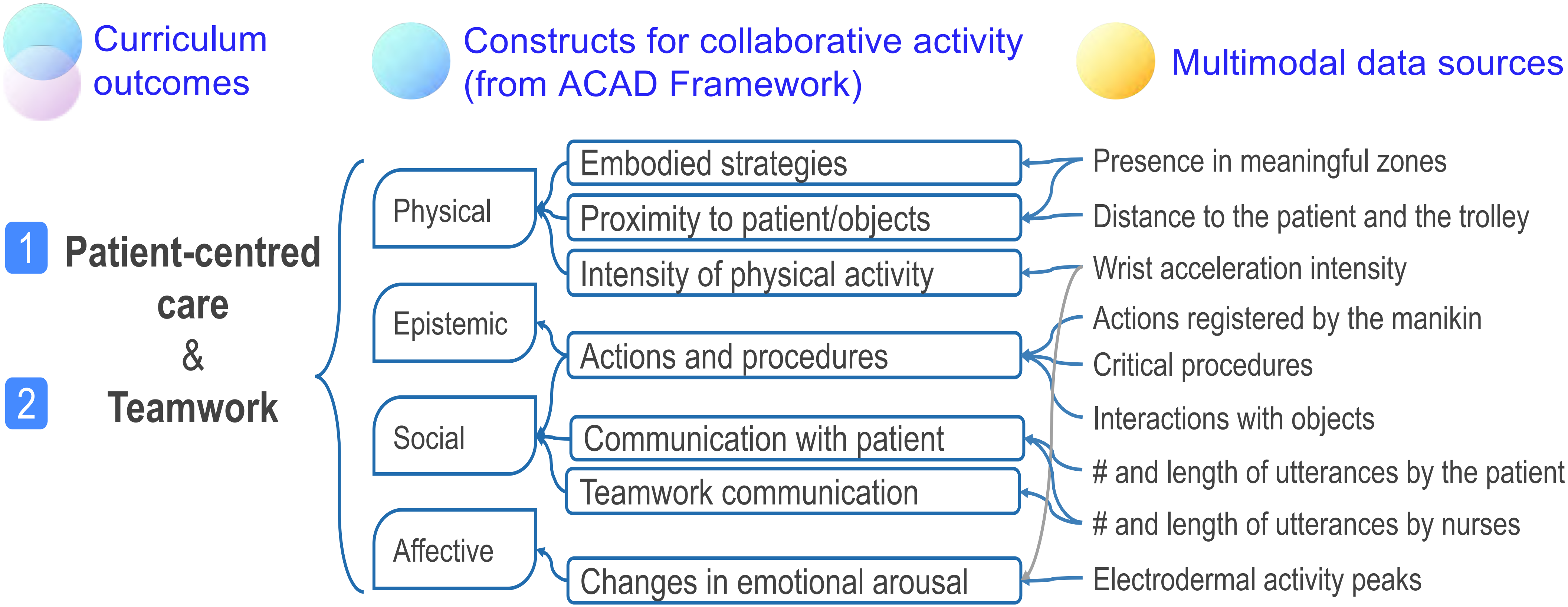
Curriculum outcomes

Constructs for collaborative activity (from ACAD Framework)

1 Patient-centred care & 2 Teamwork

- Physical
  - Embodied strategies
  - Proximity to patient/objects
  - Intensity of physical activity
- Epistemic
  - Actions and procedures
- Social
  - Communication with patient
  - Teamwork communication
- Affective
  - Changes in emotional arousal

From multimodal logs (data) → higher-order constructs (codes) as proxies → meaningful feedback on “patient-centred care” (Codes)



Multimodal Matrix: overview

dimensions of collaboration

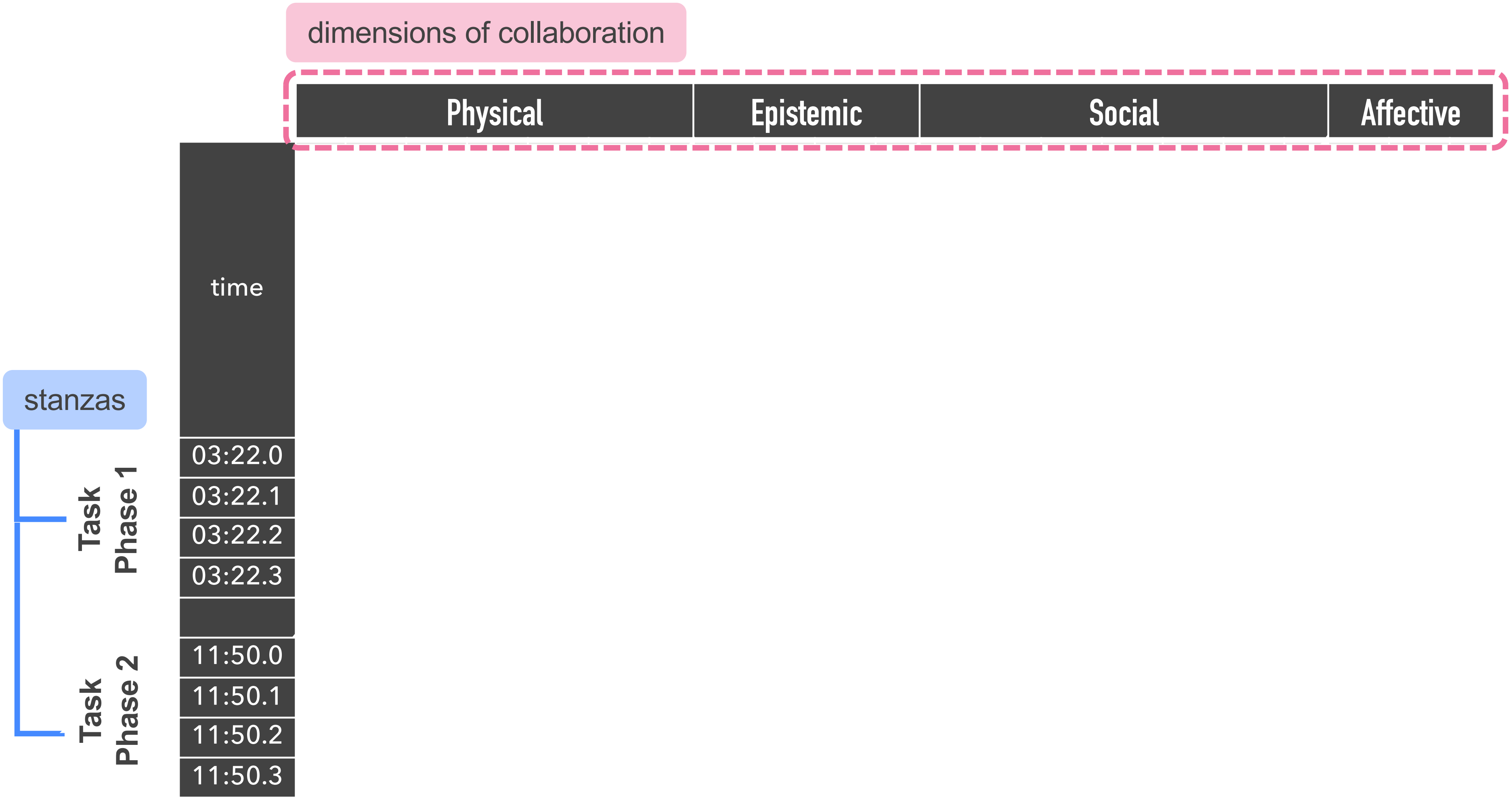
Physical	Epistemic	Social	Affective

Multimodal Matrix: overview

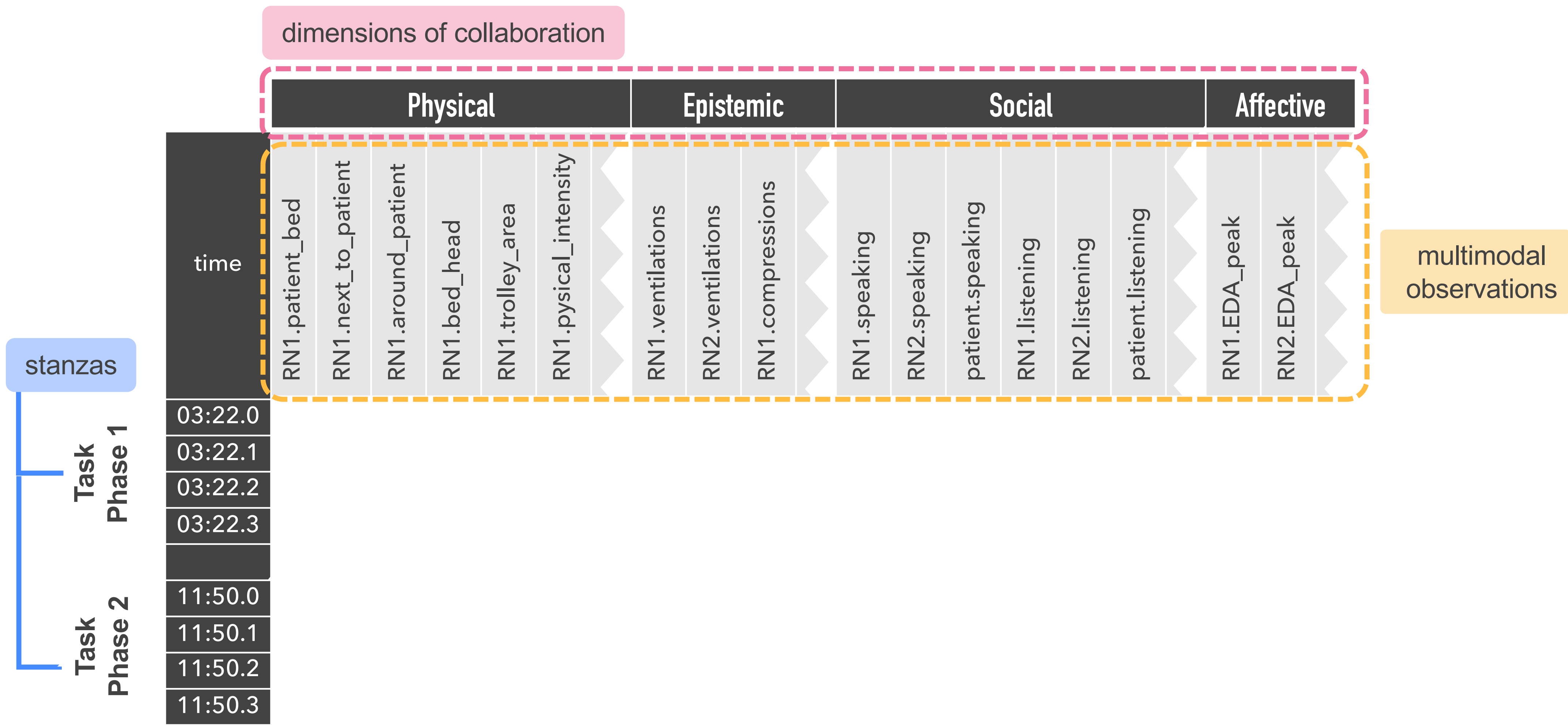
dimensions of collaboration

time	Physical	Epistemic	Social	Affective
03:22.0				
03:22.1				
03:22.2				
03:22.3				
11:50.0				
11:50.1				
11:50.2				
11:50.3				

Multimodal Matrix: overview



Multimodal Matrix: overview



Multimodal Matrix: overview

dimensions of collaboration

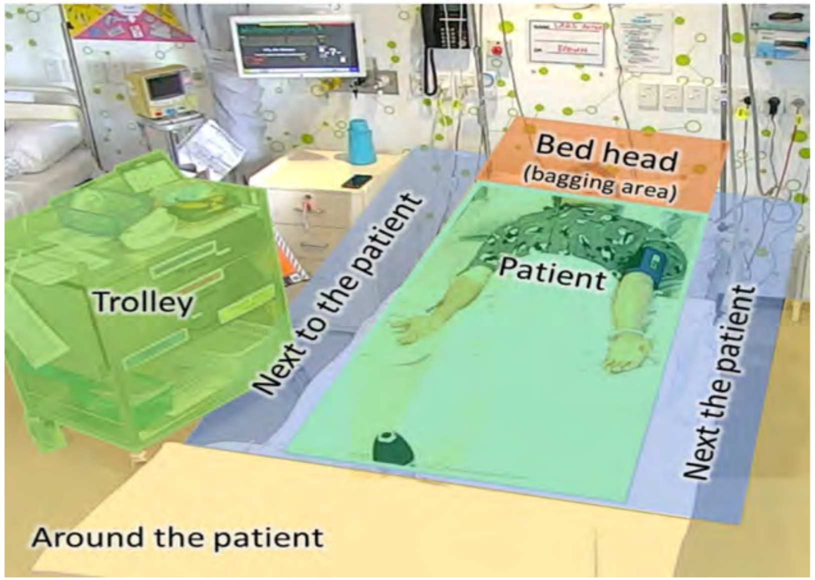
multimodal observations

stanzas

segment

		Physical						Epistemic			Social						Affective	
	time	RN1.patient_bed	RN1.next_to_patient	RN1.around_patient	RN1.bed_head	RN1.trolley_area	RN1.pysical_intensity	RN1.ventilations	RN2.ventilations	RN1.compression	RN1.speaking	RN2.speaking	patient.speaking	RN1.listening	RN2.listening	patient.listening	RN1.EDA_peak	RN2.EDA_peak
Task Phase 1	03:22.0	0	1	0	0	0	L	0	0	0	0	0	1	1	1	0	0	0
	03:22.1	0	1	0	0	0	L	0	0	0	0	0	1	1	1	0	1	0
	03:22.2	0	1	0	0	0	L	0	0	0	0	0	1	1	1	0	0	0
	03:22.3	0	1	0	0	0	L	0	0	0	0	0	1	1	1	0	0	0
Task Phase 2	11:50.0	1	0	0	0	0	H	0	1	1	0	0	0	0	0	0	0	0
	11:50.1	1	0	0	0	0	H	0	1	1	0	0	0	0	0	0	1	0
	11:50.2	1	0	0	0	0	H	0	1	1	0	0	0	0	0	0	1	0
	11:50.3	1	0	0	0	0	H	0	1	1	0	0	0	0	0	0	0	0

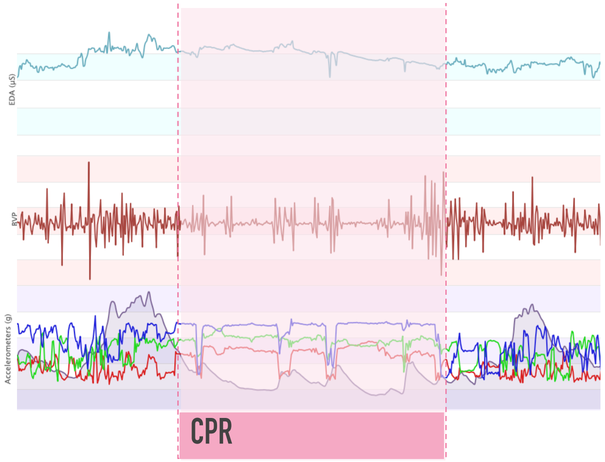
Mapping from positional Codes to digital codes in the Multimodal Matrix



	Physical				
time	RN1.patient_bed	RN1.next_to_patient	RN1.around_patient	RN1.bed_head	RN1.trolley_area
03:22.0	0	1	0	0	0
03:22.1	0	1	0	0	0
03:22.2	0	1	0	0	0
03:22.3	0	1	0	0	0
11:50.0	1	0	0	0	0
11:50.1	1	0	0	0	0
11:50.2	1	0	0	0	0
11:50.3	1	0	0	0	0

Machine coding

Classifying raw accelerometer data
→ low/medium/high physical activity



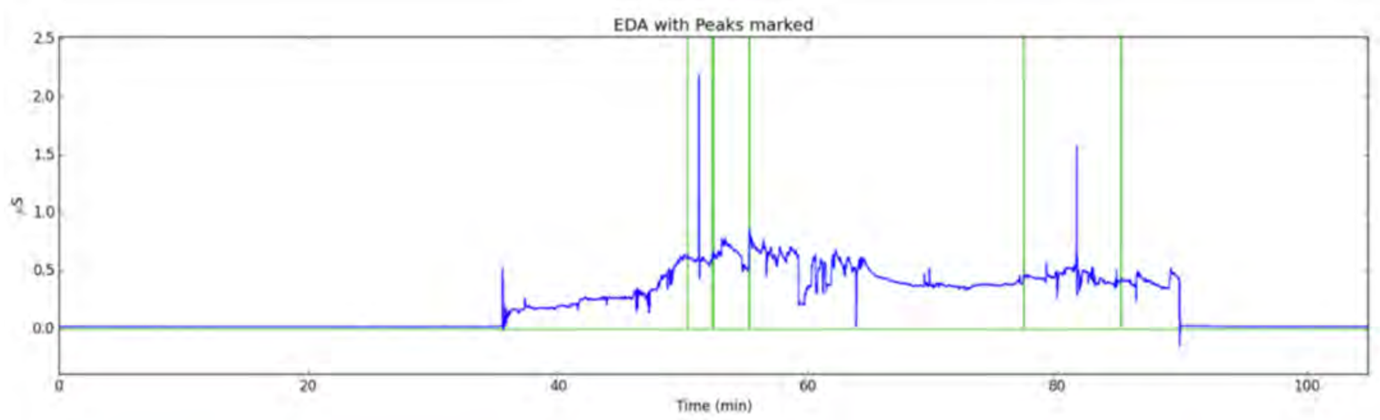
high-level of physical activity

	Physical
time	RN1.pysical_intensity
03:22.0	L
03:22.1	L
03:22.2	L
03:22.3	L
11:50.0	H
11:50.1	H
11:50.2	H
11:50.3	H

Machine coding

Thresholding raw EDA traces to focus on what’s interesting:

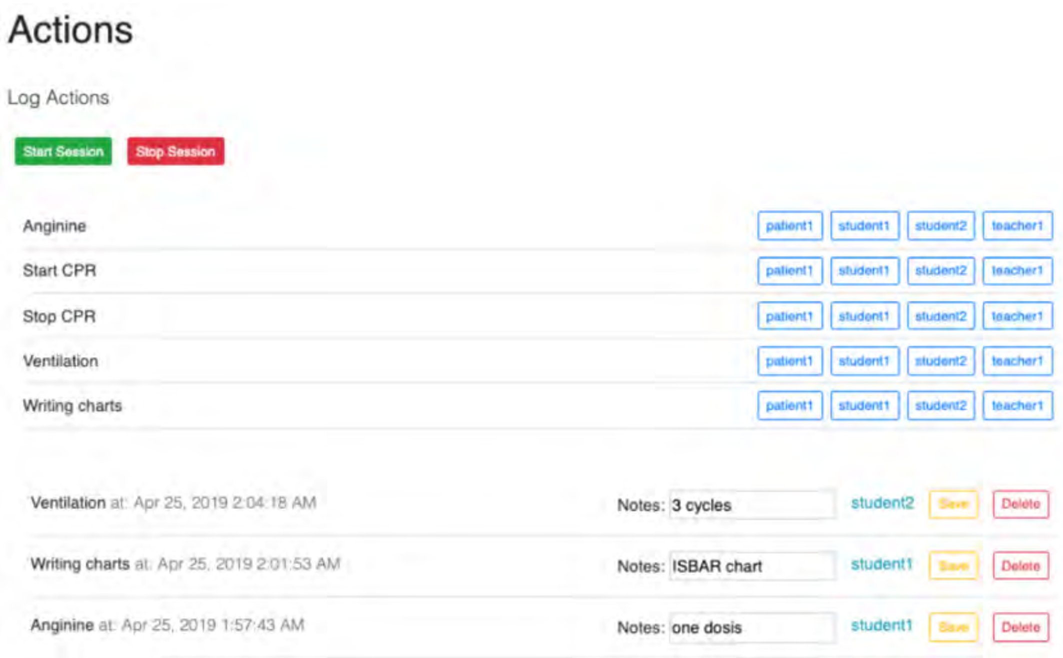
EDA peaks + low physical activity



Affective	
RN1.EDA_peak	RN2.EDA_peak
0	0
1	0
0	0
0	0
⋮	⋮
0	0
1	0
1	0
0	0

Machine coding

Observers (e.g. researchers or students)
use a tablet-based annotation tool to log key actions



Epistemic		
RN1.ventilation	RN2.ventilation	RN1.compression
0	0	0
0	0	0
0	0	0
0	0	0
0	1	1
0	1	1
0	1	1
0	1	1

Human coding

Microphones failed (too noisy) so researcher had to analyse video to code

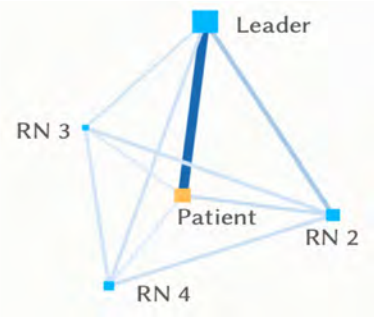
who is speaking and listening/sec.

Social					
RN1.speaking	RN2.speaking	patient.speaking	RN1.listening	RN2.listening	patient.listening
0	0	1	1	1	0
0	0	1	1	1	0
0	0	1	1	1	0
0	0	1	1	1	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

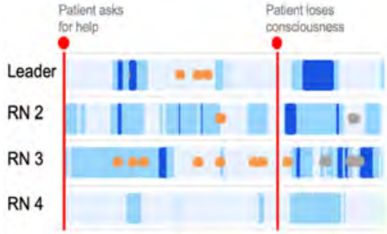
Human coding

Multimodal Matrix → visual analytics for researchers, educators and students

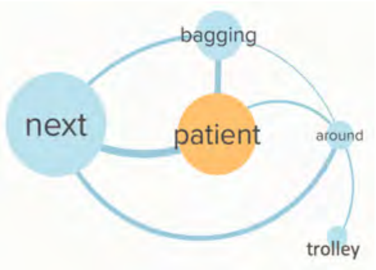
NB: social/physical/spatial/temporal *relationships* are key



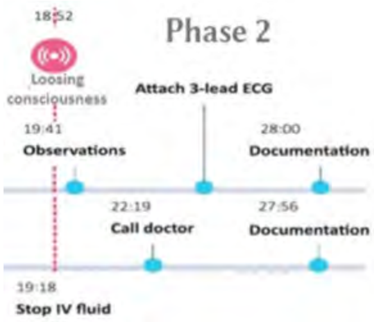
Patient-centred verbal communication, and within nursing team



Affective/cognitive arousal via EDA peaks



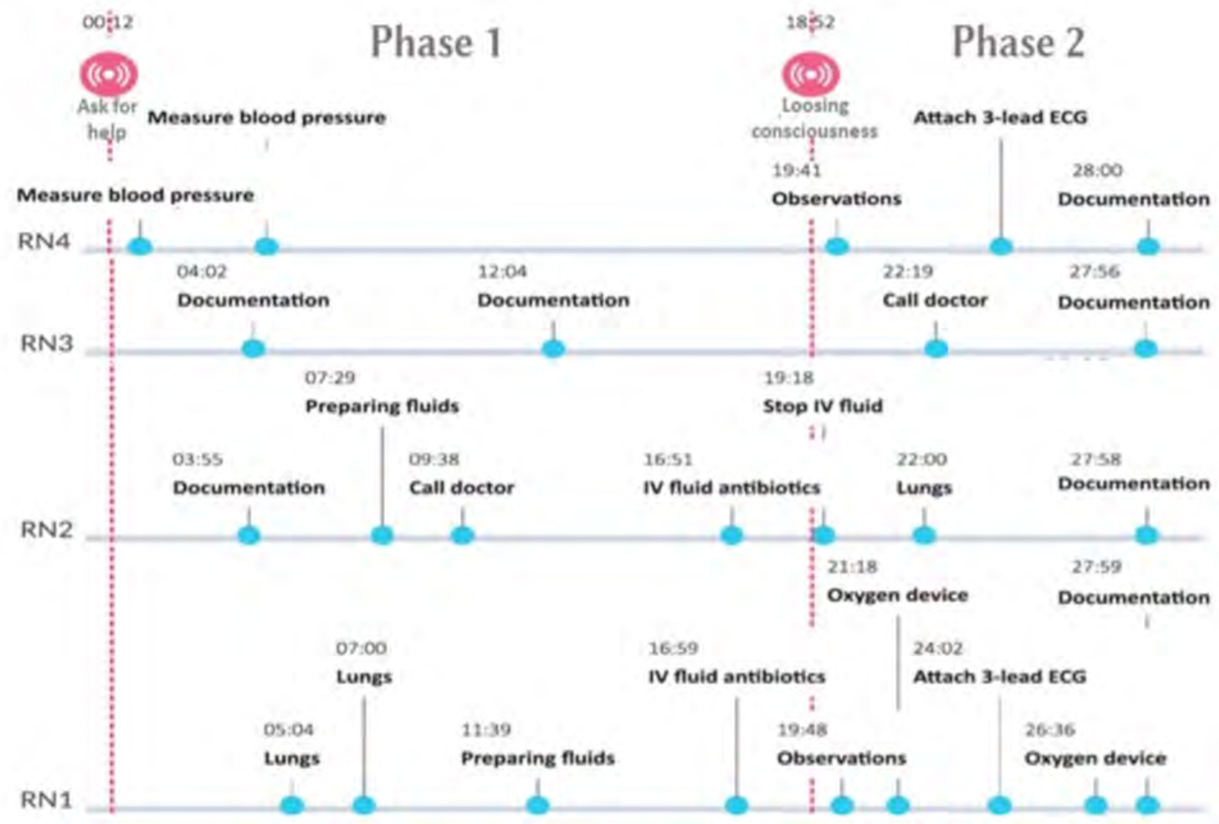
Patient-centred movement around the simulation zones



Critical actions performed by nurses

Echeverria, V., Martinez-Maldonado, R. and Buckingham Shum, S. (2019). Towards Collaboration Translucence: Giving Meaning to Multimodal Group Data. In *Proceedings of ACM CHI Conference (CHI'19).* ACM, New York, NY, USA. https://doi.org/10.1145/3290605.3300269

Team Timeline can be generated within a few minutes of a simulation to assist debriefing (user studies now under way)



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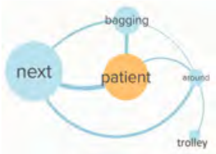
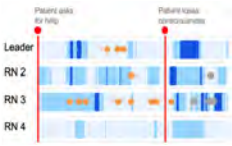
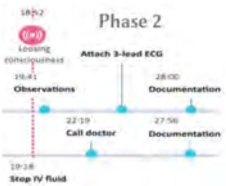
How close are we to fully automated workflow?

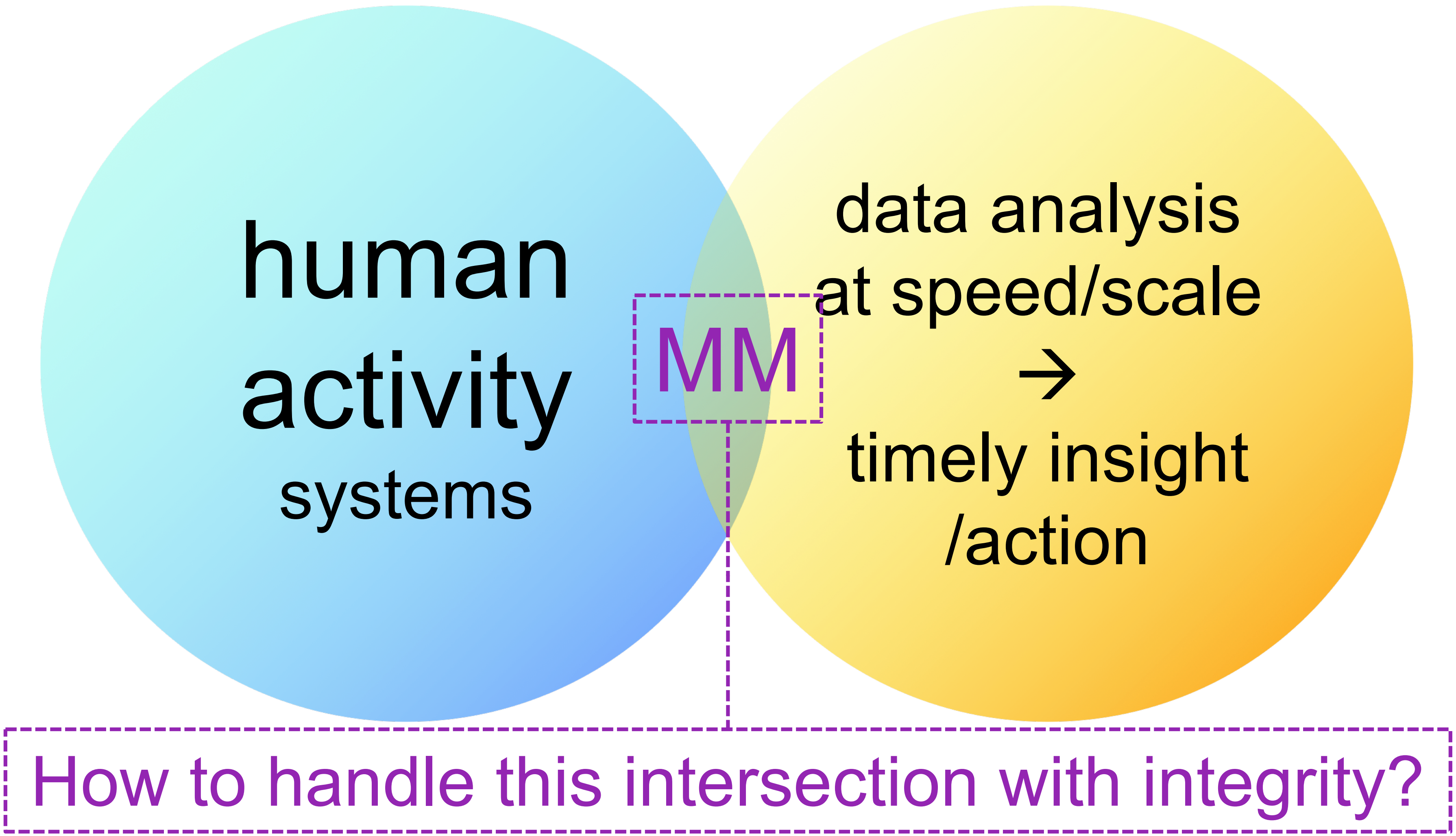






Collaboration Proxy	Data source	Manual interventions	Automated
Patient-centred speech interaction	Audio from video recording	Speech interaction manually annotated	→ Sociograms generated from speech onset/offset logs
Patient-centred movement	X,Y positions and pre-defined zones using indoor localization		→ Zone transition networks generated from localisation data
Physical Intensity and Affective reaction	EDA and accelerometer from Empatica wristband	Wristband data download	→ EDA timelines generated from wristband data
Teamwork Timeline	Timestamped actions from observation tool	Nursing actions logged by an observer	→ Timelines generated from action logs

To conclude…


human
activity
systems
MM
data analysis
at speed/scale
→
timely insight
/action
How to handle this intersection with integrity?

To conclude…

What contributions
can Q.E. make?

Principles underpinning the MM

“Meaningful Feedback”

Can this work make
contributions back to Q.E.?

MM may assist other Q.E. research

Exemplifies Q.E. for rapid <u>collocated</u> activity analysis

To conclude…

We propose that this work builds on and augments QE as follows…

1. Understand the human activity system (Discourse + Codes)
   → expert interviews + theory + co-design including envisioned practices
2. Integrate qualitative and quantitative data (discourse + codes)
   → integrated by the Multimodal Matrix to handle multimodal data streams
3. Analysis techniques read from + write to a common data representation
   → human + machine analysis can contribute coded data to the MM
4. Enable semi/fully automated analysis at scale, and visualize for users
   → partially automated analytics workflow to generate visual analytics

Buckingham Shum, S., Echeverria, V. & Martinez-Maldonado, R. (2019). The Multimodal Matrix as a Quantitative Ethnography Methodology. In: Eagan B., Misfeldt, M. & Siebert-Evenstone, A. (Eds.), *Advances in Quantitative Ethnography*. Communications in Computer and Information Science, Vol. 1112. Springer: Cham, pp.26-40. DOI: https://doi.org/10.1007/978-3-030-33232-7_3