Using diagrams in systems thinking*

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Diagrams can be helpful in:

- understanding a situation,
- analysing a situation,
- communicating with others about that analysis,
- planning to deal with a situation, both logically and creatively, and
- implementing, monitoring and evaluating those plans.

A few people find diagrams unhelpful; but many people who regularly use words find the discipline of conveying ideas in pictorial form both sharpens their understanding of the ideas and opens their eyes to alternative views those ideas. Diagrams are, like words, intensely personal ways of sharing information and seeing someone else's ideas in pictorial form can give a new view of what they are trying to communicate. Diagrams can also suggest new and unexpected relationships between ideas about a situation and new and unexpected ways of moving forward in a situation.

Gender issues in diagramming

Cognitive style plays a large part in the way we use and see diagrams. As a generalisation, men tend to prefer linear processes with clear cause and effect while women tend to be more able to handle associative logic and situations where cause and effect are less clear. Similarly, men tend to use exclusive, either/or thinking which can be developed into matrices or algorithms while women are more likely to use inclusive modes of thought disliking either/or scenarios and happier than men with parallel or multiple processes.

Both the clarity and linearity sought by many men and the inter-relationships considered important by many women are relevant to the use and usefulness of diagrams and need to be considered in each instance where a diagram is being chosen to represent a situation.

Using diagrams in different phases

Fisher and Hudson (1997) (figure 1; reprinted in Lane (1999)) have developed a way of looking at the use of diagrams as having three major phases — creativity, connectivity and communication. They suggest that skill in using diagrams comes from using all three phases in a diagramming cycle.

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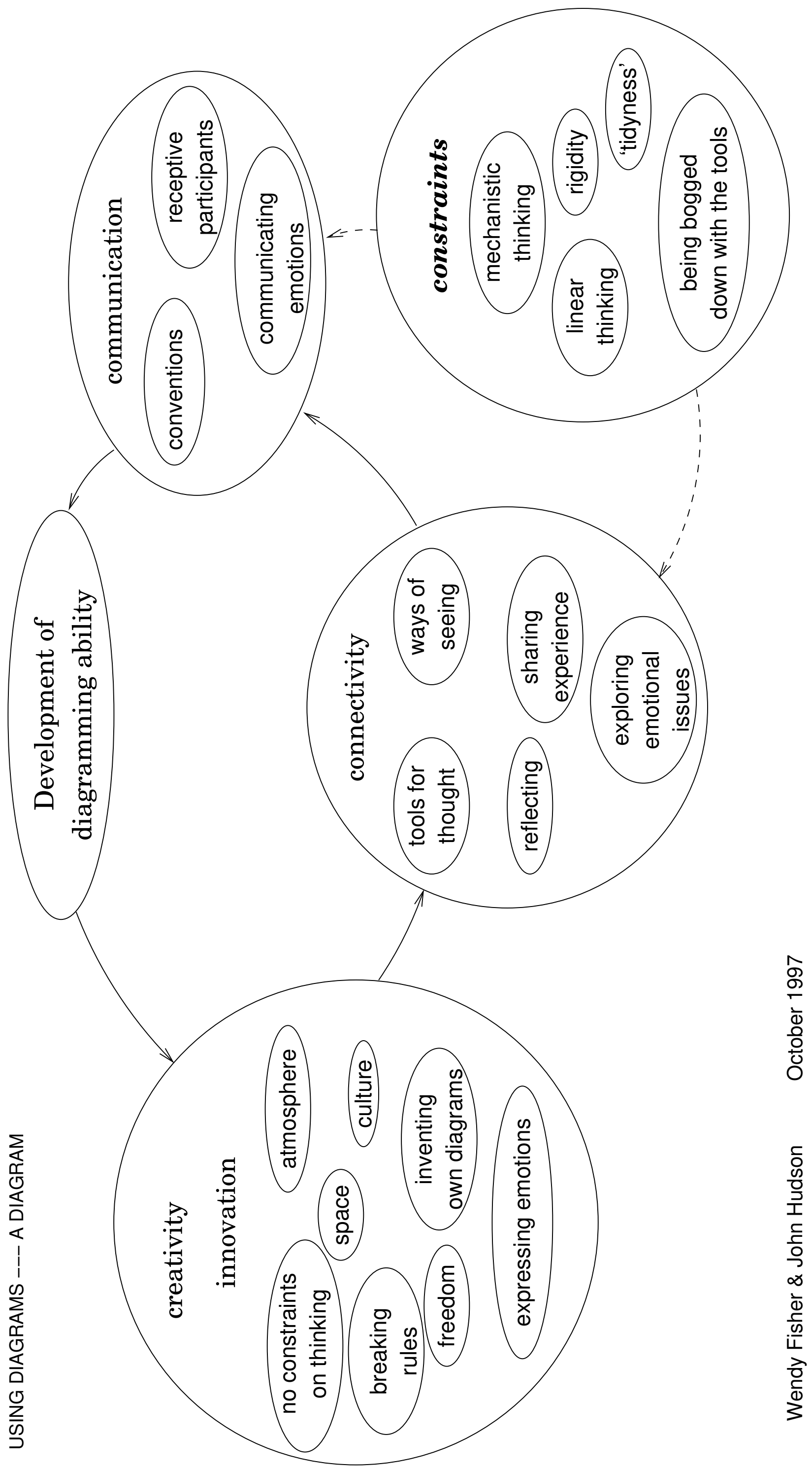

Figure 1: Using diagrams — a diagram

Table 1: Structure and process

Structure	*Process*
Spray diagram	Multiple cause
Relationship diagram	Input-output
Systems map	Flow-block
Influence diagram	Flow-process

In order to allow maximum flexibility and creativity in the *creativity* phase, there are no rules for using diagrams, though Checkland, for example, has suggested some minimum desirable elements such as structure and process in rich pictures. Normally, such diagrams are private to the analyst and only use whatever conventions are sufficient to allow the analyst to recover the ideas in the diagram at a later stage.

The purpose of the *connectivity* phase is to enable the analyst to make whatever connections are helpful for understanding a situation or planning to change a situation. During this phase it is still possible to use a private language but it is likely that the analyst will begin to use conventions which might readily be understood by others.

The purpose of the *communication* phase is to develop diagrams which enable the analyst's ideas to be shared with and/or communicated to others. Diagrams developed in the communication phase need to be structured and to use recognisable conventions. However, the use of such conventions is likely to inhibit creativity and, in order to understand and analyse the responses which the analyst receives to her/his work in this phase, s/he must return to the creativity phase.

Structure and process

Apart from the *rich picture* technique described below, diagrams are normally intended to describe either *structure* or *process* and not both (Table 1). Though some, like the *influence diagram*, may appear to contain both structure and process, the emphasis is on the *relationships*, not the processes, in the situation.

Diagrams for understanding

Diagrams for understanding are best developed within the *creativity* phase though sometimes you can go straight on to using a diagram more suitable to the *connectivity* phase. Most diagrams for understanding begin at the centre of the sheet of paper and work outwards. Buzan's *spray diagram* is built up from an initial idea with its branches; these branches have their own branches and so on until you reach the detail at the end of each twig. This technique is particularly useful for analysing printed information which may be very difficult to understand; set out in pictorial form, one can see how balanced or disjointed the information is.

However, *spray diagrams* rely on there being logical connections between the elements and relatively linear relationships between the core idea and the detail at the periphery. So they tend to be more useful when you want a relatively straightforward 'understanding' of a situation and not when you want to develop a more creative understanding.

When Peter Checkland (1999) began to analyse human systems, he developed a technique which he called the *rich picture* because it contains more than should be necessary to understand the situation. Rich pictures need a lot of space and you don't have to be an art expert — indeed, artistic flair can sometimes be a diversion from the goal of drawing useful rich pictures.

Make pictorial representations of each of the elements in a situation and annotate any interactions and relationships between the elements in the situation. These are not normally linear and the precise nature of the relationships between certain elements may be unclear. Don't try to impose order on a *rich picture*; it is intended to assist in understanding a messy human system and trying to impose order denies the very 'messiness' of the situation. For example, if you identify 'problems' in a *rich picture*, you will have pre-judged the situation and thus also what might be 'solutions'.

Having said that, a *rich picture* may suggest interactions and relationships of which you had been unaware and you may wish to 'redraw' the picture to highlight these interactions and relationships. This is perfectly OK as long as you keep the original picture to remind you what it looked like and remember that 'redrawing' a rich picture is the equivalent of moving from the *creativity* to the *connectivity* phase and imposing *your* version of a more ordered reality on the *messy* situation

Diagrams for connectivity

Relationship diagrams using the 'digraph' convention offer one way of putting more order into your understanding of a situation. Each element of a situation is named in an oval and lines between ovals indicate that there are relationships between the particular elements — but no more than this!

Systems maps are another way of developing one's understanding of a situation; a system is a collection of elements all of which interact to achieve something; systems can consist of elements or of other systems (called 'sub-systems') each of which is essential to the system. Things which are not essential to the system but have an effect on the way it operates are regarded as part of the 'environment'. *Systems maps* are essentially 'structure' diagrams. Each element or sub-system is contained in an oval and a line is drawn round a group of elements or sub-systems to show that the things outside the line are part of the environment while those inside the line are part of the system. There are NO lines connecting elements, subsystems or systems in a systems map; it is purely a statement of the structure as you see it in your mind.

Influence diagrams are developed from *systems maps* and indicate where one element in the situation has some influence over another. Arrows indicate the direction of the influence and the lines between elements may be of different thickness, shading or colour in order to distinguish strong and weak influence. Strictly speaking, influence should only be shown from elements at a higher or at the same level in the system; that is to say, sub-systems cannot influence systems and sub-systems and systems cannot influence the environment — but some people do not follow this convention.

Where a clear pattern of cause and effect can be discerned in a situation, then *causal loop* and *multiple cause* diagrams may be useful in describing the interactions between different elements in a situation. By convention, multiple cause diagrams have the elements laid out, without ovals or any other sort of enclosure, in whatever way assists in clarifying the processes. Elements are joined by arrows indicating where there is a causal relationship between the elements. Where there is cause and effect in both directions between two elements, separate arrows indicate this.

Diagrams for further analysis

Moving up the scale of understanding, a *multiple cause* diagram can be converted into a *sign graph* by indicating whether the cause has a *positive* effect on the element affected or a *negative*

effect by adding the respective signs. Not all *multiple cause* diagrams lend themselves to this treatment as you need much greater knowledge of the situation to be able to be sure about the causal chains in a situation and the effects they are likely to have.

Process engineers have long used diagrams to describe processes. Among these are *input-output* (or 'black box') diagrams and *flow-block* diagrams, in which linked 'inputs' and 'outputs' are described. These are sometimes further split into *flow-block* diagrams describing flows between components and *flow-process* diagrams describing flows between processes. Others include *decision sequence* diagrams, in which 'decisions' lead to 'actions' which lead to new 'decisions' and *algorithms* (or 'flow charts') in which the type of decision and the impact of alternative outcomes to a decision are set out pictorially. These all tend to be more suited to situations where the connectivity is relatively clear.

Diagrams for diagnosis

As the detail of the connectivity revealed through a diagram increases, many diagrams can be used for diagnosis by comparing a diagram of what should be happening with what is happening. This approach has been developed in detail by Bignell and Fortune (1984) to analyse systems failures. They argue that all satisfactory systems have functioning decision-making, operational and performance monitoring systems and that many failures can be explained by a failure in one of these aspects even when the other elements of the system were working satisfactorily. Other failures can be explained by weaknesses in connectivity between the elements of a system leading to 'systemic failures' — that is, failures in which individual elements of the system functioned satisfactorily in isolation but the ways in which they were connected together led to a failure of the system as a whole.

Diagrams for planning and implementation

The first principle in planning is: be clear about your own direction and purpose — in other words, your values and *why* you are doing anything. You can use the technique of asking why and then *why* of the answer and *why* of the answer to that until you get back to your underlying values to create an *objectives network* to help you define the direction in which you wish to go and the steps necessary to get there.

In an *objectives network*, the statements you might make about *what* you wish to do, *how* you might do it and *why* you are doing things are related to each other. *Why* people are doing things should come at the top of the network and *how* they are doing them at the bottom. With several levels, many *what* statements are also *how* statements in relation to a higher *what* statement and with multiple objectives an *objectives network* can become quite complicated but should provide a clearer idea about the important relationships between *what* you are doing and *why*.

Conceptual models can be used to analyse a 'human activity system' both to identify potential weaknesses in the connectivity of the 'human activity system' and to plan 'human activity systems' so that there is adequate connectivity between the elements in the system.

The most immediate *how* statements in an *objectives network* can probably be related to a group of people who can be viewed as a 'human activity system' about whom you can draw *systems maps* and *conceptual models*. Diagrams can be used to share understanding, diagnoses and design and the stages in implementing new relationships may be helped by the use of *flow block* and *decision sequence* diagrams or *algorithms* ('flow charts') to plan a process or a relatively stable sequence of activities. *Systems maps* may help to orient people to new relationships and

ways of working and you can use a *spray diagram* to plan any report or documentation you may produce.

Diagrams for communication

Diagrams for communication follow conventions which are widely understood; many diagrams used in the *connectivity* phase also lend themselves to use in communicating ideas. A diagram developed for communication:

- is *large*, *clear* and *well laid-out*,
- has *colour* and/or *shading* for emphasis,
- has a *title*, and
- has a *key* to the meaning of all the *symbols* used in the diagram.

Annotation, notes and/or narrative may be necessary but in general you should prefer two simple diagrams to one complicated one.

The type of diagram you draw depends on the purpose for which you draw it; bear in mind you hardly ever get it 'right' first time. Where possible present diagrams near the text to which they refer and not as appendices.

Conclusion

This short handout only touches the surface of what you can do with a diagram and the types of diagram you can use. Always think about the phase of your diagramming and the purpose behind using a diagram and choose one which fits both the phase and the purpose you have in mind. If there isn't a diagram to suit your purpose, experiment with different types of diagram but remember the features of a good diagram when you come to communicate your ideas.

References

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