The complexity of concept mapping for policy analysis

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Abstract

Concept mapping is a participatory mixed methodology that enables diverse participant groups to develop shared conceptual frameworks that can be used in a variety of policy contexts to identify or encourage complexity, and the adaptive emergent properties associated with it. The method is consistent with an evolving paradigm of complex adaptive systems thinking and helps groups address complexity in several ways: it is inductive, allowing shared meaning to emerge; it is based on a simple set of rules (operations) that generate complex patterns and results; it engages diverse agents throughout the process through a range of participation channels (synchronous or asynchronous web, face-to-face, etc.); the visual products – the concept maps, pattern matches, action plots – provide high-level representations of evolving thinking; the results are generative, encouraging shared meaning and organizational learning while preserving individuality and diversity; the maps themselves provide a framework that enables autonomous agents to align action with broader organizational or systems vision. The concept mapping process involves free listing, unstructured sorting and rating of ideas, and a sequence of statistical analyses (multidimensional scaling, hierarchical cluster analysis) that produce maps and other results that the participants then interpret. An example is provided of a web-based project that mapped the practical challenges that need to be addressed to encourage and support effective systems thinking and modeling in public health work. It is suggested that using concept mapping especially in combination with other types of human simulation provides a valuable addition to our methodological tools for studying complex human systems.

The complexity of concept mapping for policy analysis

Contemporary complexity theory leaves many in the applied endeavors of policy analysis and management bewildered. While the notion of complexity – and especially its emphasis on emergent and dynamically adaptive properties – is inherently appealing to these audiences, there is a genuine confusion about how these attractive ideas might be applied in policy and management practice. The complexity literature is replete with examples of complex systems in nature such as ant colonies and slime molds, and with generalizable complex systems using simulated abstract agents such as termites and turtles. Even apparently more relevant examples, such as simulations of city neighborhood evolution (Krugman, 1996), or of traffic jams (Resnick, 1994), seem insufficient for addressing thorny ill-defined problems of human interactions in 'soft' systems – in short, the area where much of the most important policy analysis and management work occurs.

Much of the problem for people interested in these types of systems seems to center around methodology – or the lack of it. While the scientific and philosophical underpinnings for complexity are well established, and while there is a seemingly endless literature of management advice that is purportedly based on principles of complexity thinking (McKelvey, 1999), the policy analyst and manager look in vain for structured methodologies that can be used in practice contexts to describe or encourage complexity and its attendant emergent adaptive properties.

This paper nominates for inclusion in complexity methodology a *participatory mixed methods* approach known originally and technically as 'structured conceptualization' and more widely and colloquially as 'concept mapping'. We begin with a brief introduction to the methodology of concept mapping and a review of the ways it is currently used in policy analysis and management contexts. We then present an example of a concept mapping project in public health where the focus was on the practice of systems thinking and modeling itself. The example is used both to introduce the method in some detail and illustrate its use in context. Finally, we use the results of this project to illustrate how complexity is related to the concept mapping methodology in at least three major ways: (1) concept mapping is itself a complex adaptive system (CAS); (2) the maps that result are useful for identifying the properties of complex systems in policy contexts; and (3) the maps can be used to manage human systems toward a goal while at the same time leveraging the dynamic, adaptive, evolutionary and emergent potential of complex systems. We conclude by suggesting how the methodology might be applied usefully to understand and encourage complexity in policy analysis and management contexts.

A brief introduction to concept mapping

Concept mapping is a participatory mixed methodology (Greene & Caracelli, 1997) that enables diverse individuals and groups to develop mutually comprehensible conceptual frameworks that can be used in a variety of policy contexts to identify or encourage complexity, and the adaptive emergent properties associated with it. The method is consistent with an evolving paradigm of complex adaptive systems thinking and helps groups address complexity in several ways:

- it is inductive, allowing shared meaning to emerge; it is based on a simple set of rules (operations) that generate complex patterns and results;
- it engages diverse agents throughout the process through a range of participation channels (synchronous or asynchronous web, face-to-face, etc.);
- the visual products provide simple high-level representations of evolving thinking;
- the results are generative, encouraging shared meaning and organizational learning while preserving individuality and diversity, and;
- the maps themselves provide a framework that enables autonomous agents to align action with broader organizational or systems vision.

Concept mapping is an integration of qualitative group process and quantitative analysis. There are six major steps in the process (Trochim, 1989b):

1. *Preparation and focus formulation*: The initial preparatory phase of a concept mapping project pursues the spirit of Aristotle's dictum that "Well begun is half done." In this step we accomplish three major tasks. First, we identify who the *participants* will be, often using a snowball or successive sampling approach. Second, with the participants (or a subgroup of them) we determine the focus for the project. We typically accomplish this by developing a *focus statement* or prompt that defines the conceptual domain that the map is intended to address and delimits the boundary conditions for the ideas or issues that will be mapped. To call it a 'focus' statement may be a bit of a misnomer, because the statement can be a very broad one as in "Generate specific things our organization should address" or "One specific characteristic of 'Construct X' is…" In addition, in this step, we also determine the focus for any ratings or other measures that might be collected subsequently on the set of ideas or issues. Finally, we determine the *scheduling and logistics* for the project. A concept map can be developed in a face-to-face small group meeting at a conference setting over a day or two, it can involve hundreds or thousands of participants collaborating virtually over the web, or any combination of these.

2. *Generation of ideas or issues*: In this step we generate a large set of issues or statements that address the focus statement and constitute the basis of the concept mapping project. Ideally, the participant group determines the process for generating the statements, typically through some type of idea generation (Nagasundaram & Alan, 1993; Philipsen, *et al.*, 1979) method like brainstorming (Adams, 1979; Osborn, 1948) or a free listing process (Coxon, 1999). Alternatively, they could be compiled through a methodology for coding existing text (Jackson & Trochim, 2002) or through some form of content analysis (Krippendorf, 2004). In many cases, especially when the web is used for generating ideas, more statements are created than can feasibly be handled in subsequent steps. For most projects a maximum of about a hundred statements will be at the limit of what can be effectively processed. With web brainstorming, many of the statements will be repetitive or redundant. If hundreds or even thousands of statements are generated, it is necessary to synthesize them to a more manageable number. This is typically done through a combination of group process and content analysis (Krippendorf, 2004).

3. *Structuring of ideas or issues*: In the structuring step the participants provide their sense of how the issues are organized or interrelated. This is accomplished primarily by having each participant do an unstructured similarity sorting (Coxon, 1999; Rosenberg & Kim, 1975; Weller & Romney, 1988) of the statements. This can be done either by manual card sorting, with one statement per card, or with suitable electronic technologies for sorting (e.g., Concept Systems Incorporated, 2004). Each participant is asked to place statements that they think of as similar together in groups or piles and to give each group a brief name. A statement can be placed in only one group (i.e., forced choice). There are no limits to the number of groups one can create as long as all statements are not placed in one group or each is not placed in its own group. In addition to the sort task, participants are usually asked to do one or more ratings of the statements. Typical ratings are of relative importance or feasibility of accomplishing each statement, usually measured using a simple (e.g., 0-1, 1-5 or 1-100) rating format. Finally we also typically gather some non-identifying demographic information about participants to make it possible to do subgroup comparisons of results.

4. *Representation of ideas or issues in maps*: We 'represent' the ideas or issues by applying a sequence of algorithms to the sorting data (note that no rating or demographic data is used at this step). We begin by constructing from each person's sort an $N \times N$ (where N = number of statements) binary, symmetric matrix of similarities, X_{ij}. To do this, for each sort, for any two items i and j, a '1' is placed in X_{ij} if the two items were sorted in the same pile by the participant, otherwise a '0' is entered (Coxon, 1999; Rosenberg & Kim, 1975; Weller & Romney, 1988). Then, we obtain a total matrix T_{ij} by adding across the individual $N \times N$ similarity matrices. In this matrix, values range from 0 (no people sorted the i,j statement pair in the same pile) to the number of people who sorted (all of them sorted the two statements in the same pile). The total similarity matrix T_{ij} is the input for non-metric multidimensional scaling (MDS) analysis with a two-dimensional solution. The solution is limited to two dimensions because, as Kruskal and Wish (1978) point out: "…when an MDS configuration is desired primarily as the foundation on which to display clustering results, then a two-dimensional configuration is far more useful than one involving three or more dimensions" (p. 58). The analysis creates the basic map – a two-dimensional (x,y) configuration of the set of statements – based on the criterion that statements sorted together most often (more similar) are closer on the map while those sorted together less frequently (less similar) are further apart. The usual statistic that is reported in MDS analysis to indicate the goodness of fit of the two-dimensional configuration to the original similarity matrix is called the *stress value.* Next, the x,y values from MDS are the input for hierarchical cluster analysis utilizing Ward's algorithm (Everitt, 1980) as the basis for defining a cluster. Using the MDS configuration as input to the cluster analysis forces the cluster analysis to partition the MDS configuration into non-overlapping clusters in two-dimensional space. There is no simple rule by which a final number of clusters can be selected; typically a procedural algorithm is used (Trochim, 1989b). Many different maps can be produced from these results.