QE Visualizations as Tools for Thinking

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The bring + share meal that is QE!

Overview…

How my academic journey primed me for QE

Confession: I have been a participant observer!

Visualizations as cognitive artifacts

Observations of how QE (ENA) stories are told

The future may be a more participatory QE

→ New kinds of visualizations, interactivity

→ New fluencies to wield participatory visual tools
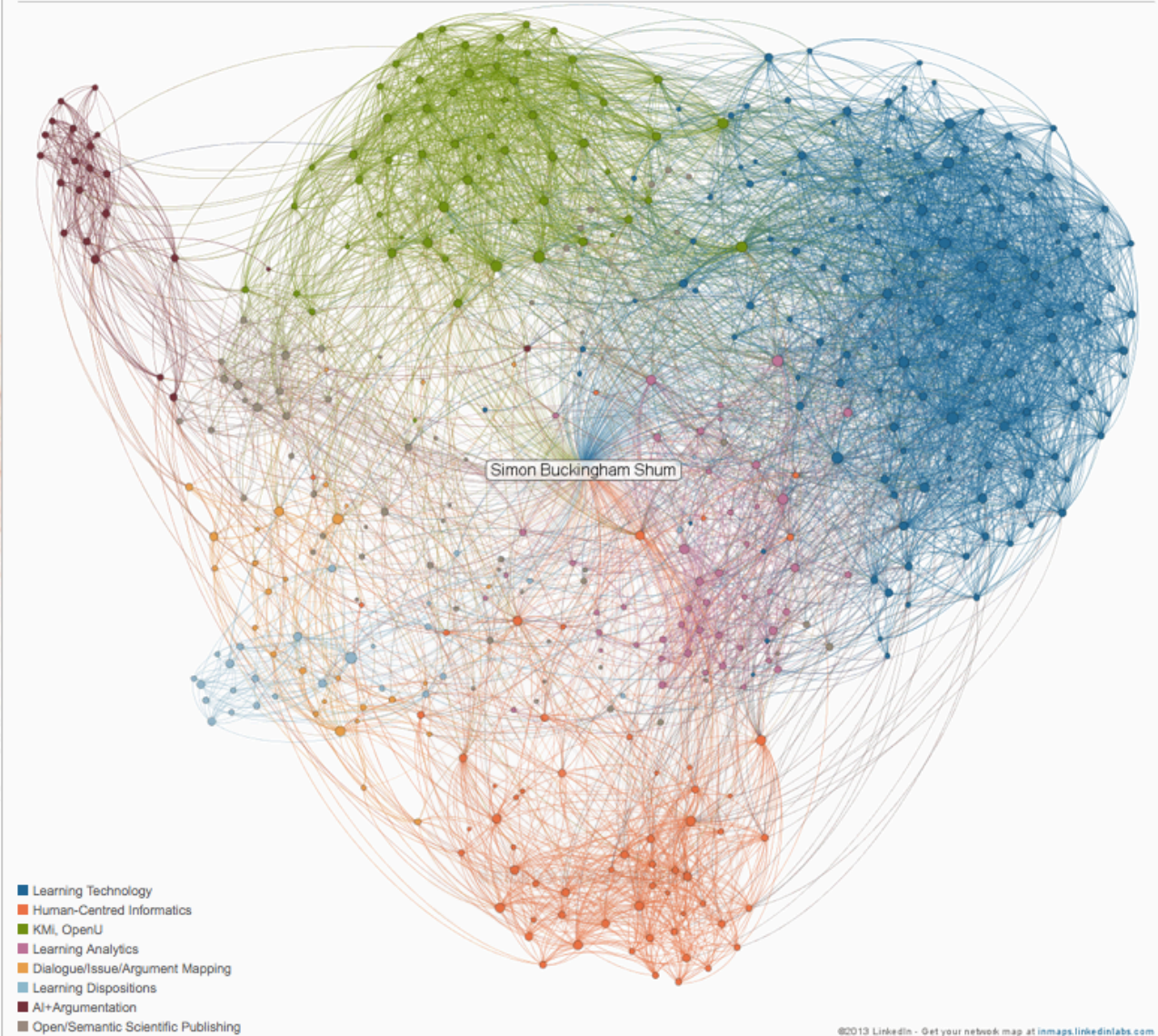
Visualizing my communities

LinkedIn Maps (2013)

Label your
Professional Networks

- ■ Learning Technology
- ■ Human-Centred Informa
- ■ KMi, OpenU
- ■ Learning Analytics
- ■ Dialogue/Issue/Argume
- ■ Learning Dispositions
- ▫ + Add Label
- ■ Open/Semantic Scientifi

LinkedIn. Maps   Simon Buckingham Shum's Professional Network
as of November 9, 2013

Simon Buckingham Shum

- ■ Learning Technology
- ■ Human-Centred Informatics
- ■ KMi, OpenU
- ■ Learning Analytics
- ■ Dialogue/Issue/Argument Mapping
- ■ Learning Dispositions
- ■ AI+Argumentation
- ■ Open/Semantic Scientific Publishing

©2013 LinkedIn - Get your network map at inmaps.linkedinlabs.com

My journey with various research tribes...

B.Sc. Psychology → M.Sc. Ergonomics (→ Cognitive Ergonomics)

Ph.D. Human-Computer Interaction (visual design rationale + cognition)

Hypertext/Semantic Web (spatial metaphors; scholarly hypertexts)

Dialogue & Argument Visualisation (Making deliberation visible, and contestable)

Learning Technology (critical thinking; synchronous groupware; open education)

Data Science/Learning Analytics/AIED (critical reflection; teamwork; dispositions; ethics)

Quantitative Ethnography (beginner; keen observer!)

This journey primed me for QE…

"Augmenting human intellect"
with interactive tools
…Douglas Engelbart's pioneering 1960s
work is my inspiration

http://simon.buckinghamshum.net/2014/07/openu-valedictory-lecture

→ a fascination with how software
helps make thinking visible
…and how thinking is shaped by
(semi)formal, interactive representations
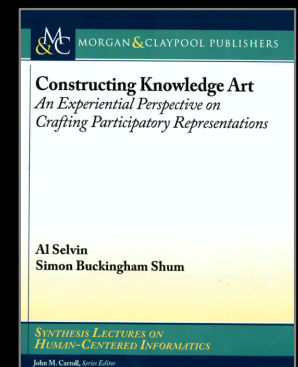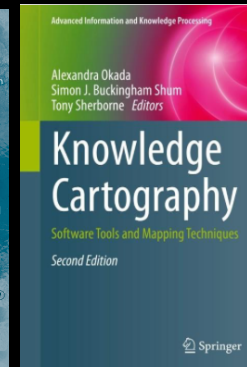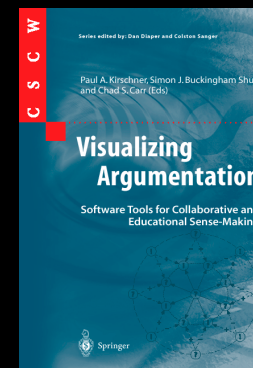
This journey primed me for QE…

A passion for research-inspired,
open source tools for researchers,
and other knowledge workers…

…co-building and supporting a
user community for >20 years

…in service of participatory
sensemaking

http://simon.buckinghamshum.net/tag/compendium

http://projects.buckinghamshum.net/compendiuminstitute/community/community.htm

Supporting a user community for >20 years

A tool, method + practice for participatory, visual, networked thinking

Compendium as a science sensemaking tool

NASA Field Trials (Mobile Agents Project)

http://projects.buckinghamshum.net/NASA_EPSRC_Mars/

Visualizations as Tools for Thinking

Example visualization: London Underground Map
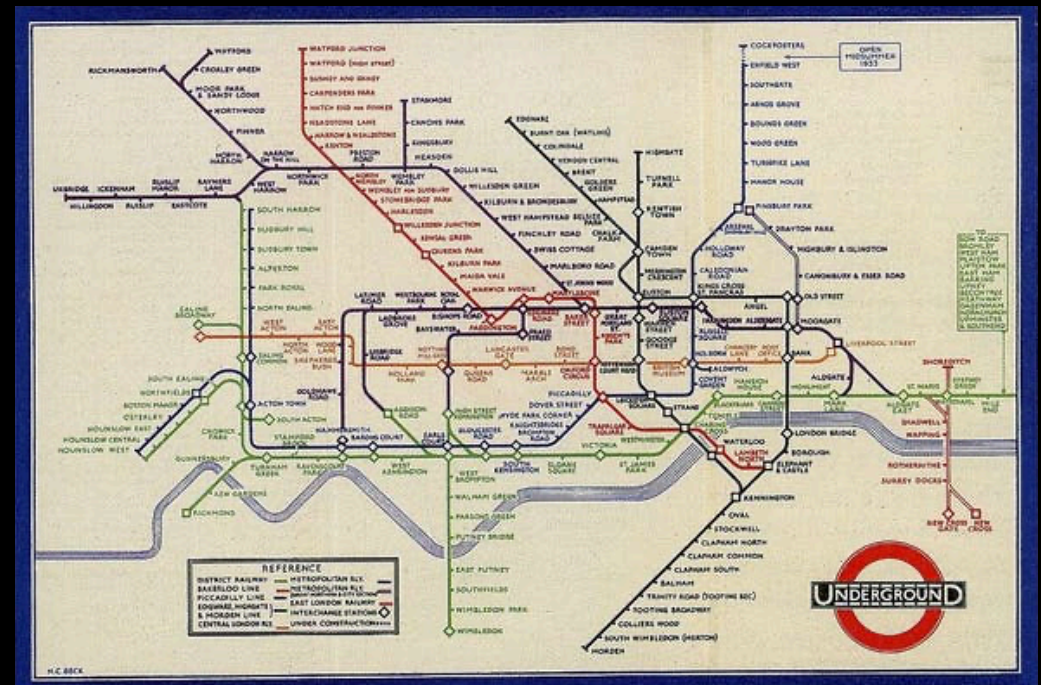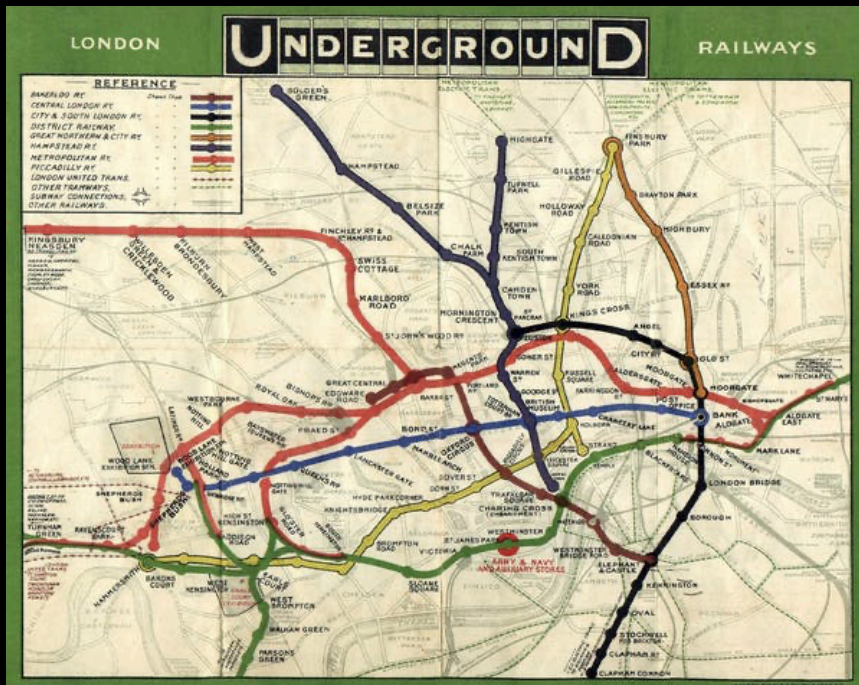
Example visualization: London Underground Map

ontology   typed nodes (stations), typed connections (lines)

data   The Tube; The River Thames!

notation   "wiring diagram" optimized for route-tracing (horiz, vertical, 45deg) at expense of geog. accuracy

interactivity   filtering and route planning apps

Finsbury Park to Custom House
Duration 52 min
Changes 2
Mode Quickest Route

① Finsbury Park
↓ Take the Victoria line (Southbound) towards Brixton for 3 min (1 stop). Service runs every 4 min.

② Highbury & Islington
↓ Take the Overground [Richmond/Clapham Junction-Stratford] (Eastbound) towards Stratford for 17 min (6 stops). Service runs every 15 min.

Route described in simple steps and drawn on the map

But what are a visualization's cognitive affordances?

A visualization's meaning is emergent from its interaction with a given viewer

Thinking with Diagrams

Edited by Alan F. Blackwell

Kluwer Academic Publishers
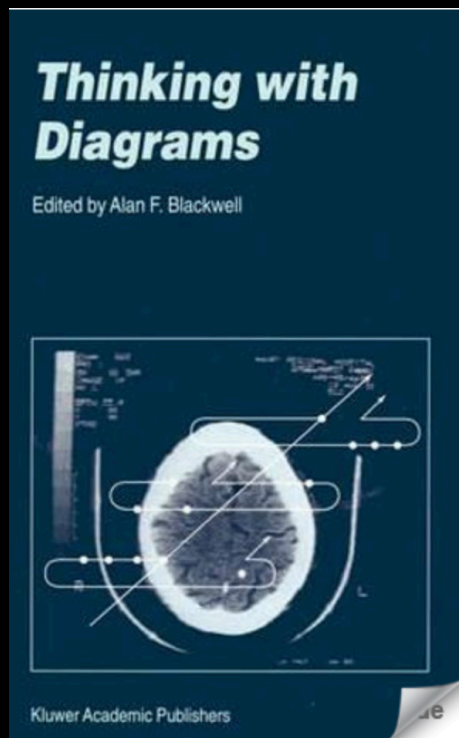
"Diagrams, in and of themselves, do not 'contain' all the information that a viewer needs to use them properly. Rather, the background knowledge that the viewer brings to the diagram plays a critical role in whether or not it can be processed satisfactorily.

[…]
For this reason, current orthodoxies about the intrinsic benefits of visualization […] need to be examined far more critically."

Cheng, P.C.-H., Lowe, R.K. & Scaife, M. (2001) Cognitive Science Approaches to Understanding Diagrammatic Representations. In Blackwell, A. (Ed.), *Thinking With Diagrams.* Kluwer: Dordrecht, NL.

Internal cognition is augmented by <u>external cognition</u> — mediated by representations

Some features include:

Computational offloading Reduce cognitive effort compared to other representations (e.g. text) by enabling the user to read off information rather than infer it and maintain it in memory

Graphical constraining Support specific kinds of reasoning

Continuous internal/external interplay A graphical representation shapes reasoning, which in turn changes what we seek and see in the display

Scaife, M. & Rogers, Y. (1996). External cognition: how do graphical representations work?
International Journal of Human-Computer Studies, 45(2), 185–213. https://doi.org/10.1006/ijhc.1996.0048

Cognitive affordances may be both individual and shared

Augments personal working memory

persistent display tuned to specific tasks

Shared language and inferences

users can read it with little/no training

agree on what can be inferred (and what can't)

point and plan together: common ground

Epistemic Network Analysis (ENA) diagrams

QE ≠ ENA

But for obvious reasons, ENA dominates the QE community at present as the fullest expression of QE principles

ENA is a compelling proof-case: QE principles can be translated into running code → powerful analytics

ENA's success is not just due to its modelling and analysis, but the visual networks it generates engage a wider audience

Cognitive affordances of ENA diagrams

Notational features:

Variable sized nodes

Connections (colour and weight)

Meaning of node positions and the quadrants open to researcher interpretation

Common node positioning enables visual comparison and calculation of subtraction networks

Centroid trajectories, + more…
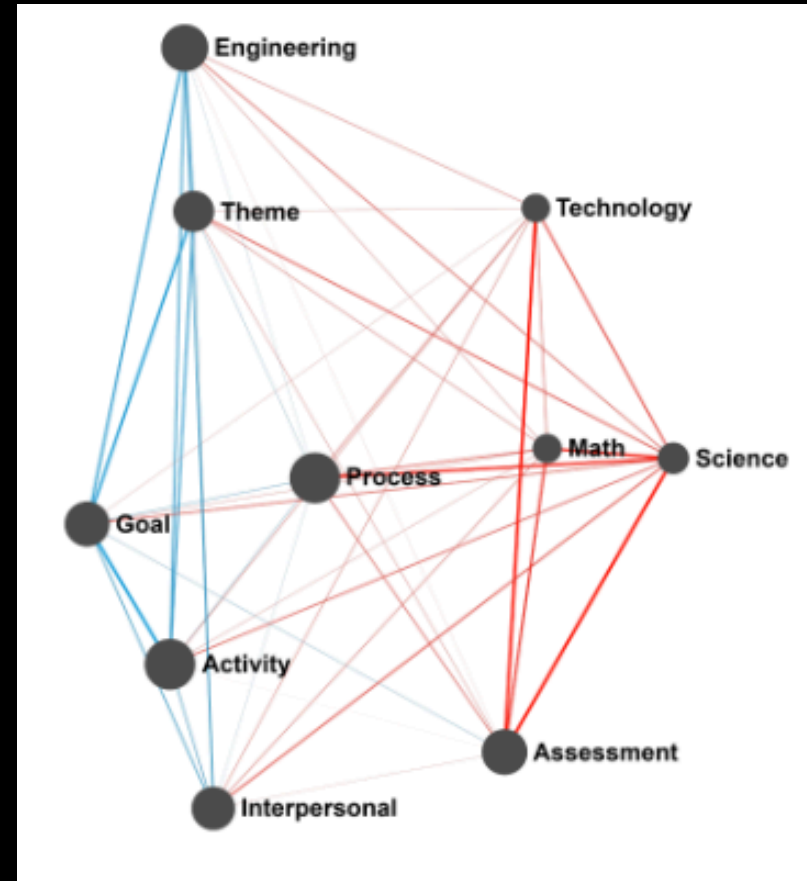
Bian Wu: https://qesoc.org/webinar-archives/#webinar-7

Exploiting our ability to detect visual changes

Srecko Joksimovic:
https://www.qesoc.org/webinar-archives/#webinar-5
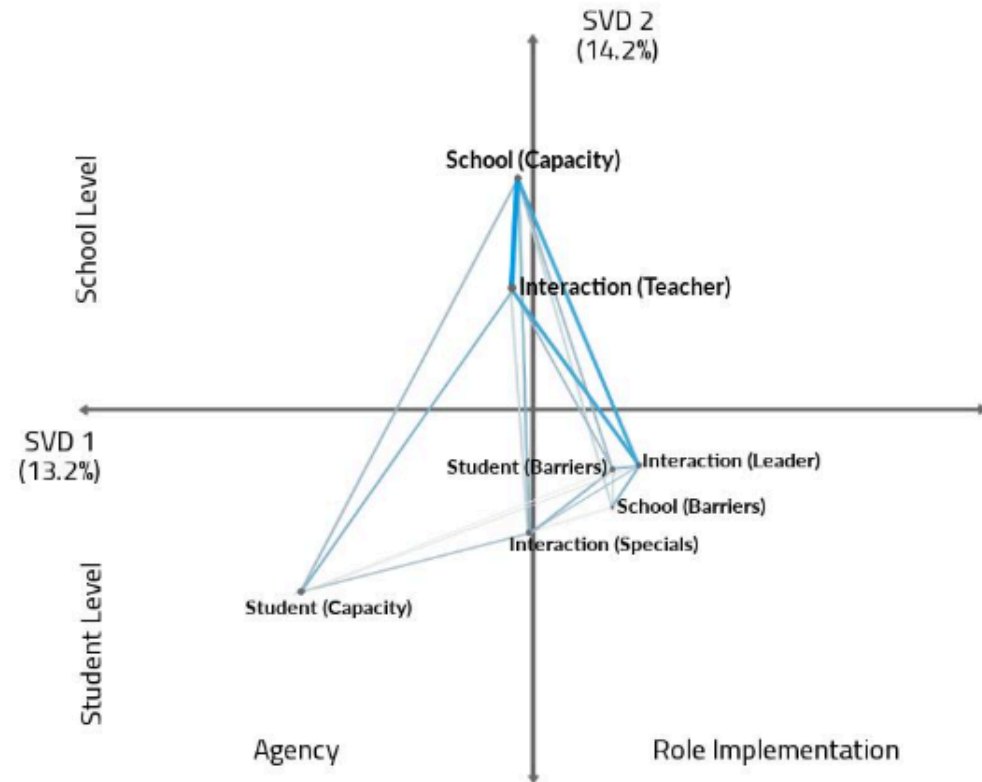
Acting as role implementers

Exploiting our ability to detect visual changes

Srecko Joksimovic:
https://www.qesoc.org/webinar-archives/#webinar-5
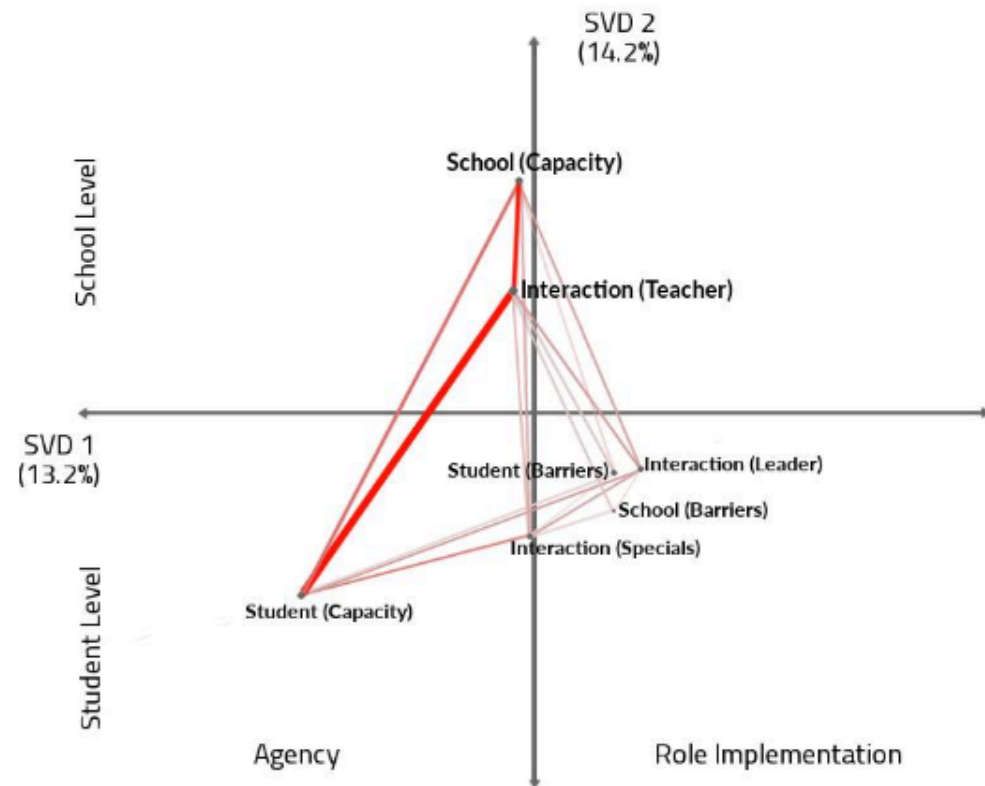
dENA extends the ontology and notation with directed edges → greater expressiveness
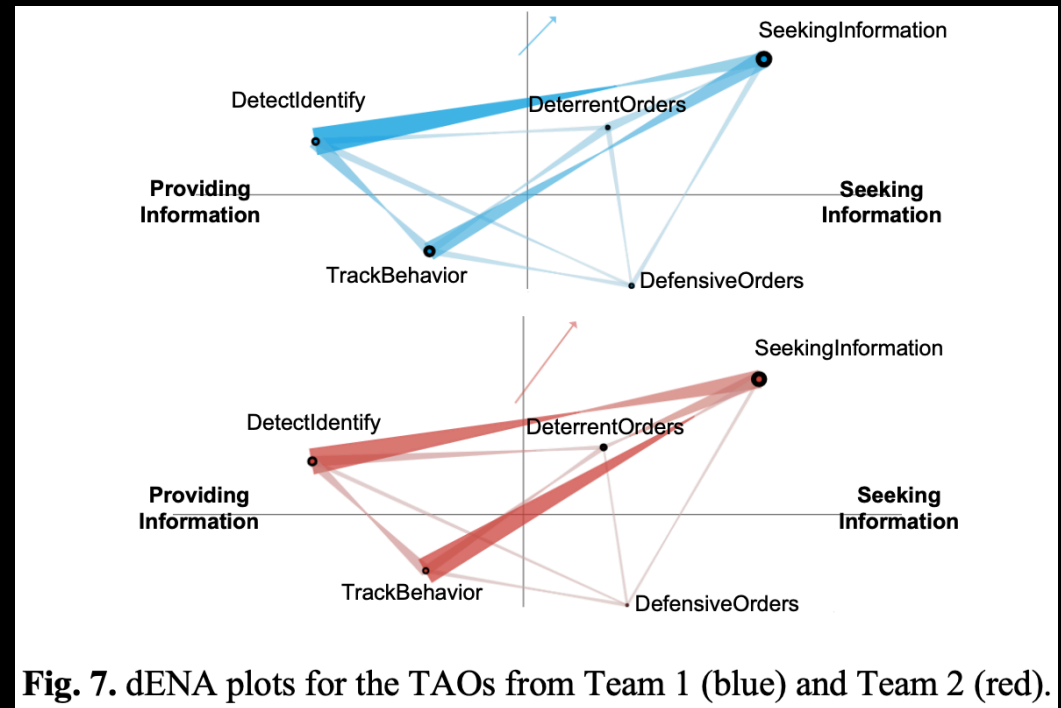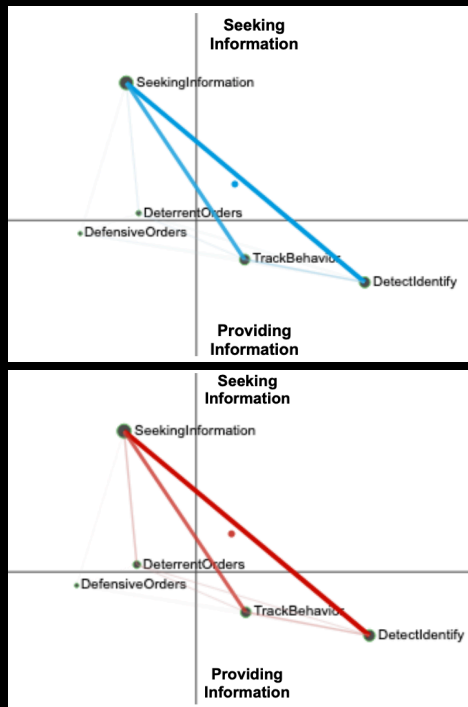
Fig. 7. dENA plots for the TAOs from Team 1 (blue) and Team 2 (red).

Fogel, A., Swiecki, Z., Marquart, C., Cai, Z., Wang, Y., Brohinsky, J., Siebert-Evenstone, A. L., Eagan, B., Ruis, A.R. & Shaffer, D.W. (2020). Directed Epistemic Network Analysis. *2nd International Conference on Quantitative Ethnography 2020.* https://www.epistemicanalytics.org/publications

Additional ENA 'narrative techniques'

When people work around, or augment software
with other tools (inc. pen+paper),
they're clues to gaps in cognitive support
→ potential software improvements

Zoom in and reduce visual noise to focus attention

Golnaz Arastoopour Irgens:
https://www.qesoc.org/webinar-archives/#webinar-4
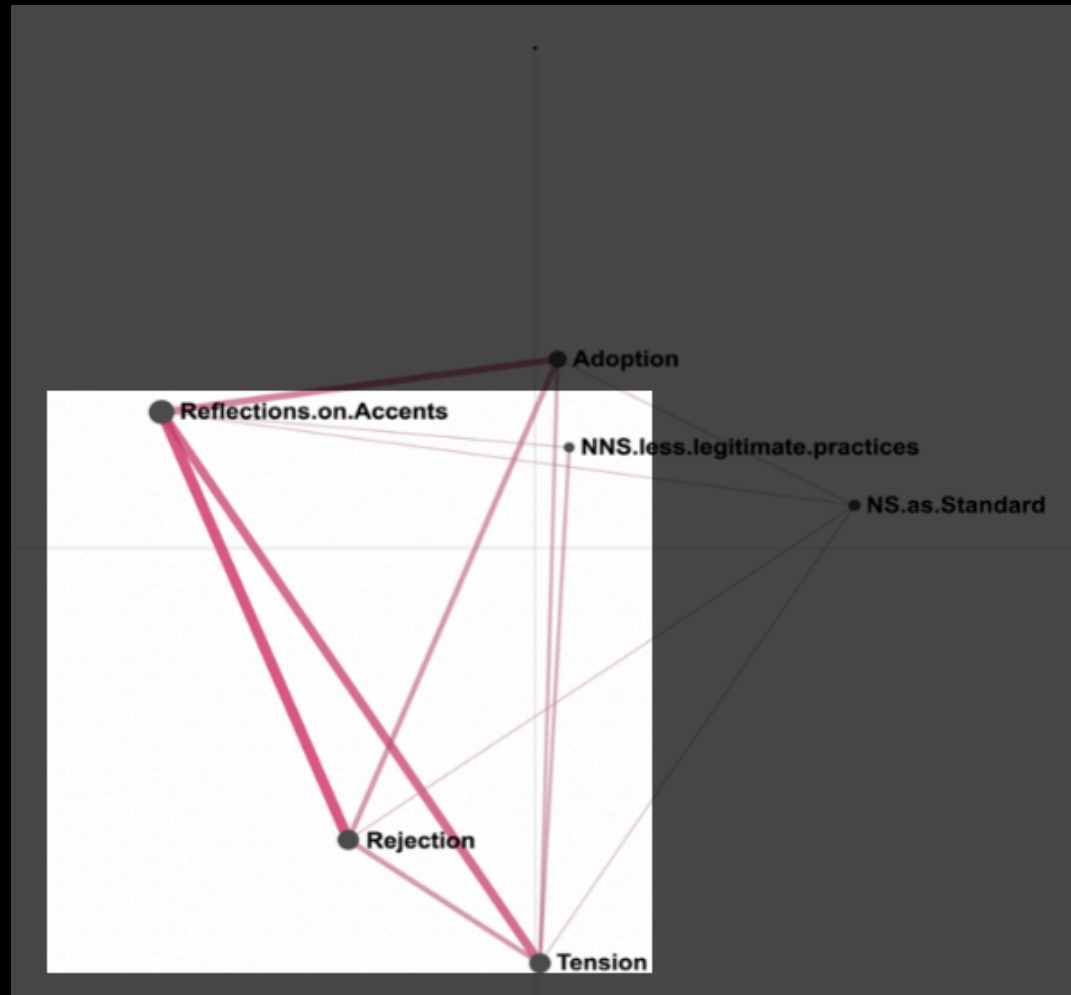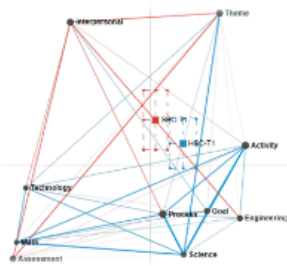
Design a gallery…

Bian Wu: https://qesoc.org/webinar-archives/#webinar-7
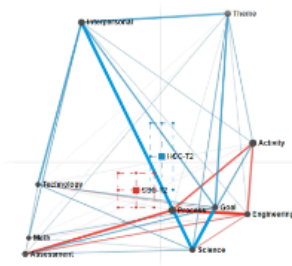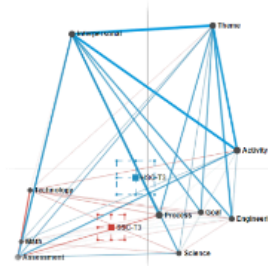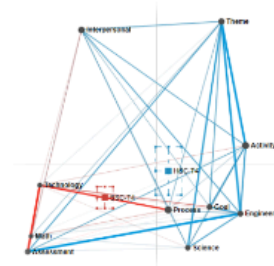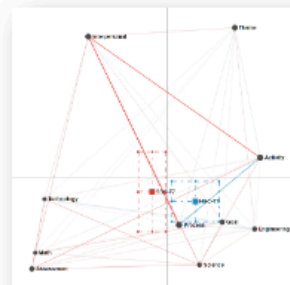
Design a gallery and highlight features to focus attention

Bian Wu: https://qesoc.org/webinar-archives/#webinar-7
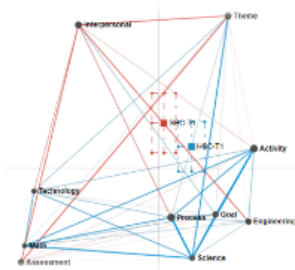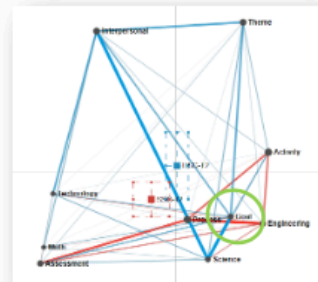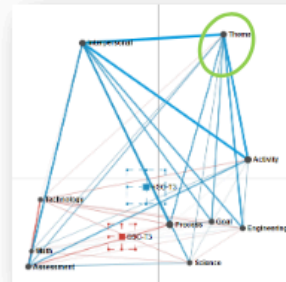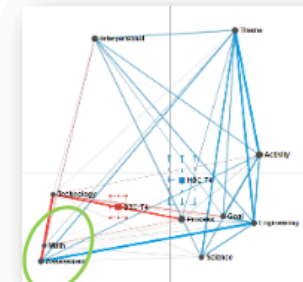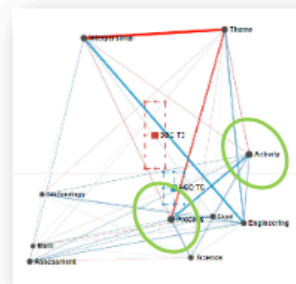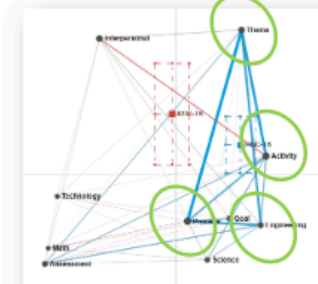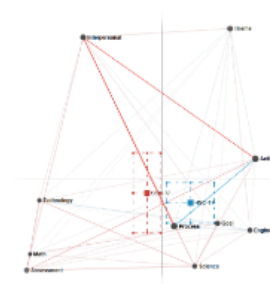
Animated ENA + synchronized video is compelling

Epistemic Analytics Lab: "Law & Order" ENA-annotated clip
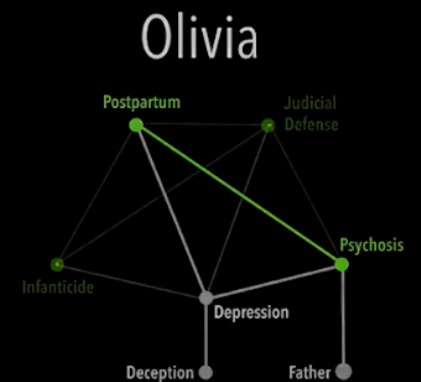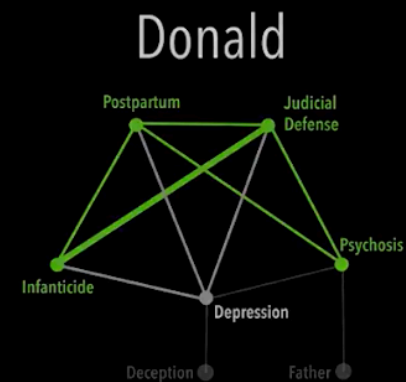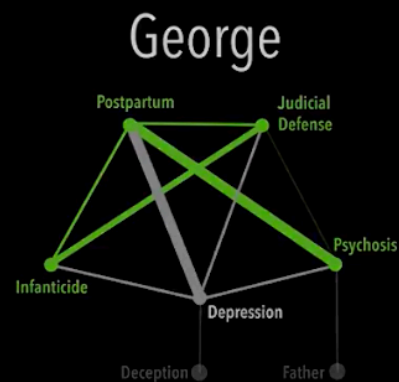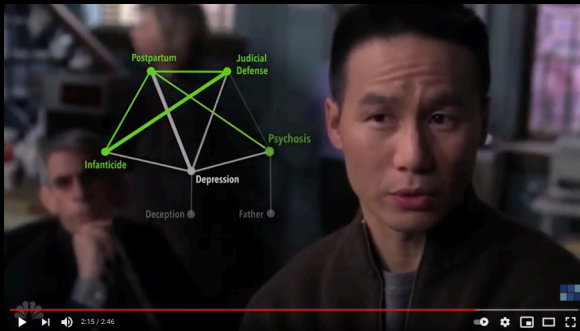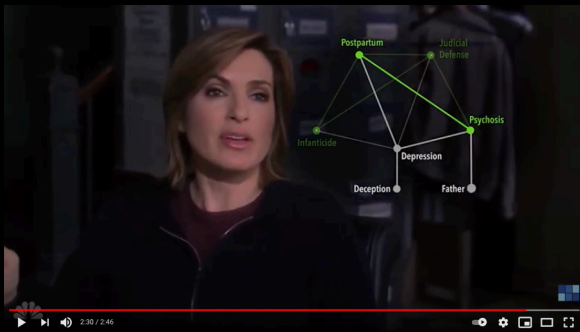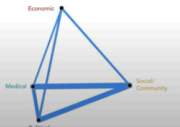
Animated ENA + synchronized video is compelling

QE Society data challenge: Ardern & Trump COVID-19 policy statements

Summary: ENA serves as an aid to shared, external cognition via processes including…

Computational offloading

Graphical constraining

Continuous internal/external cognition interplay

Shared focus of visual and deictic attention

Accessible, shared language for joint sensemaking

Additional narrative to tell the story

Who are we talking to?

Do they get to interpret?

QE for researchers to tell stories to each other

"emic"   "etic"

data → **coded data** → **data viz.** → **papers talks**

S Stakeholders   **R** Researchers

30

R

→ data → coded data → data viz. → papers talks
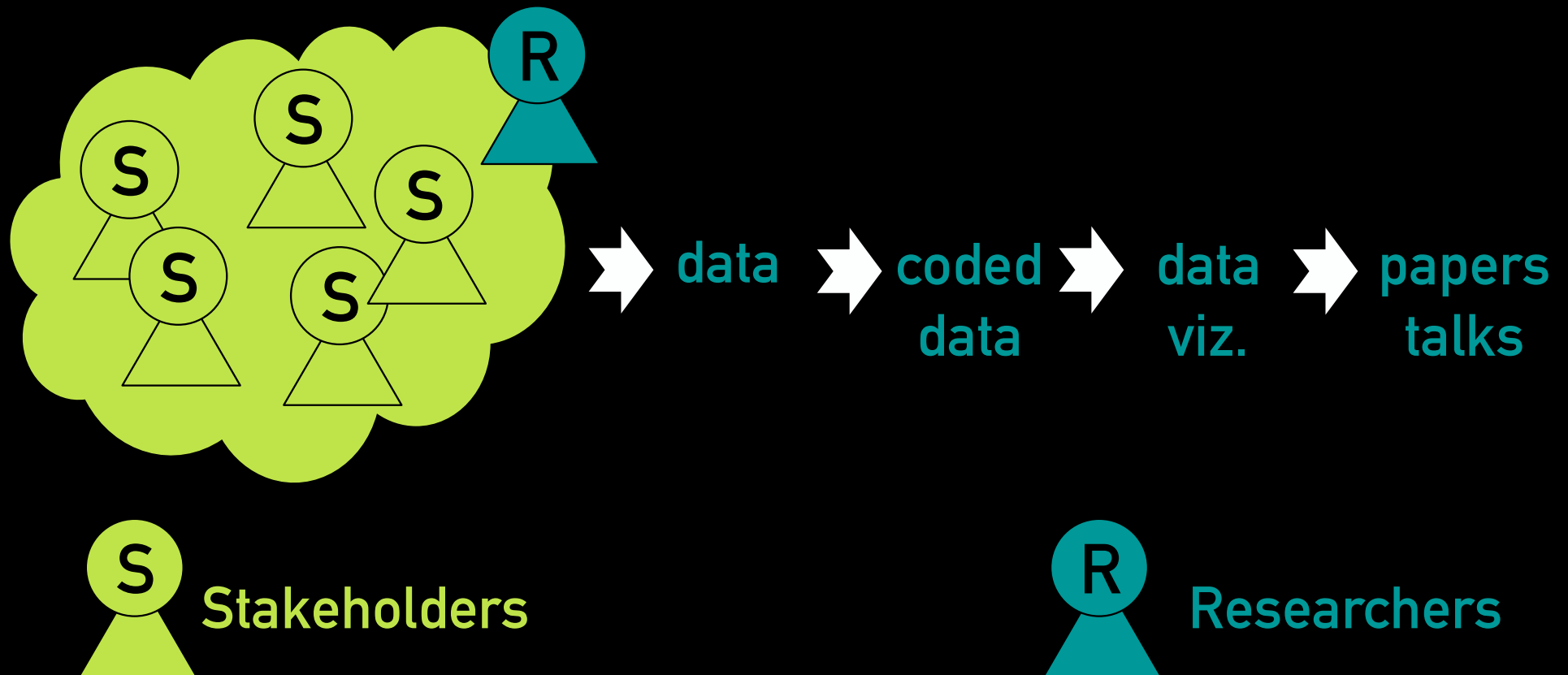
In the 'etic' world…

→ **Other researchers judge their agreement with our formally submitted papers against scientific criteria**

→ **Establishing scientific credibility has rightly been the first focus of QE as a new field.**

QE that validates with stakeholders

"emic"

"etic"

data → coded data → data viz. → papers talks
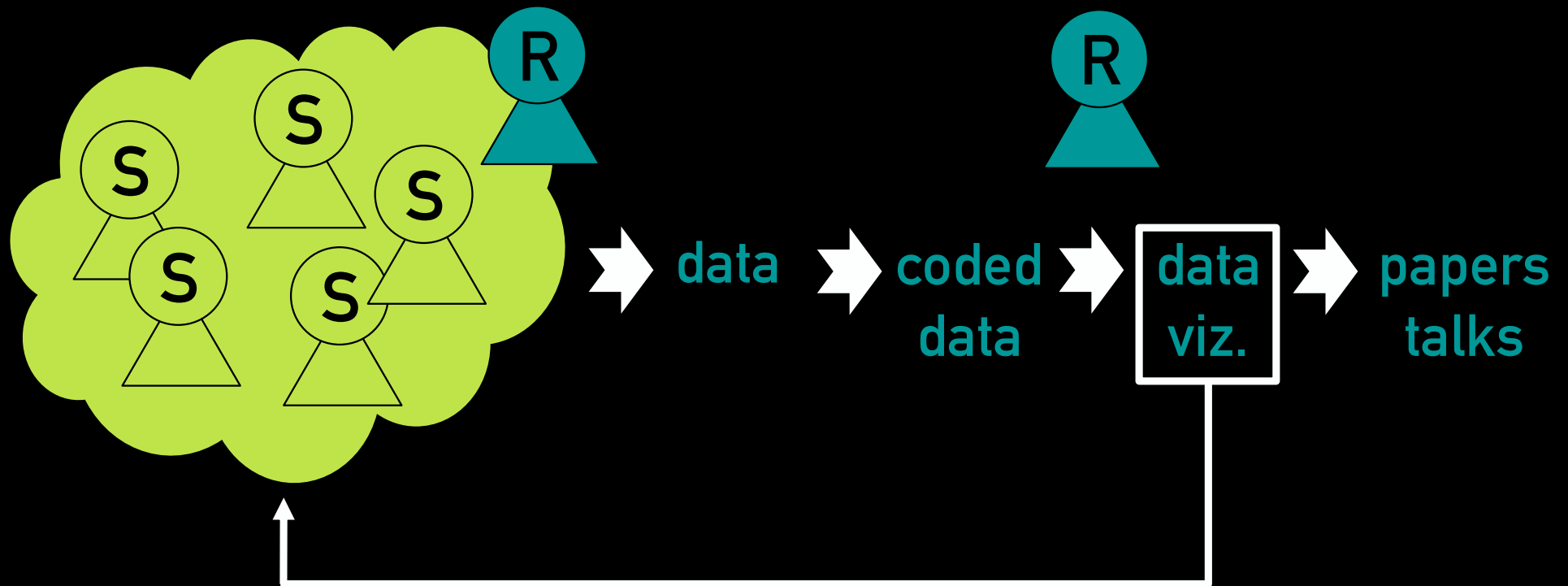
Making ENA diagrams more participatory (1)

Michael Phillips: ICQE2020 paper and his webinar:
https://www.qesoc.org/webinar-archives/#webinar-2

Maths

Science

I.T.
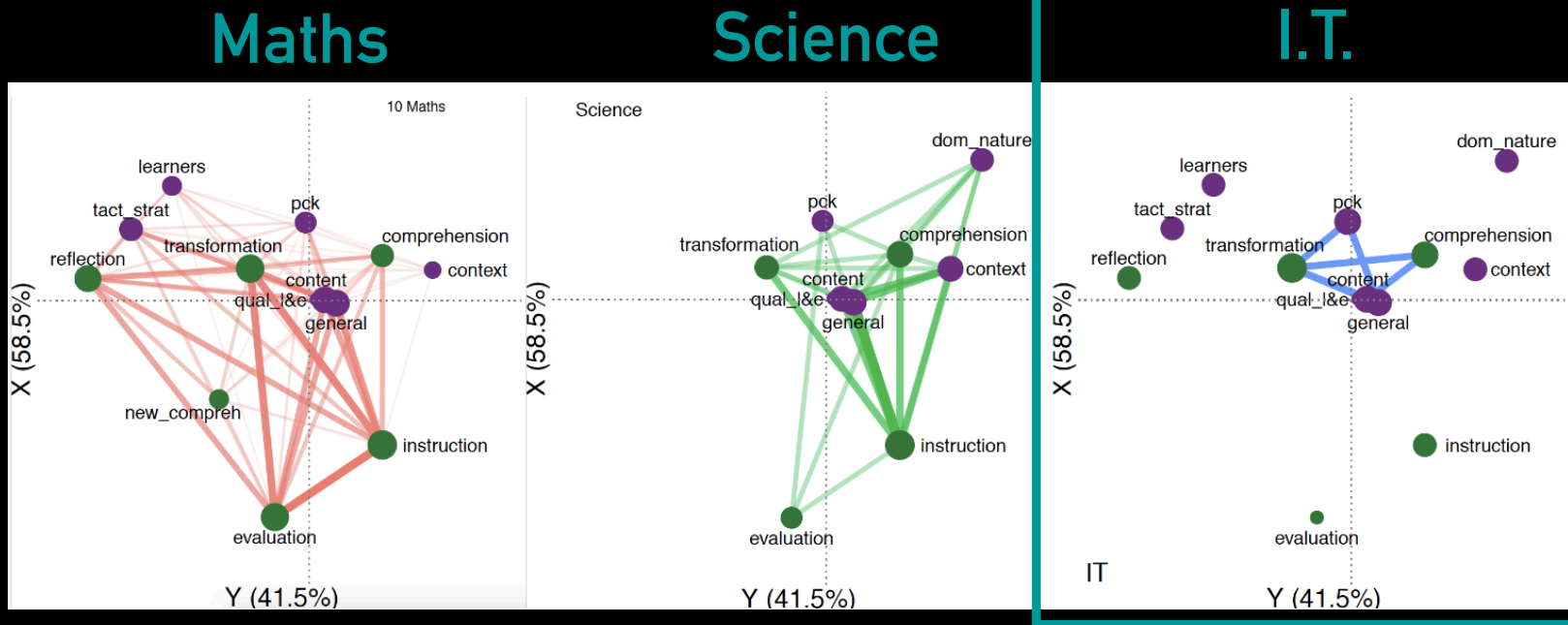
(In)validating the strange ENA for I.T. teachers: "So they were having conversations all the time […] But that didn't necessarily get translated into the kinds of documentation they had in school. They were doing this on the fly in real time. And so, all of a sudden, I realized that just using one of these data sources didn't necessarily give me the full picture."

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Making ENA diagrams more participatory (2)

Golnaz Arastoopour Irgens & Hazel Vega:
https://www.qesoc.org/webinar-archives/#webinar-4

"We needed to set the stage to co-create meaning together with the teachers, and to ensure that this network is just one interpretation of what they said…"

Making ENA diagrams more participatory (2)

"[the researcher] annotated the network during the interview [...]

There's a dotted line here between reflection on Accents and Rejection, because [...] the teacher said [...] she felt that there should have been a link between those two things, for her discourse."

Vega, H., Arastoopour Irgens, G., & Bailey, C. (2020). Negotiating Tensions: A Study of Pre-Service English as Foreign Language Teachers' Sense of Identity within their Community of Practice. In Ruiz, A. & Lee, S. (Eds), *Advances in Quantitative Ethnography: Second International Conference, ICQE 2020.* (pp.) Springer.

35
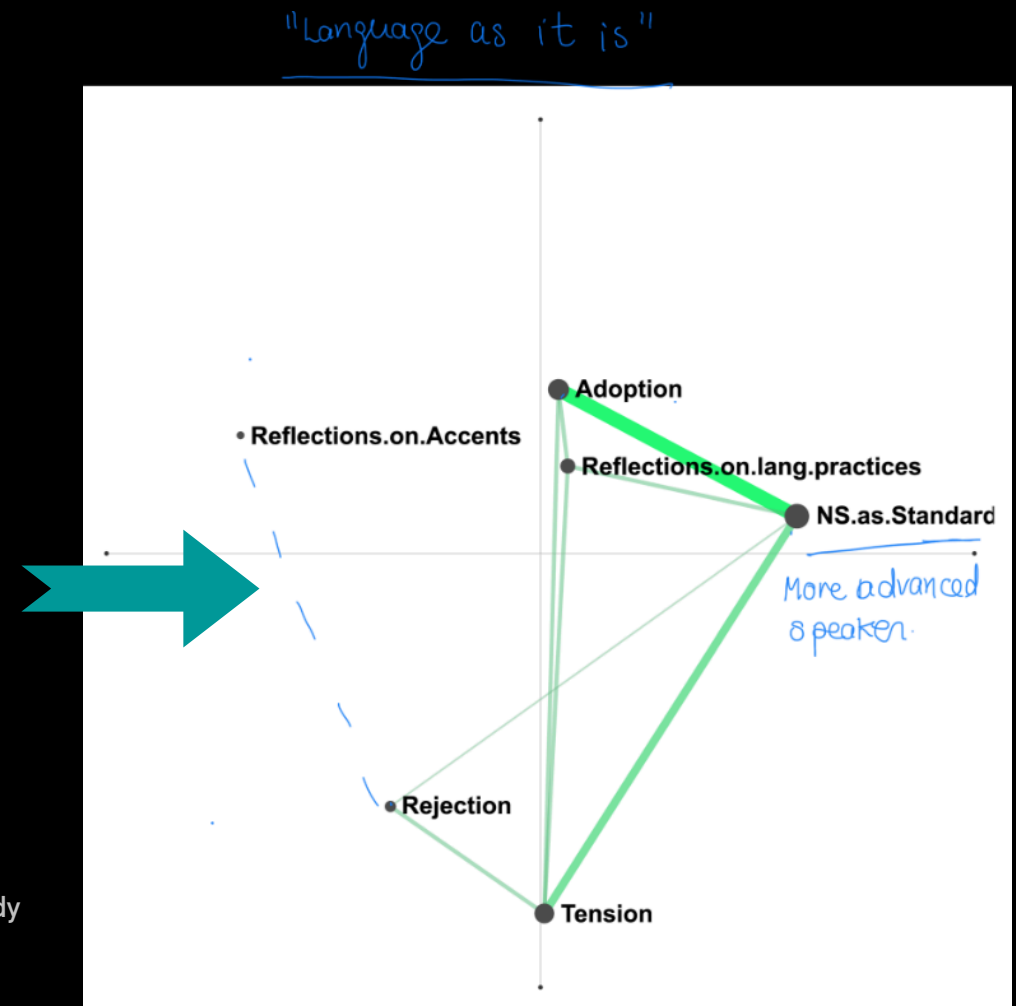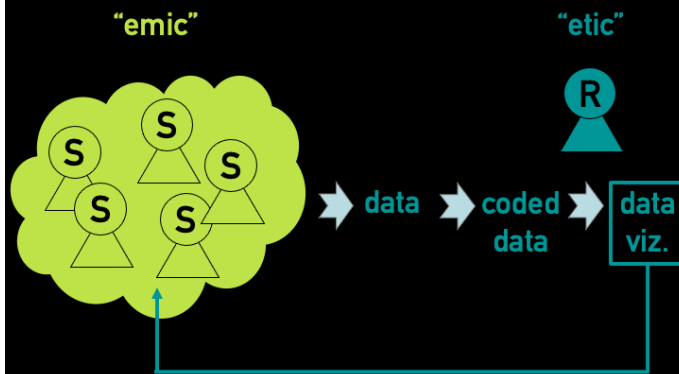
When we loop 'etic' back into dialogue with 'emic'

→ Stakeholders are given a voice to validate the analysis

→ The 'etic' could change the 'emic'

→ The 'emic' could change the 'etic'

Expanding the audience has consequences for QE visualizations

Computational offloading

Graphical constraining

Continuous internal/external cognition interplay

Shared focus of attention

Accessible, shared language for joint sensemaking

Additional narrative techniques
+ malleability → new meanings…

ONLY WORKS if the representation is
(i) intuitive and
(ii) editable

Software design implications?

As QE becomes embedded in interactive tools
to support work systems, we have to
think differently about QE visualizations

Now we're designing work systems

"emic"

"etic"

data   analysis

Work System
with a new Tool
and Users who may be different from the Stakeholders being analysed

Implications now we're designing work systems

QE is now part of a (hopefully) human-centred design process

→ increasing the diversity of voices in system design

→ changing the viz. design process (affordances vary with user expertise)

→ and the designed product (what Stakeholders/Users want to see and do in the tool)

→ …which will differ from QE researchers' viz. requirements

→ there is now no expert to provide additional narrative: it has to be in the tool

Scaffolding interpretation for non-experts in QE
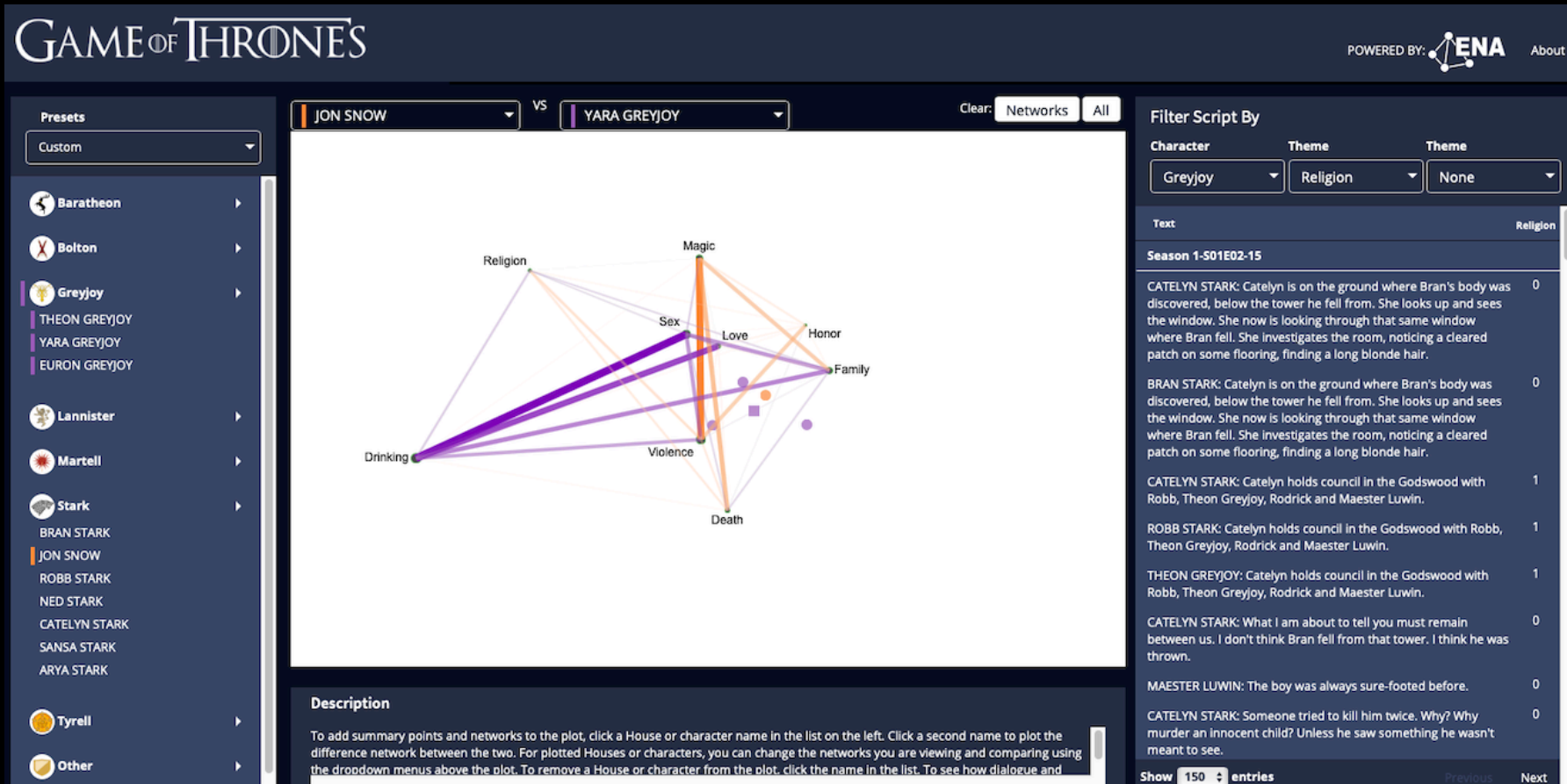
Swiecki, Z., Marquart, C., Sachar, A., Hinojosa, C., Ruis, A.R., Shaffer, D.W. (2019). Designing an interface for sharing quantitative ethnographic research data. In Eagan, B., Misfeldt, M., & Siebart-Evenstone, A.L, (Eds.) *Advances in Quantitative Ethnography: ICQE 2019*.

Embedding QE in a real-time dashboard (1)

Herder, T., Z. Swiecki, S. S. Fougt, A. L. Tamborg, B. B. Allsopp, D. W. Shaffer and M. Misfeldt (2018). Supporting teachers' intervention in students' virtual collaboration using a network based model. *Proc. 8th International Conf. Learning Analytics and Knowledge.* Pp.21–25. https://doi.org/10.1145/3170358.3170394

Embedding QE in a real-time dashboard (1)

Headline summarises key point

Nodes positioned for visual clarity, no semantics as in normal ENA

Herder, T., Z. Swiecki, S. S. Fougt, A. L. Tamborg, B. B. Allsopp, D. W. Shaffer and M. Misfeldt (2018). Supporting teachers' intervention in students' virtual collaboration using a network based model. *Proc. 8th International Conf. Learning Analytics and Knowledge.* Pp.21–25. https://doi.org/10.1145/3170358.3170394

Embedding QE in a real-time dashboard (2)

Overall status indicator re. the 'health' of a team's ENA network

Swiecki, Z., Ruis, A. R., & Shaffer, D. W. (2019). Modeling and visualizing team performance using epistemic network analysis. In B. S. Goldberg (Ed.), *Proc. 7th Annual GIFT Users Symposium (GIFTSym7)* (pp. 148-157). Orlando, Florida: U.S. Army Combat Capabilities Development Command—Soldier Center.

Embedding QE in a real-time dashboard (2)

Drill down for detail displays an interactive ENA linked to the transcript

Swiecki, Z., Ruis, A. R., & Shaffer, D. W. (2019). Modeling and visualizing team performance using epistemic network analysis. In B. S. Goldberg (Ed.), *Proc. 7th Annual GIFT Users Symposium (GIFTSym7)* (pp. 148-157). Orlando, Florida: U.S. Army Combat Capabilities Development Command—Soldier Center.

Embedding QE in a real-time dashboard (2)

Headline icon summarises overall status of network

Nodes positioned for visual clarity, no semantics as in normal ENA

Swiecki, Z., Ruis, A. R., & Shaffer, D. W. (2019). Modeling and visualizing team performance using epistemic network analysis. In B. S. Goldberg (Ed.), *Proc. 7th Annual GIFT Users Symposium (GIFTSym7)* (pp. 148-157). Orlando, Florida: U.S. Army Combat Capabilities Development Command—Soldier Center.

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Embedding QE in a post-hoc dashboard (1)

Headlines summarise key alerts
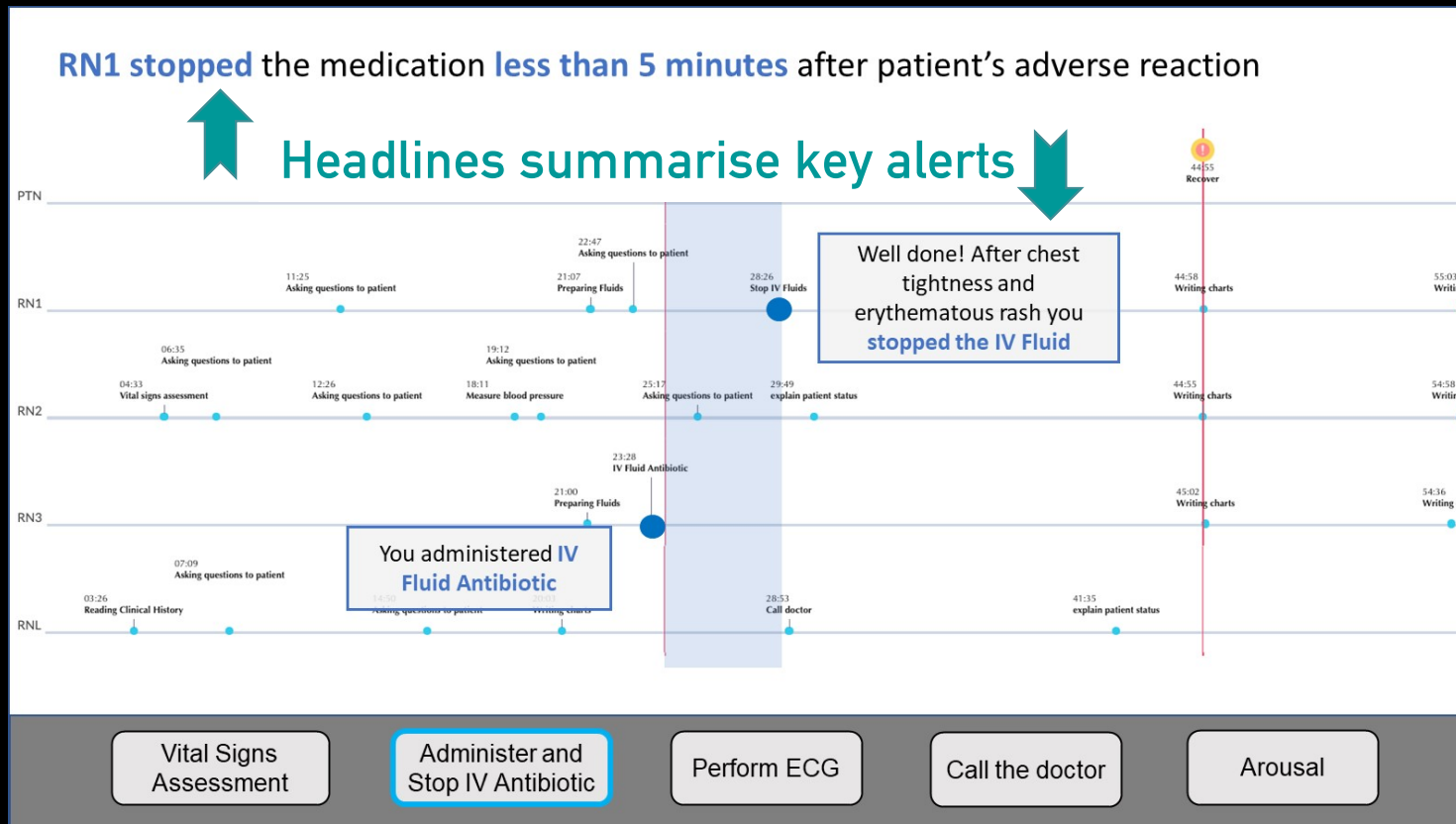
Martinez-Maldonado, R., Echeverria, V., Fernandez-Nieto, G. & Buckingham Shum, S. (2020). From Data to Insights: A Layered Storytelling Approach for Multimodal Learning Analytics. *Proc. ACM CHI 2020: Human Factors in Computing Systems*, Paper 21, pp.1-15. https://doi.org/10.1145/3313831.3376148

Embedding QE in a post-hoc dashboard (2)

ENA annotation of Spaces of Interest in the Simulation Ward
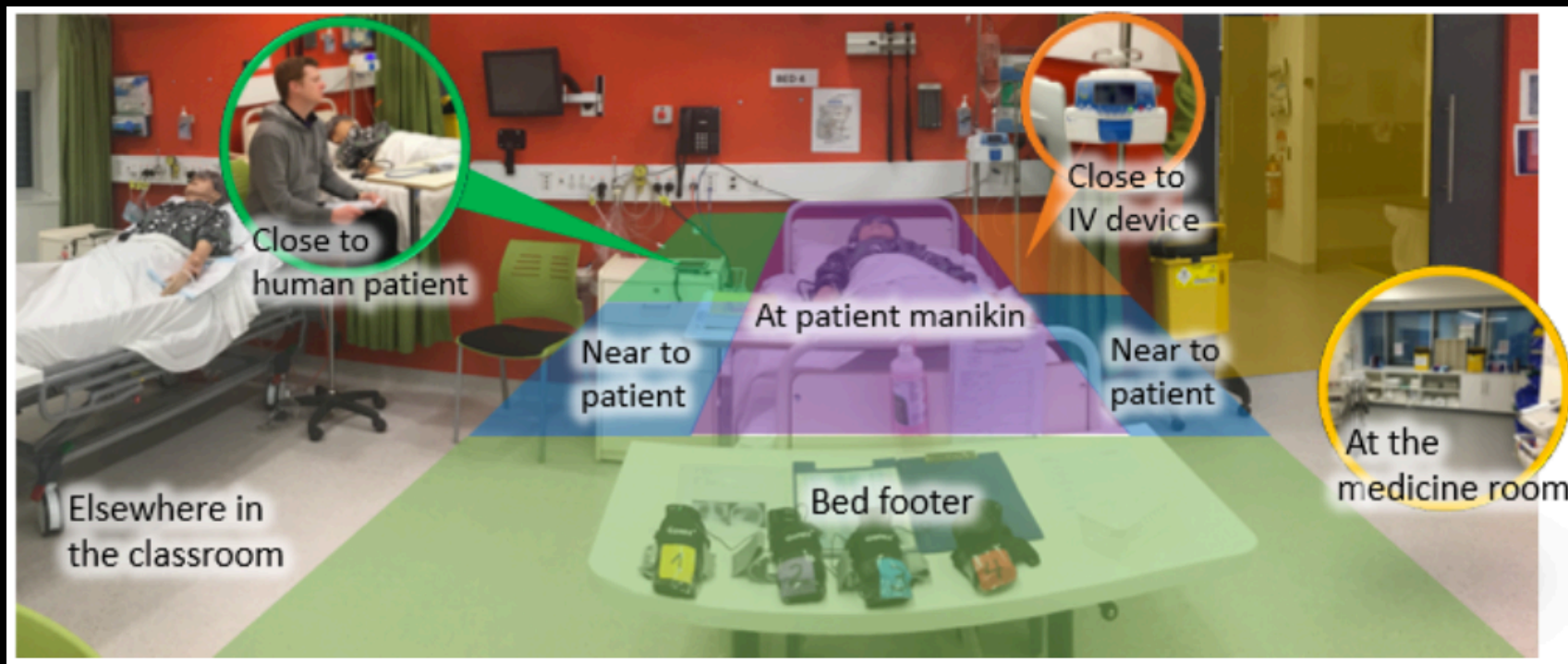
Fernandez-Nieto, G., Martinez-Maldonado, R., Kitto, K. & Buckingham Shum, S. (2021). Modelling Spatial Behaviours in Clinical Team Simulations using Epistemic Network Analysis: Methodology and Teacher Evaluation. *Proc. 11th International Conference on Learning Analytics & Knowledge.* https://doi.org/10.1145/3448139.344817

Embedding QE in a post-hoc dashboard (2)

Default ENA network: can nursing teachers interpret this?

Fernandez-Nieto, G., Martinez-Maldonado, R., Kitto, K. & Buckingham Shum, S. (2021). Modelling Spatial Behaviours in Clinical Team Simulations using Epistemic Network Analysis: Methodology and Teacher Evaluation. *Proc. 11th International Conference on Learning Analytics & Knowledge.* https://doi.org/10.1145/3448139.344817

Embedding QE in a post-hoc dashboard (2)
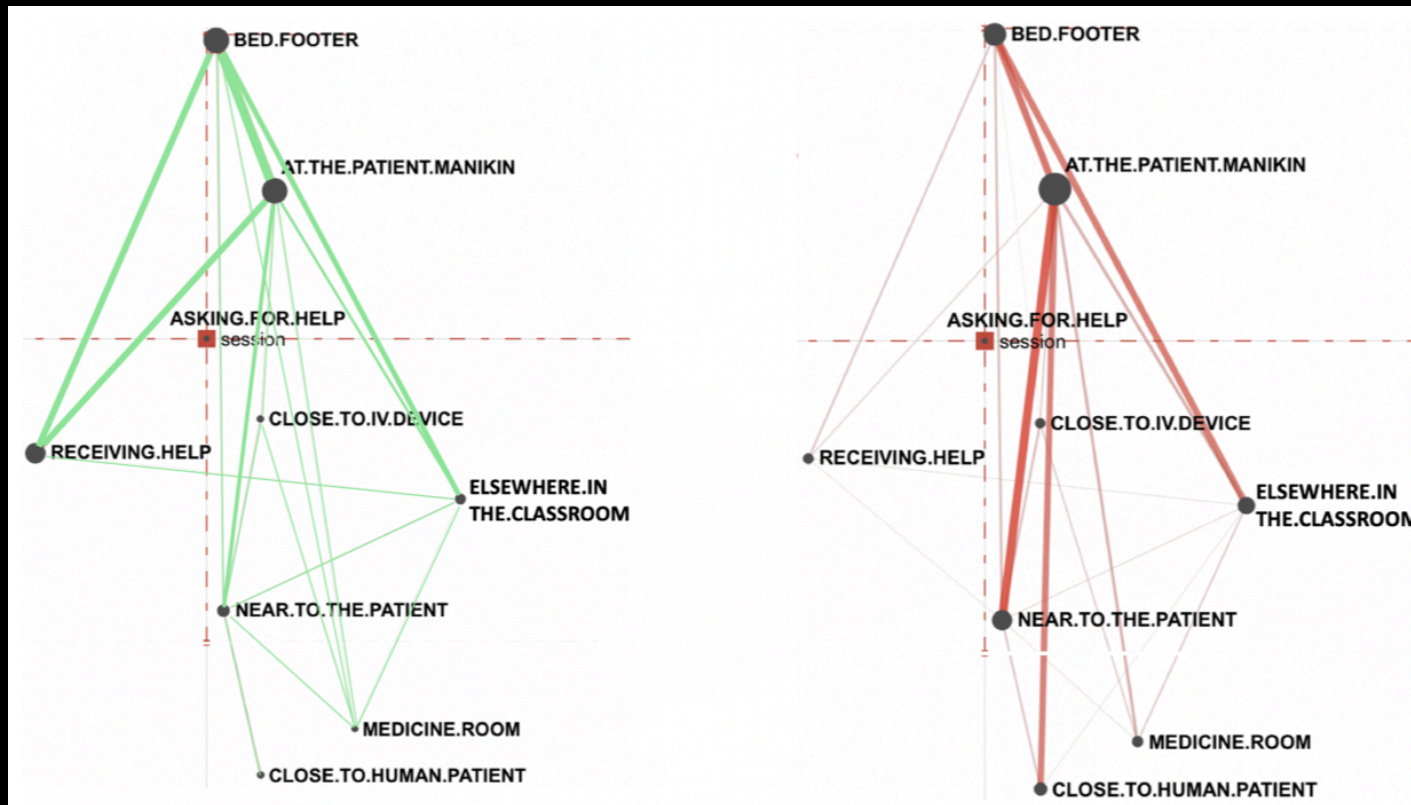
Default ENA network: can nursing teachers interpret this?
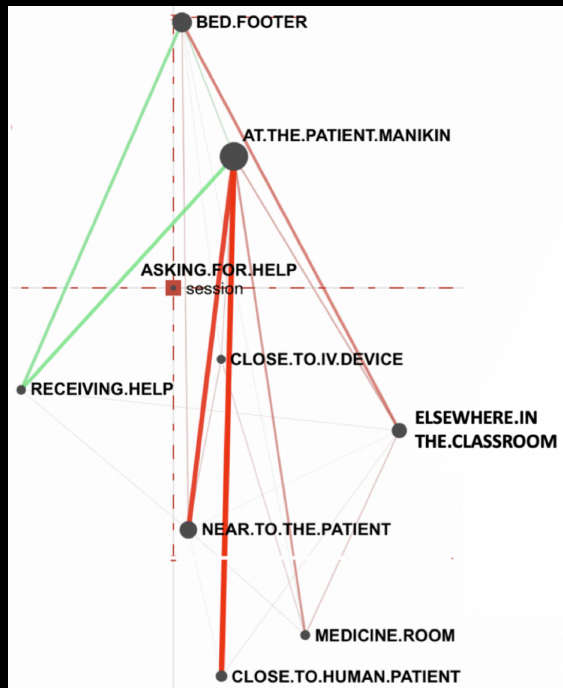
- Nodes, links, colours, thickness: intuitive after a brief introduction

- Team differences were 'read off' correctly, and validated against knowledge of the students

- Node names could be corrected

- 2 nodes should be combined

- A node needed to be split into 2 distinctive ones

- Clear incongruence between spatial location on the ward, and ENA node position

Fernandez-Nieto, G., Martinez-Maldonado, R., Kitto, K. & Buckingham Shum, S. (2021). Modelling Spatial Behaviours in Clinical Team Simulations using Epistemic Network Analysis: Methodology and Teacher Evaluation. *Proc. 11th International Conference on Learning Analytics & Knowledge.* https://doi.org/10.1145/3448139.344817

Embedding QE in a post-hoc dashboard (2)

Incongruence between spatial location on the ward, and ENA node position
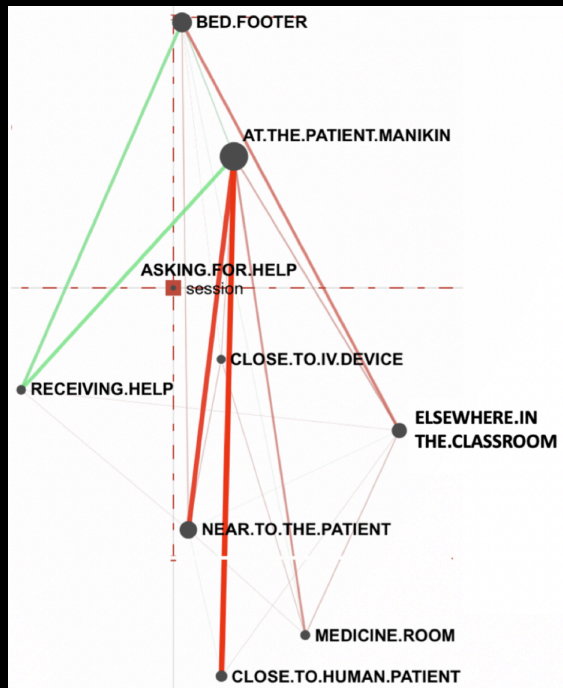
- Repeated reminders required emphasizing that node positions ≠ floorplan position

- One teacher thought the ENA seemed upside-down (medicine room is at the bottom)

- An edge passing close to a node was read as the student passed close to that location

- ENA node for the manikin patient was distant from the node for the human role-playing the patient's voice: nodes to be merged

Fernandez-Nieto, G., Martinez-Maldonado, R., Kitto, K. & Buckingham Shum, S. (2021). Modelling Spatial Behaviours in Clinical Team Simulations using Epistemic Network Analysis: Methodology and Teacher Evaluation. *Proc. 11th International Conference on Learning Analytics & Knowledge.* https://doi.org/10.1145/3448139.344817

Embedding QE in a post-hoc dashboard (2)

In the context of the nursing work system, switch to ENA-based annotation of a more intuitive visualization: the ward floorplan
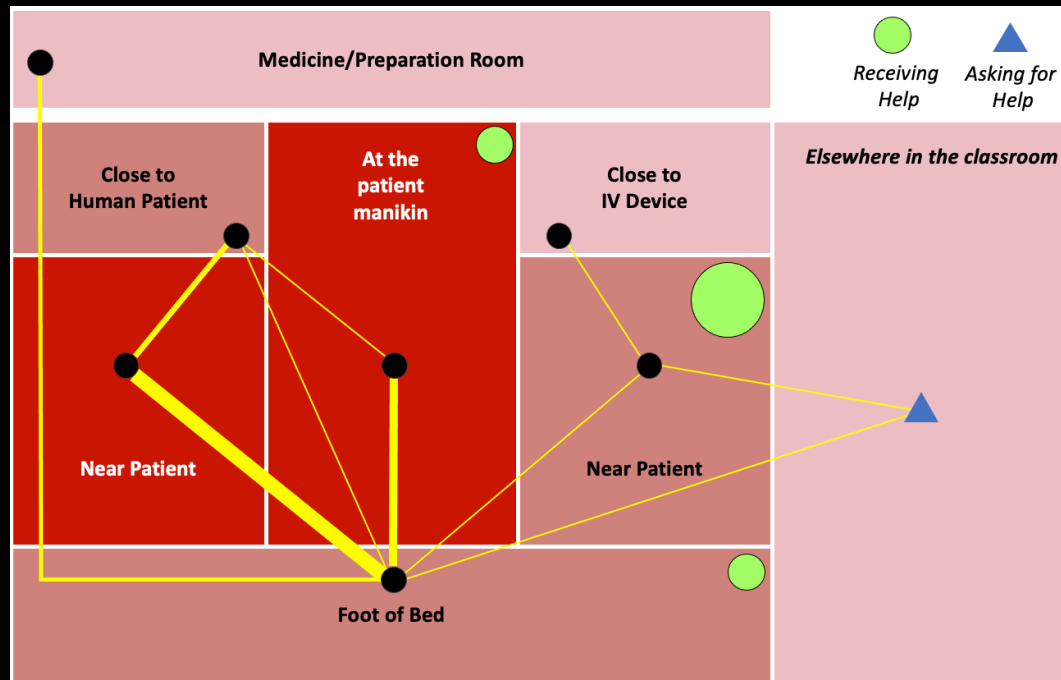
Mapping from ENA to new visual language:

ENA node size → colour saturation → a heatmap of spaces

ENA edge size → edges overlayed directly onto a floorplan → direct representation of nursing movements

Asking/Receiving Help nodes → *activity icons* in the relevant locations

Fernandez-Nieto, G., Martinez-Maldonado, R., Kitto, K. & Buckingham Shum, S. (2021). Modelling Spatial Behaviours in Clinical Team Simulations using Epistemic Network Analysis: Methodology and Teacher Evaluation. *Proc. 11th International Conference on Learning Analytics & Knowledge.* https://doi.org/10.1145/3448139.344817

Beyond networks

Interactively linked complementary representations

Might a heatmap of the underlying matrix add complementary value to what a network shows?

-8.3543	-12.213	-6.2443	0.54762	6.49059	12.1791	17.1265	13.3147	8.72477	5.57454	-5.419	-11.056
-9.1357	-10.364	-7.9723	-2.0709	3.25752	9.25487	10.5047	10.0693	5.93842	0.10855	-4.2426	-8.9772
-10.03	-4.3994	-1.5381	-0.9917	5.50332	10.2183	12.0818	10.9852	7.78772	-0.9624	-4.565	-5.9784
-5.8522	-12.397	-6.4213	0.71863	4.45775	10.1257	12.3534	11.153	7.7367	2.67381	-6.36	-10.344
-10.516	-7.2414	-4.5504	-1.9349	6.1935	12.8053	13.4849	11.15	7.12994	-1.5638	-4.2637	-5.0698
-7.1403	-7.5811	-7.0634	1.39558	6.27321	11.5314	13.6839	11.0818	7.46333	2.59721	-2.1433	-8.3837
-10.102	-7.1038	-2.8856	0.41319	3.97617	10.7921	11.9424	9.60489	6.76179	4.90051	-1.9044	-9.3386
-7.6858	-7.2163	-6.6125	-0.0338	4.66616	9.93005	13.4693	12.4432	7.07872	3.98231	-6.5729	-6.09
-5.7249	-9.7196	-7.8271	-2.173	2.82495	10.6924	12.7172	11.3539	7.49738	4.46687	-7.5825	-7.8804
-8.8359	-4.1731	-3.0441	0.69943	6.55223	11.2132	12.8189	11.7673	7.89824	2.02551	-5.1296	-7.3773
-7.5601	-7.6682	-4.4109	0.14203	7.39306	10.2342	12.8152	13.4854	8.24471	0.62016	-4.5175	-4.3867
-13.274	-11.335	-3.3422	-0.7771	5.27991	11.6112	14.8408	12.2349	6.2614	0.37632	-4.4787	-6.1484
-11.695	-6.4603	-3.6239	1.0698	6.31972	10.9803	14.0629	11.9099	7.75803	1.77744	-0.9825	-9.308
-8.6275	-5.2532	-5.2891	1.93473	5.36766	11.7437	16.6909	12.2624	7.85701	1.43301	-4.1818	-5.5088
-11.904	-8.4983	-8.3857	0.03352	4.15879	9.09481	13.5183	11.4789	6.23943	0.24375	-6.2976	-15.672
-8.2113	-7.8551	-7.789	0.2695	4.56149	10.2042	15.1734	10.6485	6.29317	-0.2718	-1.6583	-7.4736
-14.062	-10.974	-9.5847	-2.6376	4.58236	13.2043	12.6525	14.6893	7.56509	2.43389	-3.7641	-9.2942
-13.532	-7.3955	-3.9794	0.74686	6.37134	9.90527	14.4321	11.3667	6.61188	3.48346	-0.5722	-7.9366

ENA Data-to-Text?
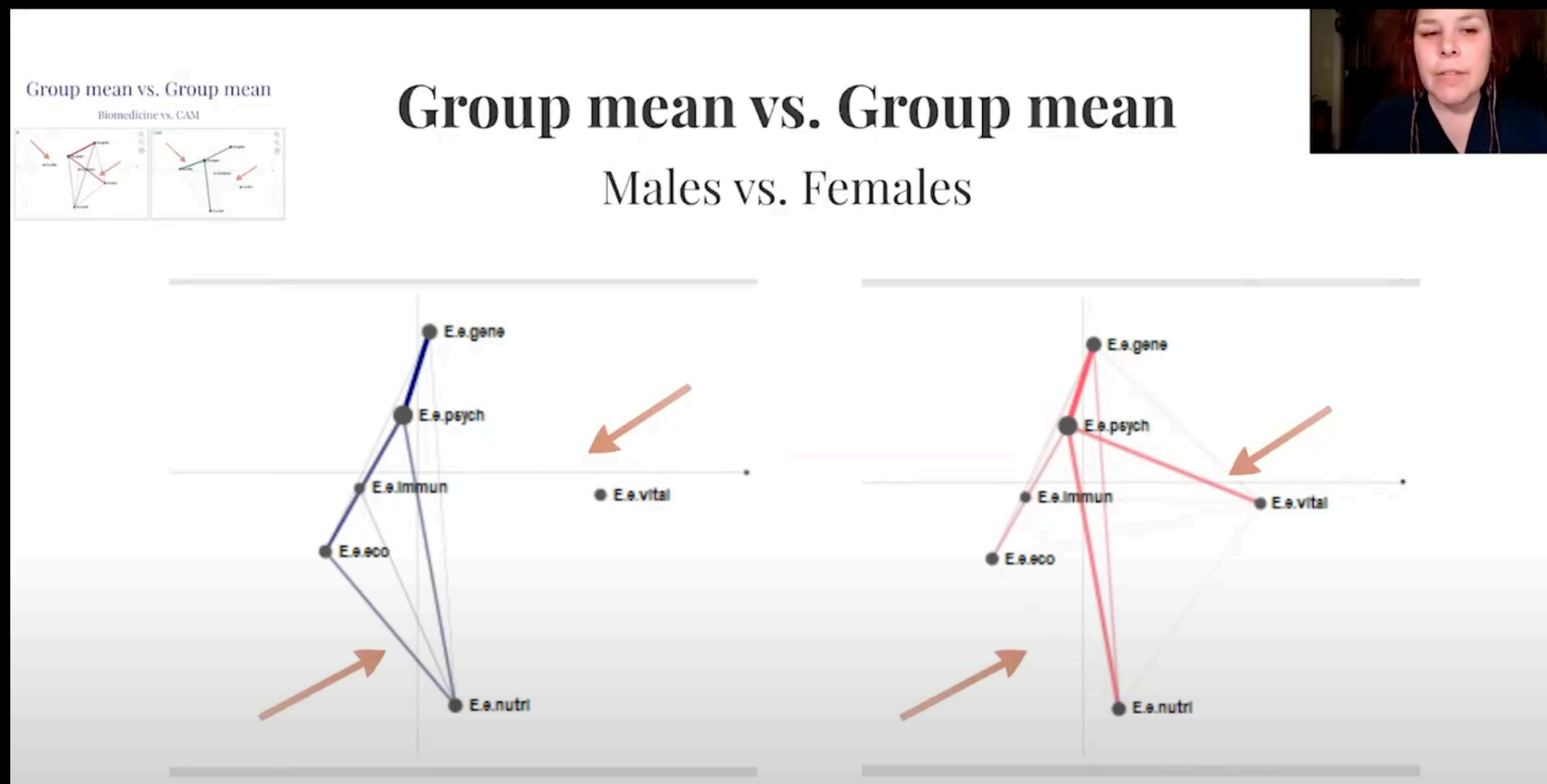
ENA Data-to-Text → prose summaries?

Szilvia Zörgő & Gjalt-Jorn Peters:
https://www.qesoc.org/webinar-archives/#webinar-1

"We can compare males and females, and looking at those two networks, we can see that vitalism is very much a female thing."
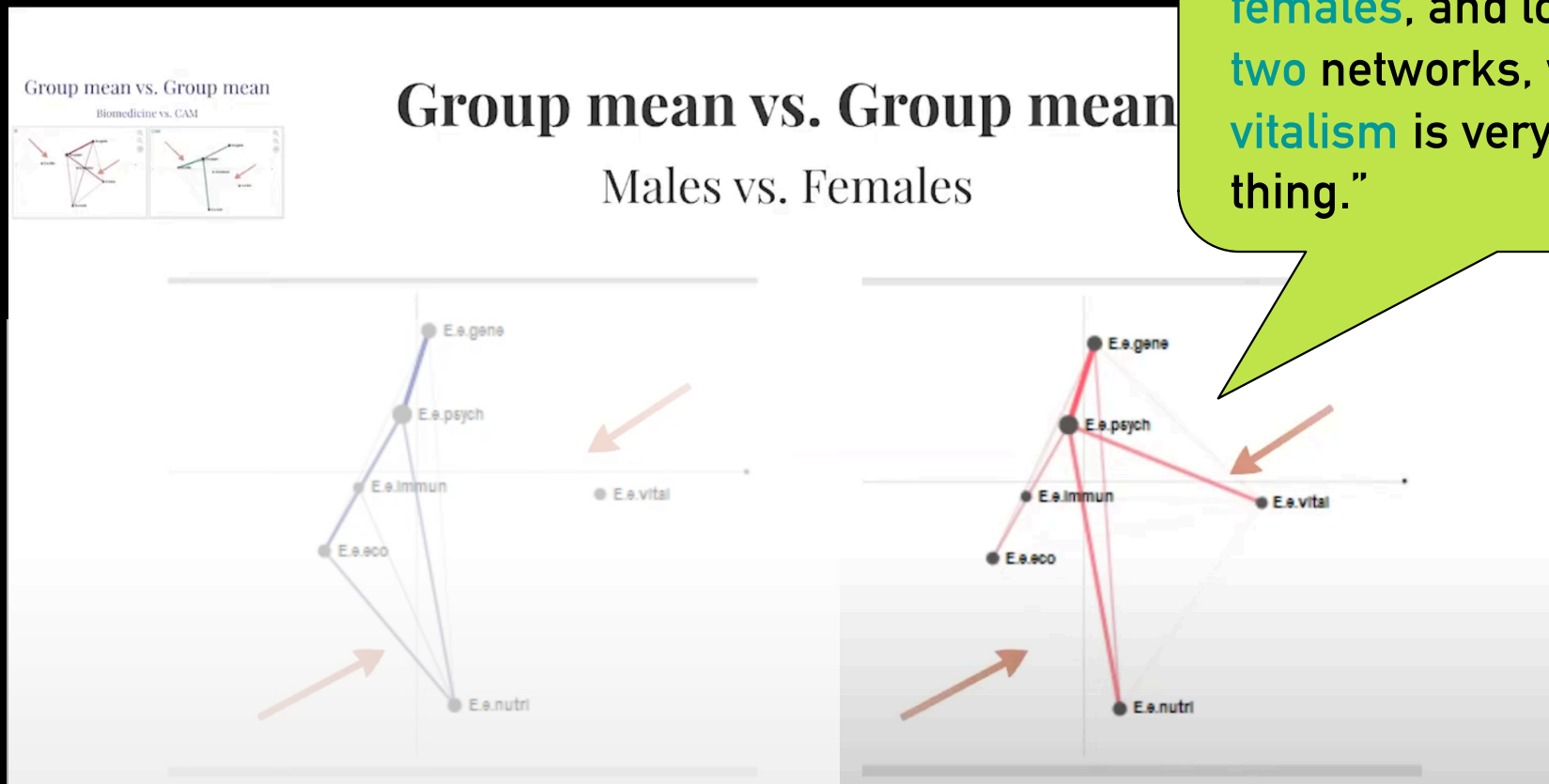
ENA Data-to-Text → prose summaries?

Szilvia Zörgő & Gjalt-Jorn Peters:
https://www.qesoc.org/webinar-archives/#webinar-1
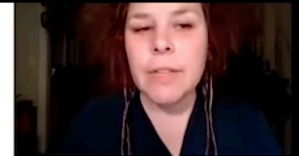
"And we can see that in contrast males emphasize the connection between ecological factors and nutritional factors."
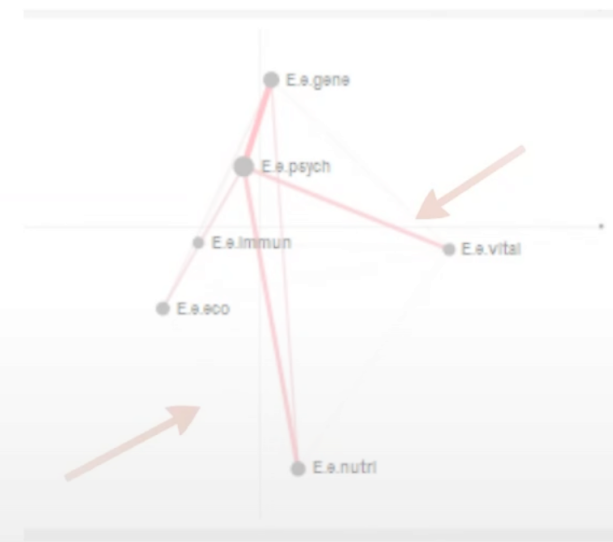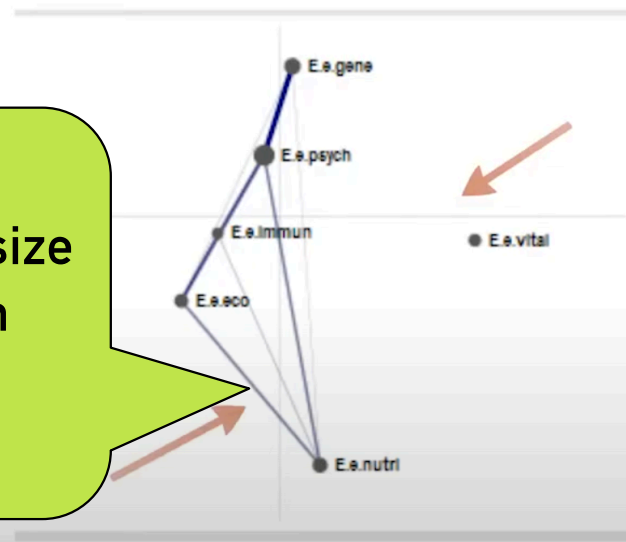
ENA Data-to-Text → prose summaries?
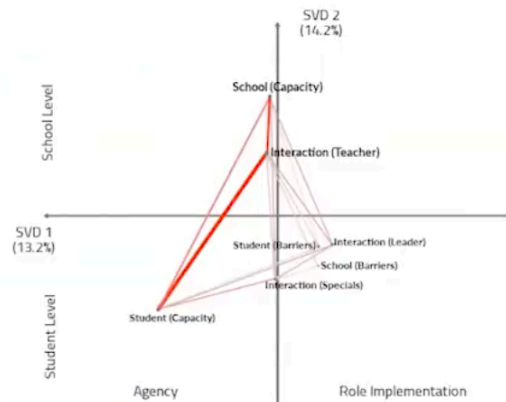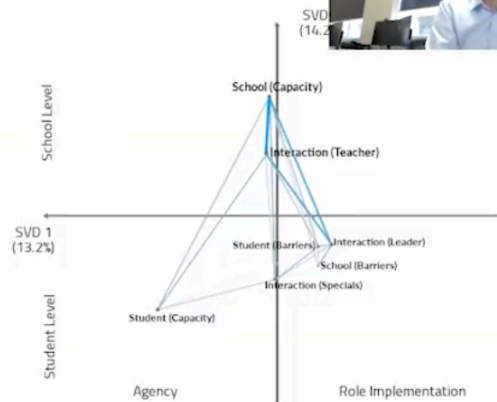
Srecko Joksimovic:
https://www.qesoc.org/webinar-archives/#webinar-5

"The results show significant differences between teachers, when acting as agents, compared to acting as role implementers."

ENA Data-to-Text → prose summaries?

Srecko Joksimovic:
https://www.qesoc.org/webinar-archives/#webinar-5

"The epistemic frame for agency indicates a strong connection between Inclusive Pedagogy and Interactions with Teachers, evidenced with those thicker lines between School Capacity, Student Capacity and Teacher Interaction."
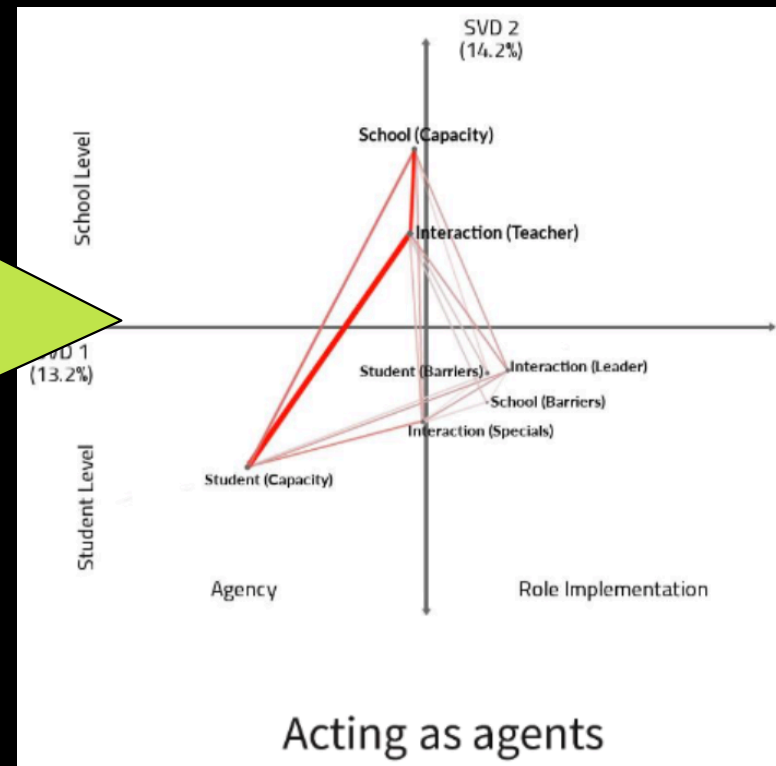
In a future ENA tool…?

We don't have to choose
between representations

We can offer them all,
and link them interactively

More participatory QE, and HCD of "QE Inside" tools, requires a new skillset

Fluency using QE visualizations for participatory sensemaking

…clues from the Knowledge Art framework

Let's revisit the earlier examples

"emic"

"etic"

data → coded data → data viz. → papers talks

Maths   Science   I.T.

"Language as it is"

Adoption

Reflections.on.Accents

Reflections.on.lang.practices

NS.as.Standard

More advanced speaker

Rejection

Tension
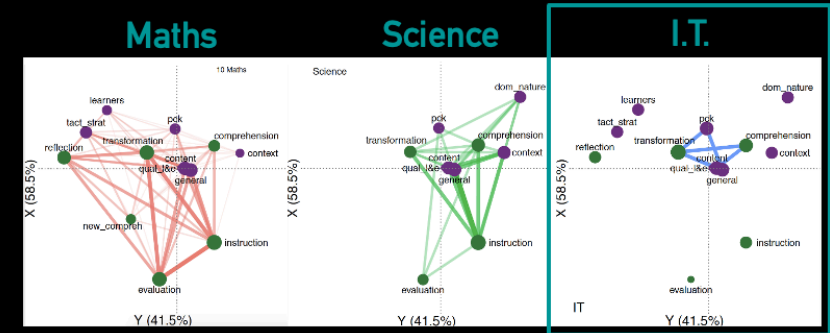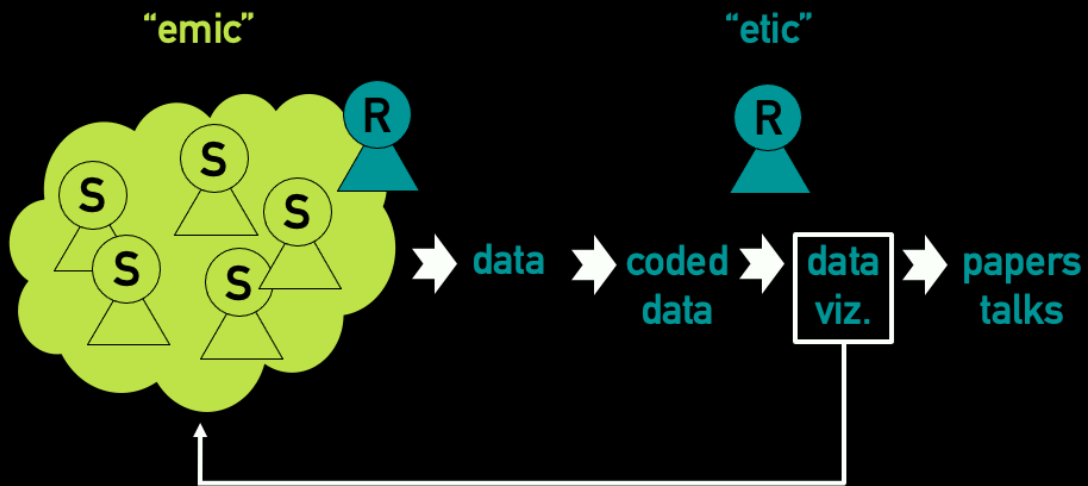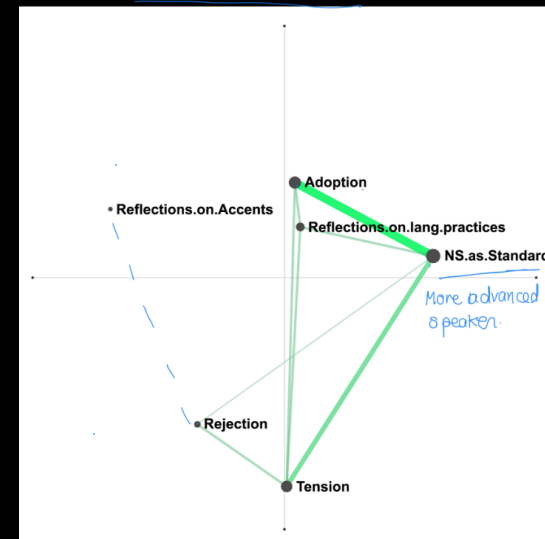
Should QE researchers be encouraging this sort of conversation? Should our tools support it?

That node name isn't quite right, we'd normally refer to…

Why isn't there a link there? Can I just add that now?

These 2 nodes are really the same thing, let's merge them, and then we can see much more clearly…

Let's make that green link much thicker, so we can see the contrast with red clearly

This node is confusing two things, it's best split up. Now we can discuss their different links

Knowledge Art framework: the focal activity

The **facilitation skillset**

of crafting **participatory**

visual representations

to facilitate **joint sensemaking**
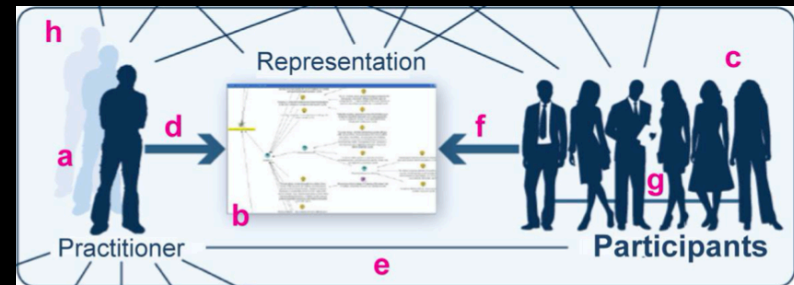
Knowledge Art framework: work system tools

The **facilitation skillset**

of crafting **participatory**

visual representations

to facilitate **joint sensemaking**
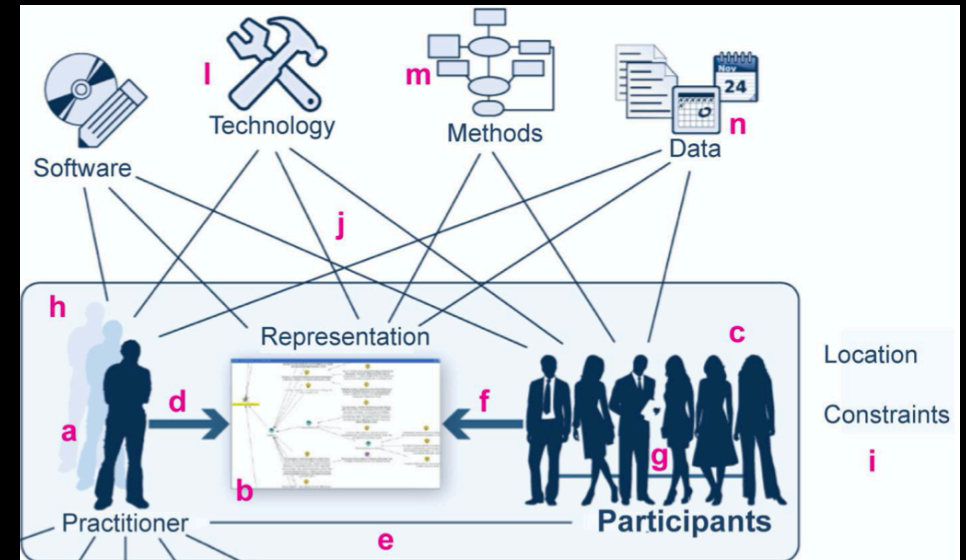
Knowledge Art framework: critical fluencies

The **facilitation skillset**

of crafting **participatory**

visual representations

to facilitate **joint sensemaking**
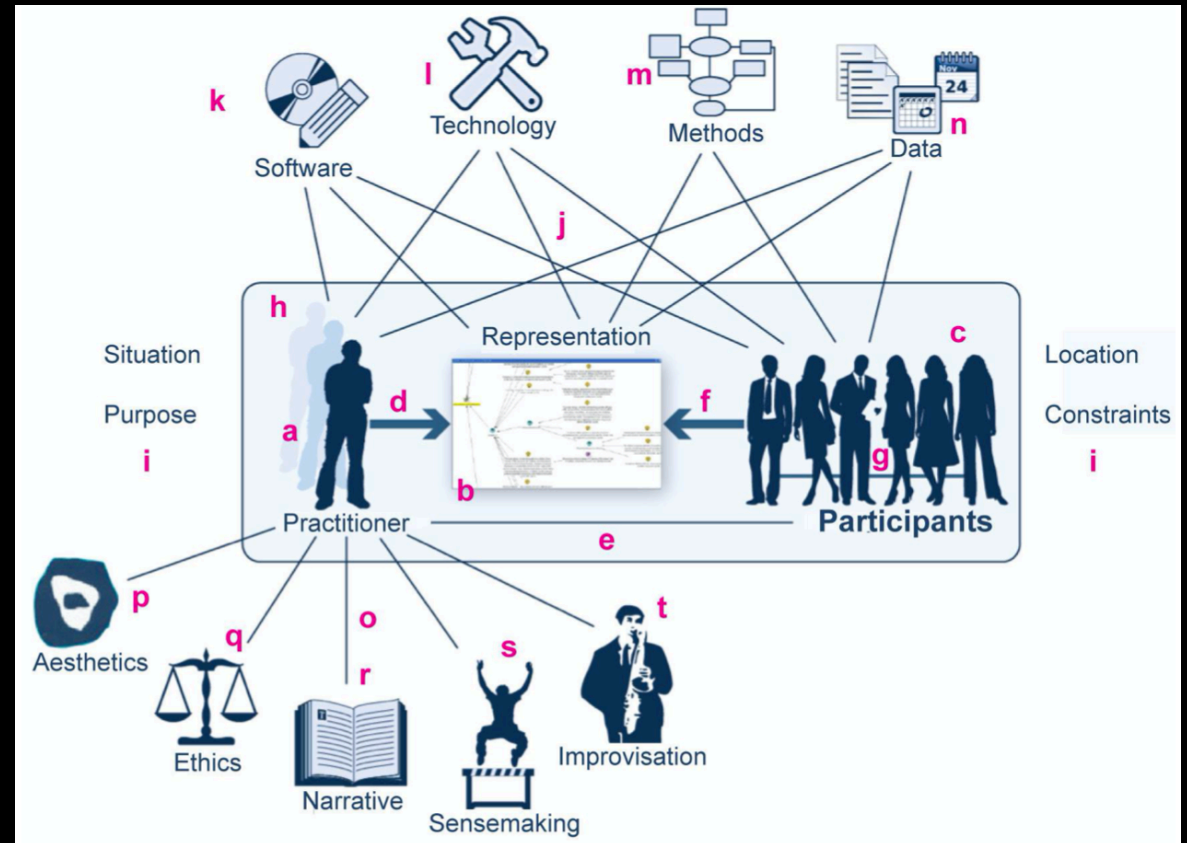
Knowledge Art framework: critical fluencies

Aesthetics. The choices we make for shaping a visualisation – what's foregrounded, excluded, how polished, how editable…

Ethics. How our moves affect the other stakeholders: recognise/ignore their contribution, change meaning, shift topic…

Narrative. The context for a session: spoken/unspoken expectations of why we're here, how we should proceed, what kinds of meanings will be made, or outputs produced…

Sensemaking. How we interpret unexpected events or anomalies

Improvisation. How well we make spontaneous, unplanned moves with the visualisation when breakdowns occur

Knowledge Artistry for more participatory QE?

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- "Raw viz" (direct from the tool, as used by QE researchers) or a simplified version, more accessible to lay people?

- Does a fixed or malleable viz open up more productive conversations? What's editable?

Knowledge Artistry for more participatory QE?

Aesthetics. The choices we make for shaping a visualisation – what's foregrounded, excluded, how polished, how editable…

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- Does a visualization empower or disempower stakeholders? Amplify or muffle their voices?

- If the viz tool can't reflect someone's feedback, what are we saying to them?

- When does the QE researcher change the topic of conversation in order to focus on un-explored parts of the viz?

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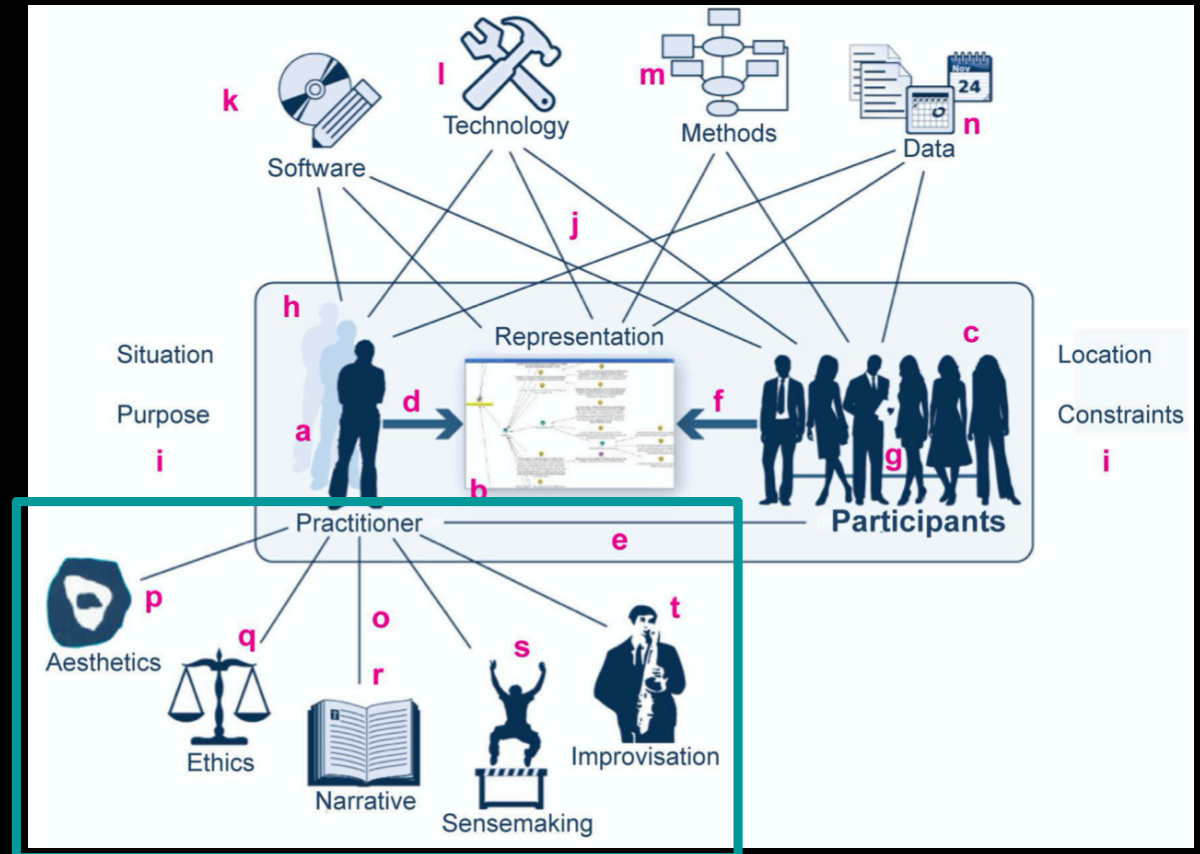# Knowledge Artistry for more participatory QE?

Aesthetics. The choices we make for shaping a visualisation – what's foregrounded, excluded, how polished, how editable…

Ethics. How our moves affect the other stakeholders: recognise/ignore their contribution, change meaning, shift topic…
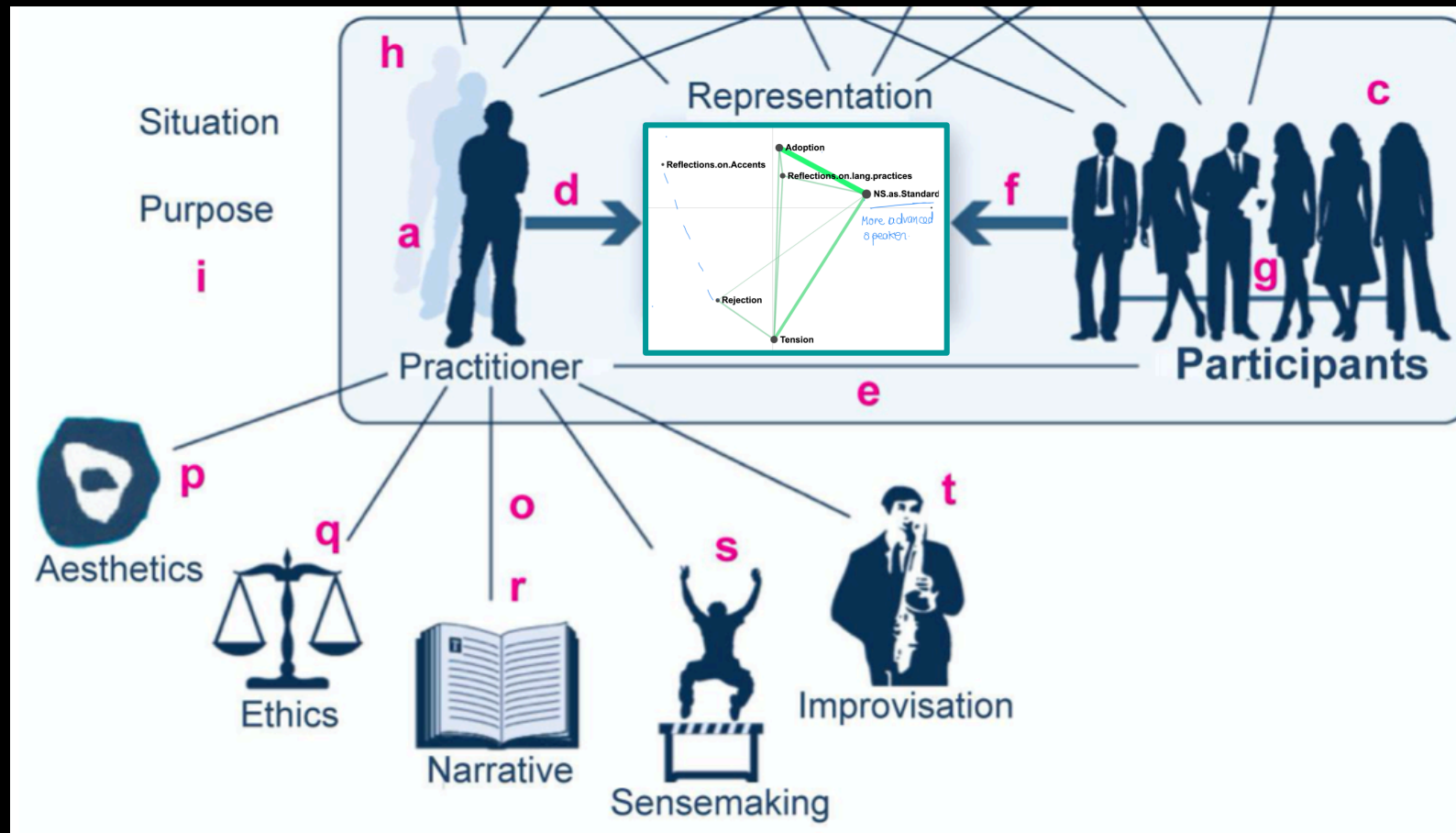
Narrative. The context for a session: spoken/unspoken expectations of why we're here, how we should proceed, what kinds of meanings will be made, or outputs produced…

Sensemaking. How we interpret unexpected events or anomalies

Improvisation. How well we make spontaneous, unplanned moves with the visualisation when breakdowns occur

- What are the power dynamics and trust levels?

- Are we here only to validate the QE researchers' story, or to elicit new stories?

- Are the stakes high? Will this viz shape future narratives? (e.g. impact people, agendas, arguments…?)

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Knowledge Artistry for more participatory QE?

Aesthetics. The choices we make for shaping a visualisation – what's foregrounded, excluded, how polished, how editable…

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- "This is the wrong ENA: can you display the ENA for teams 1–3 + 23, masking dimensions D1+D2, with comparable link weights"

- How do we handle surprise and discontinuity: what do we do if the viz conflicts with their understanding?

- Sketching and tinkering are ways to articulate and sharpen emerging thoughts: is this representationally possible, and encouraged?

Knowledge Artistry for more participatory QE?

Aesthetics. The choices we make for shaping a visualisation – what's foregrounded, excluded, how polished, how editable…

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- "Disciplined improvisation" combines pre-defined, structured methods with creative, spontaneous ones: our software toolkits need to facilitate this…

- What is our improvisational repertoire with the representations?

- What's the learning curve?

Knowledge Art: learn more…

Al Selvin: Open University 2011 PhD seminar:
http://simon.buckinghamshum.net/2011/12/making-representations-matter-al-selvin-phd

Knowledge Art blog:
http://knowledgeart.blogspot.com

Selvin, A., Buckingham Shum,S.J. & Aakhus, M. (2010). The Practice Level in Participatory Design Rationale: Studying Practitioner Moves and Choices. *Human Technology* (Special Issue on Creativity and Rationale, Ed. John Carroll), 6, (1), pp. 71–105.
https://humantechnology.jyu.fi/archive/vol-6/issue-1
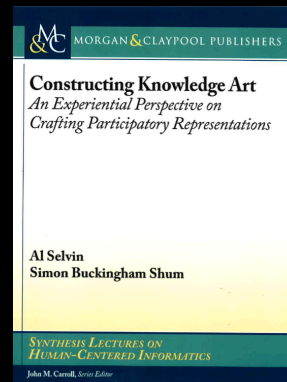
Selvin, A. & Buckingham Shum, S. (2015). *Constructing Knowledge Art: An Experiential Perspective on Crafting Participatory Representations.* Morgan Claypool (Synthesis Lectures on Human-Centered Informatics).
https://doi.org/10.2200/S00593ED1V01Y201408HCI023

Selvin, A. (2011). *Making Representations Matter: Understanding Practitioner Experience in Participatory Sensemaking.* Doctoral Dissertation, Knowledge Media Institute, The Open University, Milton Keynes, UK. http://oro.open.ac.uk/30834
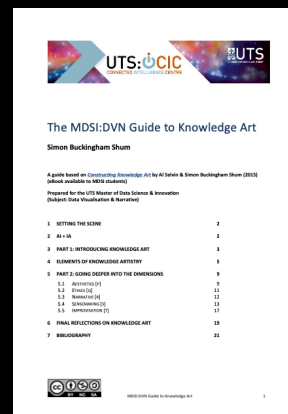
Open Educational Resources

UTS Master of Data Science & Innovation:
"Data, Narrative & Visualization" course: 2016, 2019

http://simon.buckinghamshum.net/2019/05/knowledge-art-learning-resources

To wrap up…

Sneak preview of the ICQE 2022 program?...

"Is a picture worth a thousand words? Teacher's preferences for ENA-generated prose versus networks"

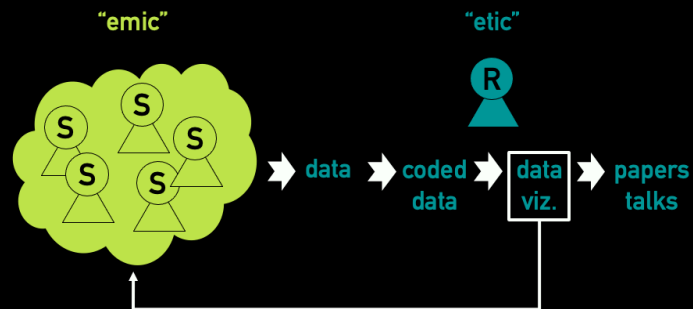"QEviz 2.0: Video plus linked, interactive QE visualizations"

"'Sorry, but that's not how we do things…' The politics of adapting QE visualizations in response to stakeholder feedback"

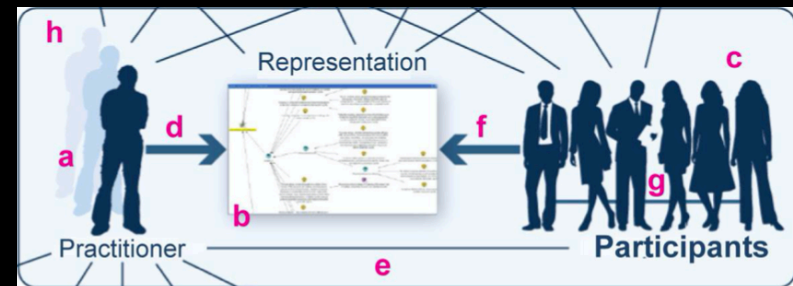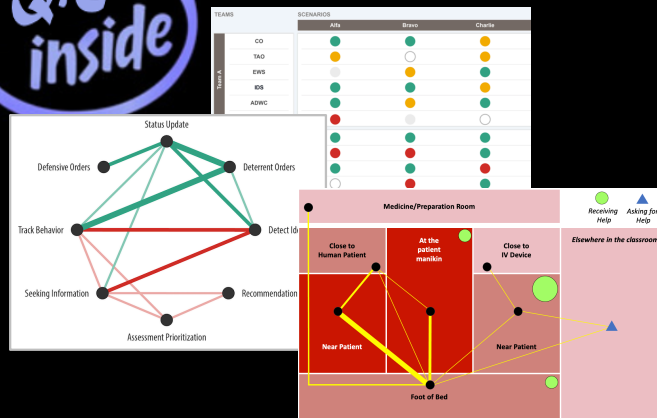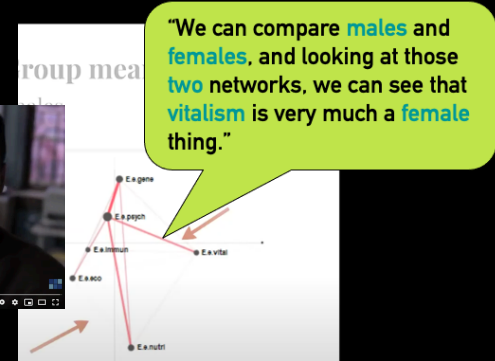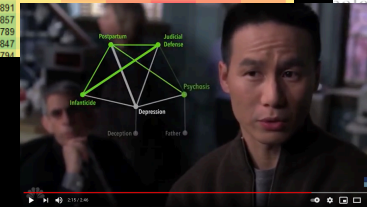"Integrating QE analytics into an ER-Nursing handover support tool: design challenges and empirical evaluation"

I hope my dishes didn't give you indigestion

Perhaps they'll go well with one you brought

To summarise…

Thank You… Discussion!…