Systems Thinking Curriculum

Overview

We want people to learn about complex systems all the way from the smallest detail up to the bigger picture of how it all fits together. As such we have designed the content on our platform to work as an integrated framework and our curricula define the overall learning experience provided. These curricula try to give the content a sense of direction and purpose, by linking back more specific content into a broader framework. Our curriculum provides a framework for cohesively and comprehensively integrating the many different domains of the subject so as to deliver a deeper understanding of the subject than would otherwise be possible. A curriculum can serve the additional functions of defining a body of knowledge to be transmitted or it can serve as a guide for the process of learning, or finally as a praxis for the subject i.e. a standard format.

Our curricula are designed to serve as a schema or meta-language through which to structure the learning experience. The brain is a neural network that is designed and optimized to process patterns. We interpret the world through patterns and we create schema or models that work as frameworks within which we place more specific detailed information. We learn by putting things into larger patterns and associating them with other things in those structures that we already know. To learn effectively it is important to have generic models within which to fit the specific details or else the details of the subject will become decontextualized, the student won't be able to relate to it, retain it and use it effectively. The basic heuristic is in having generic concepts come first and then the specific details can fit into this and be more effectively interpreted, retained and used.

The most important thing is a conceptual and intuitive understanding of what at the topic is about, thus the primary objective is to communicate the central concepts in an intuitive fashion and then build from there. This should enable students to be able to understand and communicate in a few words what a topic is about and how it relates to others. The curriculum structure is distributed out into four levels, frameworks, courses, sections, modules. A framework defines a category of courses, a course is a subject, a section is a theme in a course and a module is a topic. In all instance, we aim for a modular design so that courses, sections, and modules can be mixed and matched as needed by teachers and students.

Curriculum Content

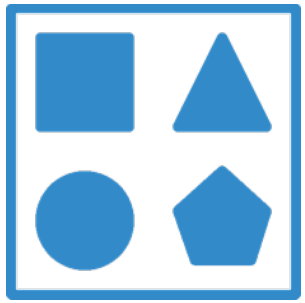
Our curriculum is designed as a synthesis of the many different perspectives and approaches to systems thinking. After much time spent reviewing the literature on the subject, we identify four basic interpretations to the term systems thinking that forms the outline to our curriculum.

Metacognition

Systems thinking as looking at our own way of thinking and trying to improve it

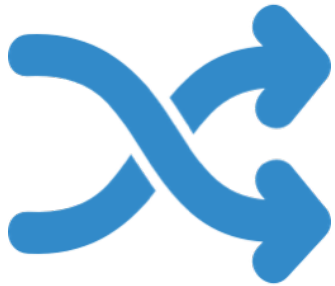
Holism

Systems thinking as a holistic way of thinking, seeing the whole not just the parts



Systems Model

Systems thinking as reasoning based upon the model of a system



System Dynamics

Systems thinking as dealing with feedback loops that govern the system's dynamics

Metacognition & Critical Thinking

Systems thinking starts with a recognition of our own way of seeing the world and how this leads to our actions that create the world around us. It involves a degree of metacognition to try and expose our mental models and open them up to other people so that we can understand how we think and try to improve our reasoning.

Holism & Systems Paradigm

Systems thinking is holistic in nature, meaning it is primarily a way of thinking based on synthesis. Whereas analysis breaks things down through reductionism, synthesis looks at how they are put together through the process of emergence. Central to the systems thinking paradigm is looking at how parts are interconnected and interdependent to give rise to the whole.

Systems Model & Systems Theory

The model of a system is clearly another central part of systems thinking, from some interpretations systems thinking can be defined as simply thinking using the model of a system. Many people will approach the subject from this perspective and understanding the model of a system is a key part of being a systems thinker. The model of a system gives some structure to our reasoning and a common language with which to communicate insight through.

Systems Dynamics

Many people will directly associate systems thinking with system dynamics, where we look for the feedback loops and the set of linkages between the parts that creates its overall behavior. Dynamics is the study of how something changes over time and system dynamics can be understood to deal with the feedback loops and causal relations that drive a system's development.

1| Critical Thinking

Systems thinking is a form of metacognition, it firstly asks how do I think and see the world, and how does that effect my actions and the outcomes in the world. As such systems thinking is in contrast to a more analytical approach of inquiry that takes an objectivist position, which assumes that the world is largely transparent to our senses, that our reasoning is largely sound and little attention is paid to how we reason or see the world. Systems thinking balances this more objectivist stance by including subjectivism, that is to say how the world appears to us is not in some unmediated form but it is in fact constructed by our cognition and thus in any given inquiry it is of first importance that we question the assumptions and methods through which we reason in order to ensure that we are not making systematic bias, flaws in our reasoning, misconceptions and many other well documented cognitive flaws that humans are prone to and that lead to suboptimal outcomes; knowledge and actions and results that are incomplete.

This is the domain of critical thinking were we take our thinking apart to examine how it works and how it might work more effectively so that we can become effective at the process of reasoning in a coherent, logical, undistorted and unbiased fashion. Metacognition is typically referred to as thinking about thinking. The activity of examining the processes by which we think about and arrive at our own beliefs. It involves both analysis of one's cognitive process and structure but also monitoring of ongoing processes and adjusting them according to meta-standards. With metacognition, we are using our cognitive capabilities as a system and are specifically and consciously designing it to be more effective and in order to do that, it is necessary to bring the full logic of one's reasoning to the surface and to attempt to make it explicit.

Cognition

The first part in understanding how our reasoning works is in understanding how the brain works, as this strongly shapes how we reason, placing significant constraints on how we think and a source of the many flaws that we are prone to. In this section, we try to outline how the brain works as a neural network and how reasoning happens in patterns reflecting its underlying biological structure. We talk about the evolved nature of its condition and its hierarchical structure. We also try to highlight how nearly everything that we perceive as reality is in fact constructed by our brains and is subject to manipulation and a multiplicity of possible flaws and thus the need for critical thinking.

Logic

The aim of critical thinking and science is to try and derive what we might call objective knowledge. That is to say, knowledge that remains relevant under scrutiny from many different perspectives and within many different frames of reference, this is objective knowledge in that it is not contingent upon a specific subject or context, but is relevant to many different contexts and from different points of view. This objective knowledge we can also call logic. Things in our world work in a particular way because they are systems that are governed by a logic of how their parts are interrelated; when we understand that logic we understand how they work. With systems thinking and critical thinking, we are trying to develop standards and methods for deriving this objective knowledge about the world around us, the structure of systems, their logic; the way systems work. Thus at the heart of critical thinking is logic and in this section of the curriculum, we explore this very fundamental theme.

Reasoning

In this section, we expand upon our understanding of logic to talk about the full process of reasoning. Whereas logic refers simply to the instructions and interrelationship between things, reasoning refers to the full process we go through in amassing information, assessing it, interpreting it and generating knowledge. One of the main themes throughout this section will be that of subjectivity and objectivity in our reasoning. With systems thinking, we are trying to overcome our own single perspective to see the world from different perspectives and to be able to synthesize that into a more coherent understanding. One of the fathers of systems thinking, a man named Churchman, once said: "systems thinking begins when you first see the world through the eyes of another". Churchman is suggesting that people can step outside of a system they are in and mentally try to consider it through the lens of other people's values and this requires us to overcome our own narrow perception to create a balanced process of reasoning that includes different perspectives to create objective knowledge.

Argumentation

Much reasoning does not happen in isolation but in fact, as part of groups, we as groups and society have to come to a consensus on our shared view of things and make decisions collectively and this happens through the exchange of ideas within conversation and debates, or what is called argumentation. To make progress in coming to a joint view of the world it is required that one understand the workings of arguments and how people create cases, support them, make inferences and present their case to others in an effective manner. One needs to understand the difference between mere opinions and valid reasons given, to be able to overcome one's own specific perspective, opinions, and values, so as to construct arguments that are based on sound evidence, constructive inference and presented in a way that is accessible and intelligible to others.

2I Systems Paradigm

Once we have understood the basic workings of thinking we can turn our attention to the two fundamentally different approaches to reasoning that create all-encompassing worldviews, or what we call paradigms. This is the distinction between holism and reductionism. Systems thinking has been defined as an approach that attempts to balance holistic and analytical reasoning. In systems theory, it is argued that the only way to fully understand something is to understand the parts in relation to the whole. Systems thinking concerns an understanding of a system by examining the linkages and interactions between the elements that compose the entire system. By taking the overall system as well as its parts into account this paradigm offers us fresh insight that is not accessible through the more traditional reductionist approach.

Synthesis & Analysis

At the heart of systems thinking is a way of seeing the world that is characterized by a holistic vision and we call this the systems paradigm. Under the term systems paradigm, we include all of the major concepts in the holistic approach. The central issue here is in making a clear distinction between the two basic worldviews of holism and reductionism and their counterparts synthesis and analysis; which are the two processes of reasoning that form the foundations of systems thinking.

Nonlinearity

The second major theme to introduce here is that of nonlinearity and nonlinear causality, a recurring theme across all of the systems sciences. Much of the knowledge we have about the world is based on our conception of cause and effect and a major distinction between the analytical and synthetic approach is that between linear and nonlinear causality. Nonlinearity, in all of its shapes and forms, leads to a very different conception of the world than our more classical, mechanistic vision. Systems thinking does not deny the importance of linear cause and effect in our world; linear thinking is seen as a prerequisite capability, but one that does not suffice when dealing with systems that entail any degree of complexity, in such a case we must be capable of using both linear and nonlinear thinking and understand the distinction between them.

Relational Paradigm

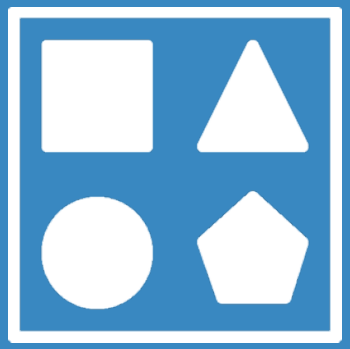
As systems are really defined by the interdependencies between a set of parts, the systems paradigm has, since its origins, been focused on the connections between things, and the context created by this, rather than the parts themselves. In certain circumstances, it is the connections that largely create or define the component parts, which is an inversion to our more traditional conception where components are seen to create the connections. This can be called the relational paradigm, a way of looking at the world in terms of the connections between things, the networked patterns they form and how these shape and define the overall system.

The relational paradigm focuses our attention on how the relations between a system's parts can be a determining factor in shaping and conditioning the elements and in defining the overall makeup of the system. From here a discussion on connections leads naturally to talking about interdependence and integration.

Process Thinking

A central part of the systems thinking paradigm is the idea of processes of change; that the world is fundamentally in a state of change or dynamic becoming. Systems theory sees the world in terms of constant change and macro-level processes that exert a downward cause in shaping the parts. Events are often interpreted as the product of systems archetypes that shape and give rise to them. One might say that no one could ignore the fact that our world changes and that the traditional analytical paradigm has plenty of models for dealing with change. However, it is important to make a somewhat subtle but important distinction between the terms "change" and "process." where process involves feedback and evolutionary dynamics.

Processes are seen to shape the development of systems through differentiation and integration, where the parts become more specialized and diverse or more interconnected and integrated. The systems paradigm sees the world not just in a state of change, but in fact in a state of becoming, a state of transformation. Here we are talking more about evolution rather than our traditional mechanistic conception of change, that is largely reversible in time. With evolution, new structures and functions emerge within the overall system that are time irreversible; processes that actually change the whole system. Instead of studying how things are now, we add to this also their potential; what they might become and how this can condition their current behavior.



3I Systems Theory

Systems theory is the study of entities of all kind through the model of a system. The model of a system is what make systems thinking concrete and a functional tool. Becoming a systems thinker requires a good understanding of the different aspects of the model of a system. The model of a system is an alternative modeling framework to that which works within the analytical reductionist paradigm, what is called set theory.

The model of a system looks at the world in terms of the interrelationships between things and how they work together to enable some function. This is in contrast to the set-theoretical framework that is focused on component parts and their properties. The main aim of this section to the curriculum should be to provide students with the standardized language of systems theory through which they will be able to describe and model systems of all kind in a more coherent fashion whilst also being able to effectively communicate this to others. We break this element of the curriculum into four main sections, firstly understanding what a system is, then looking at synergies, functions, environment and dynamics.

Systems & Sets

This section focus on making clear the general concept of a system and how it is distinct from a set. A system may be defined as a set of parts and relations between those parts through which they are interdependent in forming some overall organization. Here we make the distinction between a system and a set to illustrate how the world can be seen to be understood through these two basic modeling languages. The first being that of set theory, that describes any combination of elements that are not interdependent as a whole, and that of systems theory that describes compositions of elements that are interdependent in forming a functional whole. Sets are nothing more than the sum of their parts while systems form something greater or less than the parts through the interdependencies - called synergies - between the parts.

Synergies

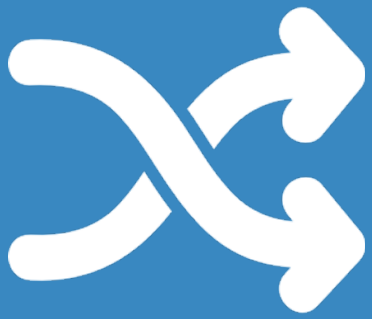
Systems thinking is focused on how the parts fit together to form the whole, it is focused on the interdependency between things and these interdependencies are modeled in terms of synergies. Synergies describe how two or more things are interdependent, with this interdependency creating a relationship that adds or subtracts value to the combined organization and makes it nonlinear. Here we look at the two primary forms of synergy, what can be called positive and negative synergy. Negative synergies describe how things interact in a destructive fashion - what is also called interference - so that the outcome is less than the sum of its parts, while positive synergies describe how the parts interact in a constructive fashion to create an outcome that is greater than the sum of its parts.

Functions

At the heart of the model of a system is the idea of inputs, processes, and outputs. Systems perform functions and are defined by the resource that they process. In this section we firstly need to communicate what a process is, introducing it as a function that transforms some input to create an output. We introduce the idea of an algorithm, illustrating how processes and functions can be understood as the system performing an operation on the input, according to a set of instructions so as to generate an output. We introduce the idea of energy and entropy, to talk about how systems take in some resource, perform an operation on it and in so doing generate an output that can be of value - energy - and also an output that is of a lower value what we call waste or entropy. Once this is understood we can then talk about the efficiency of a system as a ratio between the energy and entropy inputted and outputted.

Environment

A talk about processes leads naturally to a discussion on the system's boundary and its relationship to its environment. In this section, we deal with how systems operate within some environment and interact with other systems. We define the boundary in terms of its integration i.e. inside the boundary the system is integrated and has autonomy outside it loses autonomy as it must interact and interoperate with other systems. At this stage, the idea of an open vs. closed system may be introduced. The concept of systems hierarchy can be introduced where smaller subsystems are nested within systems that are nested within whole environments. Finally, in talking about the system's environment we can begin a discussion of how the system changes over time and the ideas of sustainability and sustainable dynamics.



4I System Dynamics

Systems dynamics is an area of systems thinking that tries to understand and model the dynamic behavior of systems through feedback loops and stocks and flows over time. System dynamics presents an integrated modeling language for looking at the overall dynamics to a system. For many people in management, systems thinking is tantamount to system dynamics as it can offer a very practical tool for quickly modeling a large system.

With analytical thinking, we often see the world in terms of linear cause and effect but systems thinking looks for the nonlinear cyclical interplay between elements that form feedback loops which give the system a certain dynamical behavior. The central aim here is in understanding the basic types of feedback loops and how they give rise to different dynamics and learning to identify these dynamics within the world around us as they can be seen in all types of systems. The model of feedback loops, that is at the heart of system dynamics, will appear very simple but it is also a very powerful approach.

Causal Links

Causal links describe the causal relationship between two or more things and try to capture whether they move together in the same direction or in different directions. A positive causal link means that the two nodes change in the same direction, i.e. if the node in which the link starts decreases, the other node also decreases. Similarly, if the node in which the link starts increases, the other node increases. A negative causal link means that the two nodes change in opposite directions, i.e. if the node in which the link starts increases, then the other node decreases, and vice versa. Causal links can tell us a lot about the innate structure of a system, in that they describe the types of interdependencies between things and these interdependencies go a long way to understanding how they will behave and interact. Often when elements states are positively correlated - positive causal link - they will often work cooperatively, when they are negatively correlated - negative causal link - this will often induce competition.

Feedback Loops

When the idea of a causal link is extended to include a link that feeds back to the original node where the link began this is called a feedback loop. Just as there are two types of causal links there are two types of corresponding feedback loops. A Positive feedback loop means that values associated with the two nodes within the relation change in the same direction. So if the node in which the loop starts decreases, the value associated with the other node also decreases. Here the ideas of virtuous and vicious cycles can be introduced. A discussion on negative feedback leads naturally to talking about homeostasis and how systems use negative feedback to regulate and stabilize their behavior while positive feedback leads to rapid change and runaway effects. Likewise, the two types of feedback loops can be used to illustrate the concept of linearity and nonlinearity, as negative feedback leads to incremental change while positive feedback leads to exponential change.

Causal Loop Diagrams

System dynamics uses what are called causal loop diagrams to understand the overall structure and interdependencies within a system. A causal loop diagram is a map of a system with all its constituent components and their interactions. By capturing interactions and consequently the feedback loops, a causal loop diagram reveals the structure of a system. By understanding not only the structure to these relations but also the nature of those relations, it becomes possible to model and simulate a system's behavior over a certain time period.

Stock & Flow Diagrams

To perform a more detailed quantitative analysis, a causal loop diagram is transformed to a stock and flow diagram, which helps in studying and analyzing the system in a quantitative way, typically through the use of computer simulations. A stock is a term for any entity that accumulates or depletes over time. A flow in contrary is the rate of change in a stock. Stock and flow diagrams help us to understand the ebbs and flows of the processes that are taking place within the system and the corresponding behavior of the system over time.