Complexity Theory and Systems Thinking

Complexity management is about the application of complexity theory to the method and practice of management. So before we can start talking about complexity management we need to have a basic understanding of what complexity theory and complex systems are, and that's what we are going to cover in this section. This section may sound a bit theoretical but if you are new to the area of complex systems it will definitely be of use to you during the course.

Complexity theory has emerged out of a number of different areas over the past few decades, in particular from physics, mathematics, computer science and ecology. All of these very different areas have found themselves trying to model, design and manage what we now call complex systems, and here is the definition of a complex system that we will be using in this course. Complex systems are systems composed of many different parts that are highly interconnected and are capable of adaptation.

So let's unpack that a bit. Firstly, complex systems are a type of system. A system is just a set of things that perform some collective function. So the human body is a system in that it consists of many individual organs that work together as a functioning entirety. A business is another example of a system – many different individuals and departments functioning as an integrated system, to collectively produce some set of products or services. And of course, there are many other examples of systems such as transportation systems, eco systems, information systems and so on.

Not everything is a system though. If we take a random collection of things, say a hard drive, a light and a watch and put them together, this is not a system. It is simply a set of elements because they are not interconnected and interdependent in performing some collective function. It is because of the fact that the elements within a system perform some collective function that systems are said to be greater than the sum of their parts, that is to say that the system as a whole has properties and functionality that none of its constituent elements posses. A plant cell is an example of this. It is composed of many inanimate molecules, but when we put these together we get a cell that has the properties of a living system. So it is not any element that has the properties of life but it is the particular way that we arranged these molecules that gives rise to this emergent property of the living system as an entirety.

A key thing to understand about systems thinking is that it represents an alternative to our modern scientific way of thinking, that is primarily focused upon breaking systems down into their constituent parts in order to analyze these parts, and then tries to understand the whole system as simply the sum of these individual elements. This approach works well when we are dealing with sets of things that do not have emergent properties. But because some systems, in fact many systems, have these emergent properties as an entirety, this method, which is also called reductionism, does not always work best, in which case we need to use systems thinking which places a greater focus upon understanding systems in their entirety and within the environment that gives them context.

OK, so that's a very quick overview to systems thinking, but to get to complex systems we need to add complexity to this. Systems have a number of properties that make them complex.

Firstly, the number of elements within our system – this is quite straightforward. The more parts there are to our organization, the more complex it will be.

Secondly, complexity is a product of the degree of connectivity between these elements. The more interconnected and interdependent they are, the more complex our system will be. Within simple systems there are few connections between elements and it is relatively easy to understand the direct relations of cause and effect, that is to say we can draw a direct line between a single cause and a single effect. Thus, we call these simple organization linear systems.

But when we turn up the connectivity within the system and especially when there are a high number of elements, these cause and effect relations become more complex as there may be multiple causes for any given effect or vise versa, as opposed to our simple linear system. We call these more complex systems nonlinear systems. Nonlinearity is a key property of complex systems and we will be coming across it many times in this course.

Next, complexity is also a product of the degree of diversity between elements. When all the elements within our system are very similar or homogeneous then it is much simpler to model, design or manage, as opposed to dealing with a heterogeneous organization composed of many diverse parts, each with their own unique set of properties.

Lastly, complexity is a product of the degree of autonomy and capacity for adaptation of the elements within the organization. When the elements have a very low level of autonomy, then the system can be designed, managed and controlled centrally in a top-down fashion. But as we increase the autonomy of the elements within the system this becomes no longer possible as control and organization become distributed, and it is interactions on the local level that come to define how the system developed.

This gives rise to another important feature of complex systems, that is self-organization. When elements have the autonomy to adapt locally, they can self-organize to form global patterns. The process through which this takes place is called emergence. Thus, as opposed to simple linear systems where order typically comes from some form of top-down, centralized coordination, patterns of order within complex systems emerge from the bottom up. Self-organization will be another recurring theme in our exploration of managing complex systems.

OK, now we know a bit about complexity theory and have a working definition for what a complex system is. So when we hear someone talk about a complex system, we know what they mean: a system composed of multiple, diverse parts that are highly interconnected, and capable of adaptation. We could even have a few examples in mind such as financial markets with lots of different, highly interconnected traders adapting to each other's behavior as they interact through buying and selling. Or an ecosystem with multiple different species that are all interdependent and adapting to each other and their environment.
Or a supply chain network with many different producers and distributors interacting and adapting to each other in order to deliver a product. There are many more examples of complex systems, but I hope you get the idea and we will move on to talking about management and our traditional approach to it.