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)
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

→ a fascination with how software helps make thinking visible

…and how thinking is shaped by (semi)formal, interactive representations

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

The Compendium as a science sensemaking tool is a project that aims to improve collaborative work and knowledge sharing among scientists and researchers. The project, funded by NASA, involves the development and field testing of a mobile agent system designed to support real-time collaboration during mission operations.

The Compendium system provides a platform for scientists to share, collaborate, and make sense of data and information in real-time, enhancing decision-making processes and improving the efficiency of scientific endeavors.

The project draws on various technologies and methodologies to achieve its goals, including advanced knowledge technologies, mobile agents, and distributed computing. By leveraging these technologies, the Compendium aims to create a dynamic and interactive environment that supports effective communication and knowledge management in scientific research.

In summary, the NASA Field Trials (Mobile Agents Project) represents a significant endeavor in the realm of technology-enhanced collaboration, with the Compendium acting as a key tool to facilitate scientific sensemaking and decision-making in real-time operational contexts.

For more information, visit the project website at http://projects.buckinghamshum.net/NASA_EPSRC_Mars.
Visualizations as Tools for Thinking
Example visualization: London Underground Map

https://theconversation.com/sublime-design-the-london-underground-map-26240
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
But what are a visualization’s cognitive affordances?
A visualization’s meaning is emergent from its interaction with a given viewer

“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.”

Internal cognition is augmented by external cognition — 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

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://gesoc.org/webinar-archives/#webinar-7
Exploiting our ability to detect visual changes

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

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](https://qesoc.org/webinar-archives/#webinar-7)

Unit: individual
Stanza window: 6
Conversation: design discussion of each task
*Static scaffold group*
*Adaptive scaffold group*
Design a gallery and highlight features to focus attention

Bian Wu: https://qesoc.org/webinar-archives/#webinar-7

Unit: individual
Stanza window: 6
Conversation: design discussion of each task
Static scaffold group
Adaptive scaffold group
Animated ENA + synchronized video is compelling

Epistemic Analytics Lab: “Law & Order” ENA-annotated clip

https://www.youtube.com/watch?v=wrTiXNleHZA
Animated ENA + synchronized video is compelling

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

https://youtu.be/Sy-gwY3SxQ0

https://youtu.be/Sy-gwY3SxQ0
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”

Stakeholders

Researchers

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
(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.”
“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…”
“[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.”

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”

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

“etic”

data
analysis

R
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

Embedding QE in a real-time dashboard (1)

Embedding QE in a real-time dashboard (1)

**Embedding QE in a real-time dashboard (2)**

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

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<th>Charlie</th>
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Embedding QE in a real-time dashboard (2)

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

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

Embedding QE in a real-time dashboard (2)

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

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Embedding QE in a post-hoc dashboard (1)

Roberto Martinez-Maldonado et al: https://www.qesoc.org/webinar-archives/#webinar-8

Headlines summarise key alerts

RN1 stopped the medication less than 5 minutes after patient’s adverse reaction

Well done! After chest tightness and erythematous rash you stopped the IV Fluid

You administered IV Fluid Antibiotic

Vital Signs Assessment  Administer and Stop IV Antibiotic  Perform ECG  Call the doctor  Arousal

Embedding QE in a post-hoc dashboard (2)

ENA annotation of Spaces of Interest in the Simulation Ward

Embedding QE in a post-hoc dashboard (2)

Default ENA network: can nursing teachers interpret this?

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

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

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

Beyond networks

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

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</table>
ENA Data-to-Text?

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

Group mean vs. Group mean
Males vs. Females
“We can compare males and females, and looking at those two networks, we can see that vitalism is very much a female thing.”
“And we can see that in contrast males emphasize the connection between ecological factors and nutritional factors.”
“The results show significant differences between teachers, when acting as agents, compared to acting as role implementers.”
“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.”

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

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

- 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?
Knowledge Artistry for more participatory QE?

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

• “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?

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

• “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

https://humantechology.jyu.fi/archive/vol-6/issue-1

https://doi.org/10.2200/S00593ED1V01Y201408HCI023


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...

"We can compare males and females, and looking at those two networks, we can see that vitalism is very much a female thing."

Thank You... Discussion!...