Unravelling complex systems

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Imagine a scenario where diagraming techniques are being used to support design, development, analysis of risk or consideration of inclusivity. How do practitioners define a system boundary, choose an appropriate tool and understand when it is right to use methods developed for application in another industry? Through a workshop, we consulted experts to understand how they use 'systems mapping' techniques from healthcare and beyond. Does a picture really paint a thousand words? When analysing systems, is it possible to avoid getting bogged down in organisational complexity or outpaced by the speed of change?

Given the dynamic and sometimes intangible aspects of sociotechnical systems, we were interested in what can be learnt from the experience of those who conduct systems mapping. For example, how are system boundaries defined, tools selected and methods transferred between industries? In the future, we are intending to develop a resource for IEHF members that lists some relevant techniques and provides a quick guide to application. In the meantime, here are some of the points that came up.

Define a clear system boundary

It's important to carefully consider the limits of the analysis. A clear, tangible and reasoned system boundary is needed. For example, analysis can be focussed on a single equipment type:

"…things surrounding infusion pumps, for example, it is neat and tight, there is a clear start point in the interaction between the human and the infusion pump, there is a clear end point when it is turned off."

Standards suggest that boundaries can be set using facility layouts, naturally occurring entities, geographical constraints or other separable units. These could include structures relating to software, hardware, process, procedure or the organisation as a whole. It is also important to state what is inside the system boundary, as well as what is outside of it. There is a risk of setting too small a boundary and missing critical influences, for example, a finance department not paying a supplier. Alternatively, there is a potential to set the boundary too wide, and then lose focus, for example, failing to complete an analysis prior to the system of interest changing.

An illustrative metaphor, relating to risk analysis, would be that of a spotlight illuminating the system of interest. A focussed, narrow beam would provide a very detailed description of a specific aspect. A wider beam would reveal more of the system but in less detail. This also applies to constraining analysis within the system. Stopping rules or generic principles may help, for example, expanding to a predetermined number of levels, or stopping when the analysis reaches a specific component type.

Choose the right method(s) and avoid becoming overwhelmed

In other industries, there are frameworks that can be applied to structure analysis. Examples include MODAF (Ministry of Defence Architectural Framework), which allows information about business systems to be captured and organised using a set of common rules. MODAF is used for the production of enterprise architectures and provides the advantage of being able to switch between strategic, operational or technical views.

Selecting the right technique given constraints on time and resource is important. Mismatches run the risk of those involved becoming 'lost' in the analysis. For example, even tried and tested techniques, such as the Unified Modelling Language (UML), can result in representations containing an overwhelming level of organisational complexity. UML supports development of object-orientated software and has the benefit of being widely recognised and adopted. Unfortunately there may be issues scaling to large and dynamic systems:

"So Universal Modelling Language, I'm trying to use that for work we are doing on risks and collaborative working…it seemed like it was going to be great and then we got lost in the number of swim lanes, basically we had about three Olympic sized swimming pools of swim lanes."

Along similar lines, modelling languages such as IDEF (Integration DEFinition) can be used to represent information exchanges

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between organisational units. IDEF has the benefit of being applicable to a wide variety of systems. At the functional level, if there are inefficiencies or gaps in transfer, they can be highlighted.

If the aim is to represent decision-making and action in dynamic organisations, or to take into account cognitive aspects, Cognitive Work Analysis (CWA) may be of use. CWA is a constraint-based framework, frequently applied to complex sociotechnical systems. It is a powerful method, but difficult to apply and often long winded. There may be a need for large amounts of upfront investment, sometimes for limited payback. This is coupled with difficulties in anticipating what systems will look like in the future. For example, within the context of hazard analysis in healthcare, where the aim is to spot potential failures, the task at hand is huge:

"…but we're talking about systems that are failing so much, all the time, the idea of spotting where something might fail in the future is almost ridiculous."

Be careful when transferring techniques across industries

Healthcare brings unique circumstances. This means that approaches used by other domains may not be applicable:

"I think the MOD type of example, of let's document everything, you would be crazy to even start that in healthcare because it's changing all the time everywhere in front of you."

There are also questions regarding the appropriateness of borrowing techniques from (for example) aviation, when it is often the case that healthcare gives rise to unique, complex and/or changeable circumstances.

"I don't really work in healthcare but I have never understood why you went to the aviation industry as the one. I don't see any real similarity… I wonder if you ever understood what happens on, say a chemical plant or an oil refinery, because if Boeing build a plane they don't build one plane they build thousands, but they're all the same. Every chemical plant is different and it's a very dynamic situation."

It should be noted that in many healthcare contexts, adoption of approaches commonly used in the aviation industry has proven worthwhile.

There are also limitations to gaining access to operational contexts, when the role of the human factors researcher isn't clear to those on the ground:

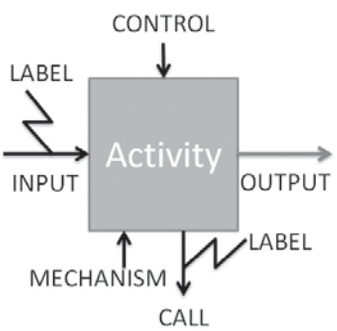
"and so if you go in, and you start talking with… people on the ground about mapping the process, you immediately turn people off, we said to a group of surgeons that we want to process map and they said no way, we have done that before, we lost a load of staff working for us…"

Fortunately, this isn't always the case:

"I said, here is a process, can you tell me where the system fails? Now surgeons don't want to admit to failure but on the other hand we are in a competitive situation now. They raced to the front of the process map and classed as many as they could."

Don't forget about the human in human factors

Diagramming methods also apply within the context of inclusive design. Here, inclusion is taken to be understanding the relationship between product and task demand and human capability. Most designs ignore the requirements of the mild to moderately impaired and fail to match the design of products, environments and processes to the known perceptual, cognitive and movement capability ranges of people. Inclusive design techniques can be combined with systems mapping to counteract this with cost benefits. The aim is to make sure that a product or service is matched to the capabilities of the wider population, including those with impairments, and the older population.



An example of IDEF0

When addressing the extent to which a system is inclusive, as with aspects relating to the analysis of risk, one of the main concerns is making sure that psychosocial factors are incorporated:

"How do you map experience and emotion… because that's the constant thing that's going to throw any of your little models out of the way."

There are methods that can support, for example, influence diagrams can be used to take the output of ethnography and develop models that structure relational impacts. The difficulty is, (as with other methods) that there is a balance to be achieved between detail and abstraction. When taken alongside the range of challenges expressed across multiple diagraming methods, there is a need for clear and concise guidance:

"Systems mapping has a wide ranging applicability, but challenges are experienced during implementation. Future research could ease adoption though provision of appropriate guidance and support." ❖