Fuzzy Cognitive Maps: a participatory workshop tool

**Fuzzy Cognitive Mapping** is a widely used 'participatory modelling' methodology in which a group of stakeholders collaboratively develop a simple, semi-quantitative map or model of an issue during the course of a workshop.

Stakeholders produce a 'cognitive map' made up of key factors, actors, and connections where relationships or influences exist. The map is intended to represent what they believe to be the causal structure of their system. The map can be built using a white-board or simple pen and paper materials on a large table. The map can also be developed using our Control Nodes tool.

**Why use Fuzzy Cognitive Maps?**

Such models provide thinking tools which can be used for discussion and exploration of complex issues, as well as sense checking the implications of suggested causal links. Such “hands on” complexity science can increase stakeholder motivation and understanding of the scope of whole systems approaches.

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11 Steps in creating Fuzzy Cognitive Maps in workshop setting:

1. Pick a focal problem
2. Gather knowledge
3. Pick a focal factor
4. Brainstorm factors
5. Consolidate factors
6. Connecting factors
7. Check the connections
8. Weight the links
9. Map analysis
10. Verification
11. Scenarios

*Detailed instructions on pages 2-4*

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**Diagram:**

- **Weak**
- **Medium**
- **Strong**

- Ecological sustainability
- Infrastructure
- Community acceptance
- Feedstock
- Jobs
- By-products
- Competitiveness
- Fossil fuel price
- Knowledge
- International instability
- Existing industries
- Technology
- Funding
- Policy
- BBE Energy
- Land Availability
The diagram on page 1 is an example map. We can see the factors in the system represented by the rectangles, and the connections between them by arrows denoting the strength, direction, and nature (positive or negative) of the influence.

The following 11 steps give a detailed breakdown of how to generate your own Fuzzy Cognitive Map (FCM). The instructions here are written so that you can use pen, paper, post-it notes etc, however, you could also use our Control Nodes tool to develop a map.

**Decide on a focal problem**

In order to make a FCM you must first decide on the **problem area** which you wish to explore. FCM is most useful in situations in which many sorts of factors are interacting to influence what happens, but your problem can be anything. It is best to be relatively **specific** with your problem area by narrowing to, for example, a particular time and location with which you are familiar. For example in our Humber case study FCM the focal problem area was the current development of bio-based economy in the Humber region. A more specific problem is easier to think about, than more diffuse or general ones.

**Plan for gathering knowledge**

Once you have defined your problem area, you need to bring together the **relevant people or sources of information** to map it fully. If working alone, bring together any data, records or other information sources before you start. If you will be running a workshop think of key groups or individuals with different perspectives or expertise on the issue. Think broadly and include those who are impacted on or participate directly with the system rather than simply experts on the generalities. In this way you can map the reality of what is happening on the ground and may discover unexpected connections.

**Decide on a focal factor**

As a hook to help you begin, you should think of a **focal factor** within your problem. This should be a variable (something that can increase or decrease) within your system which is both important to you and central to the problem area. For example in the Humber FCM the focal factor was the amount of production of bio-based energy.

**Brainstorm factors**

Thinking as widely as possible, all participants should individually **brainstorm all the factors** that they think impact in some way on the focal factor. These can be from any domain, technical, social, economic, political, ecological etc. They can be quantifiable, e.g. prices, or qualitative such as social attitudes. All factors should be able to increase or decrease. It is helpful to write all individual factors on separate post-it notes.

**Consolidate factors**

Using a whiteboard or table top ask all participants to **place their factors together and start to group them** if they duplicate the same idea. After all factors are placed discuss the groupings. Are grouped factors really the same or are there important differences? Discuss and clarify what you mean by each factor to come to a common understanding. Once grouping is final, list consolidated factors each on a single post-it. It is best to start with fewer factors to focus thinking, so if you have more than 20, pick out the 20 most important to start with, retaining the others for later.

**Connecting factors**
Next, **start drawing your map**, drawing the connections which show how factors influence each other. Start by putting your focal factor on the map. Then, together as a group discuss and add factors that directly influence it either positively (if they increase the focal factor increases) or negatively (if they increase the focal factor decreases). Draw these connections in, adding factors as you go. Then, think about what the focal factor influences. Draw connections from the focal factor to others on the map or list. When you get stuck, move onto a new factor, either already on the map or on the list. What connections go to or from this factor? Make sure you cover all factors. Some participants may disagree about the presence of particular links, so make sure that you discuss and agree the rationale for each link. This is an important part of the process as it allows you to learn about different stakeholders’ perspectives. The combined knowledge of a diverse group will make the map more realistic and allow you all to learn as you construct it together. Make sure that one single voice or perspective is not dominating the exercise.

**Check the connections**

Once you have an initial map constructed, it is important to stand back to **check and reflect** on it. Try these tips to get over common problems:

- Considering the whole map, look for any nodes with very few connections, are they missing connections?

- There is often a bias towards mapping positive rather than negative influences. If this seems to be the case, go through all the factors again, specifically thinking about how they may decrease others. Add any negative connections that come up.

- Often duplications arise when both direct and indirect effects on a factor are drawn, but the real causal chain is indirect. If both, A influencing B, then B influencing C and, A influencing C (i.e., A->B->C & A->C) are marked on the map, check that A->C is a genuine separate process.

- Are there any obviously important factors missing (e.g., things that have come up repeatedly in discussion, but which are not on your list)? If so add these factors and their
connections. Remember however that you will never be able to include everything in a basic model.

**Weight the links**

Once you have all your causal links in place, it is useful to get an idea of their relative strengths. The easiest way to do this is simply to **rank all links or interactions in order of strength**, strongest to weakest. Then divide the list into 3 groups, strong, medium and weak influences. Label the links accordingly.

**Map the links**

Now you have constructed your map you can use it to think about your problem. For detailed analysis you can use our Complex Control Tool, however you can use a “quick and dirty” structural analysis to start thinking about your problem in new ways.

- Look for factors which have many incoming or outgoing connections (so called high in-degree or out-degree nodes). The former are highly influenced, the latter are highly influential in your system. Do you see anything that you don’t expect? What practical implications might this have?

- Now look particularly at factors up or downstream from these highly connected factors. Factors which are influenced directly or indirectly by a highly influenced factor may vary for many different reasons. Are there possible unexpected indirect effects on these which might be important? Factors which are upstream of a highly influential factor may provide unexpected sources of change or control over large sections of the problem domain. Do you see indirect sources of influence or impacts which you might not have realised were there?

- Look at factors which have outgoing links only. These are drivers, factors which influence your problem, but are not influenced by it. Do these cause problems? Do you just adapt or react to them?

- Conversely, look at factors which have incoming links only. These are sinks and according to your map influence nothing else in the system, no matter how much they are changed. Is this true? What might possible consequences be? Might there be threshold values at which they might start to influence the rest of the system?

**Verification**

By starting to examine the map you have produced in detail, you may find that certain causal influences don’t make sense to you. This is an opportunity to **“sense check” the map**, but also to re-evaluate your own ideas about the system. In general it is also useful to verify any map you have constructed by showing it to other stakeholders or individuals with knowledge of the problem domain and asking them what they think is missing or incorrect. Disagreement on structure can suggest areas that need further investigation or modelling in order to clarify causal connections. However, remember that this map is subjective; there will always be different opinions about what the causal connections are.

**Scenarios**

The map that you have drawn shows the present structure of your problem, but you can use it to think about **possible change**. Think about different scenarios, such as possible changes on the horizon for your problem or ways in which you might want to do things differently. How would the map be structured differently in these cases? Would new factors have to be added? What difference does this make to your thinking if you analyse these new and different maps? Drawing maps for different scenarios is a way to preserve and examine disagreements between different perspectives. Different ideas about how the system works from different groups can illustrate important social aspects of a problem.