biomatrix web

simplicity underlying complexity

Biomatrix Post-MBA Programme

Overview of General and Biomatrix Systems Theory

Manual

Table of contents

Note on Intellectual Property Ownership

Introduction

Welcome to the ***Biomatrix Post-MBA Programme***.

It is an action learning programme that involves video lectures on theory and template driven exercises that apply the theory to a case study relevant to the learners.

It consists of the following modules:

- Module 1: *Overview of general and Biomatrix systems theory* provides an overview of the key concepts of systems thinking in general and Biomatrix systems theory specifically
- Module 2: *Systemic problem (dis)solving* outlines the steps involved in (re)designing a system and explain the methodology for analysing problems and brainstorming solutions
- Module 3A: *Seven forces of system organisation: Activity system perspective* explains the seven forces of system organisation and their application to system design in general and an activity system design specifically
- Module 4: *Implementation planning* plans the implementation of a system design
- Module 5: *Systemic change management* describes how systems change and how one can manage change in a systemic manner
- Module 3B: *Seven forces of system organisation: Entity system perspective* explains the application of seven forces of system organisation to an entity system design.

Getting the most from the module

1. Watch the whole video series

Before working your way through the module one section at a time, watch the whole video series to get a broad overview.

Do not stress if you do not understand everything in the first viewing. One cannot understand a single systems concept fully before one understands them all. Systems thinking requires iterative learning, so be prepared for the tension of incomplete knowing. Your questions will very likely be answered in one of the following video lectures.

2. Work with one section at a time

The content of the knowledge provided in the videos, summary of theory and additional reading is the same. However, there are differences in emphasis and the level of detail for the sake of deepening insights and providing additional explanations.

When working with individual sections:

- Watch the relevant **video** again.
- Read the **summary of theory**. You can do so either online or download the manual.
- Go through **additional reading**.
- Do the prescribed **exercises** to apply the new concepts to your case study. Some of the exercises you will fill in within the e-learning platform. Others - where data needs to flow from one exercise to the next or from one module to the next - you will be asked to answer in your Google sheet, a link for which is provided in the Resources section.

- Do the **self-reflection** and **contextual reflections,** there is no real learning without reflection.

Your case study

In an open enrolment delivery of the programme, the learners come from different organisational backgrounds and do not have a shared case study system of which they are part.

Hence you have to choose a personal case study which you will work with throughout the entire programme.

We recommend that you use your personal work function, as there could be synergistic learning with other learners who also use their work function as their case study.

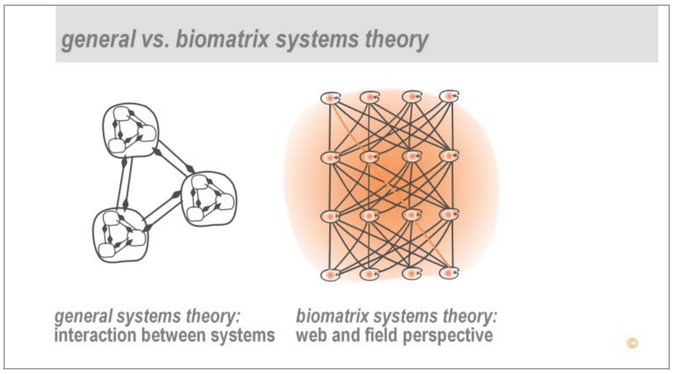
Your chosen case study has to be a system that you manage yourself and that you have sufficient control over to be able to effect significant change. *For example, even if you are the head of the education department of a country, you cannot choose the redesign of the education system as your case study, as this would be a collective effort between different stakeholders associated with different parts of the system (this could however be done as an in-house programme for your department.) Instead, your work function case study would be that of being the manager of the department and your focus would be to improve and if possible redesign the function for the purpose of increasing effectiveness and efficiency. It is likely that most parts of your function redesign would also be applicable to the heads of other government departments.*

Throughout the programme you will also reflect on the various systems concepts you learned and their relevance for your case study.

Part 1

Introduction to General and Biomatrix systems theory

Visual summary



Summary of theory

General systems theory

General systems theory (GST) is a wholistic theory. It is a body of knowledge that uses key concepts from different models and theories, such as cybernetics, operations research, systems dynamics, ideal systems (re)design, complexity theory, chaos theory and ecological thinking.

Systems thinking has been evolving since the 1960s, although some concepts were conceived earlier (e.g. the concept of holism which was coined by Smuts in 1926).

Major thinkers who contributed significantly to the development of the core concepts of general systems theory include Ashby, Ackoff, Bateson, Von Bertalanffy, Beer, Boulding, Capra, Checkland, Checkland and Scholes, Churchman, Forrester, Flood and Jackson, Gharajedaghi, Gomez and Probst, Koestler, Laszlo, Maturana and Varela, McNeil, Meadows, Senge, Vester.

Since then, many other thinkers contribute to its further development. Most recently, complexity theory and chaos theory have added some new insights.

Biomatrix systems theory and approach

Biomatrix systems theory is a comprehensive systems theory. It builds on and extends the various concepts developed by the above mentioned systems thinkers. Due to some unique contributions it also integrates them into a coherent theory.

We have also added some new tools and methods to those used by the other systems thinkers and integrated them into a coherent systems methodology. This is referred to as the Biomatrix systems approach.

Comparison: General versus Biomatrix systems theory

Although they share the same core concepts, there is a subtle, yet fundamental, distinction in how most systems thinkers depict the universe and how Biomatrix systems theory perceives it. This distinction is illustrated in the figure above and can be explained as follows:

- General systems theory emphasises the interaction between systems and their parts. These interactions can form process chains and feedback loops.
- Biomatrix systems theory distinguishes between a
  - **web perspective** comprised of different systems (i.e. activity and entity systems) that mutually co-produce each other across levels in the systems hierarchy of the biomatrix
  - **field perspective** comprised of the information (i.e. ethos) that underlies the web of the biomatrix and each of its systems. It represents the conceptual reality which in-forms the manifestation of systems in physical reality.

Biomatrix systems theory does not replace the thinking evolved through general systems theory. Rather, it extends, contextualises and clarifies it by some unique conceptual contributions.

Additional reading

It is useful to read the following section of *Biomatrix: A Systems Approach to Organisational and Societal Change (*3rd edition*):*

Introduction to systems theory (pages 1-5)

Self-reflection

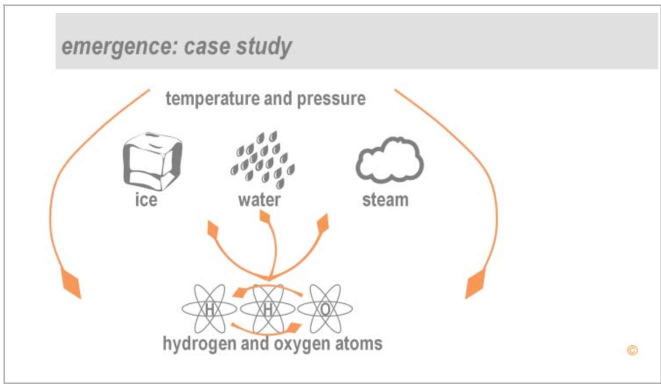
Reflect on your exposure to systems thinking to date.

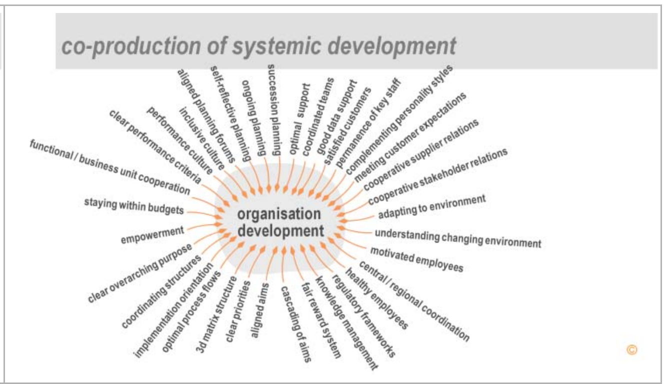
Part 2

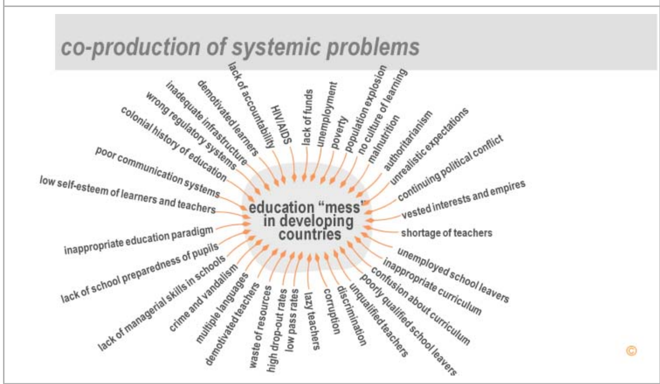
Essence of systems thinking

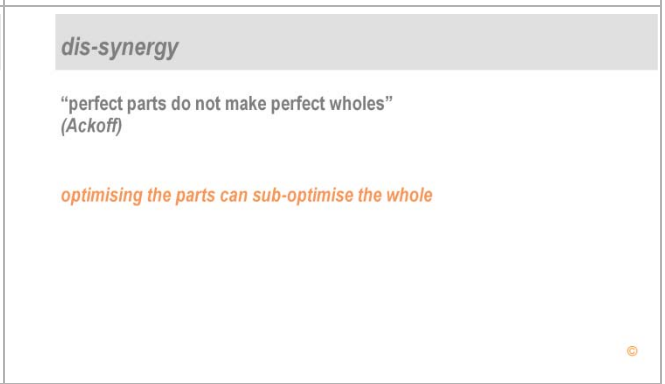
Essence of systems theory

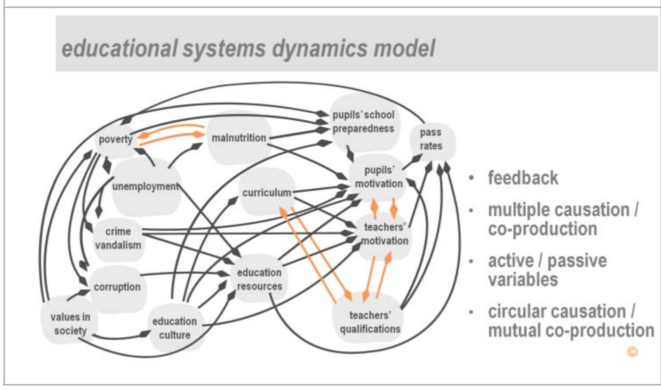
Visual summary

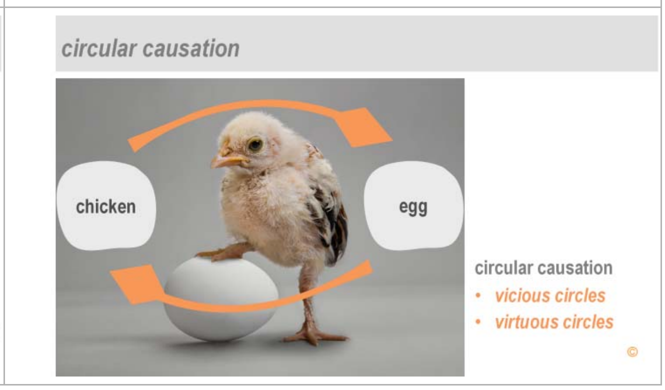












Summary of theory

What is a system?

A system is a 'whole' that cannot be divided into independent parts, because the behaviour of the parts and their effect on the whole depends on the behaviour of all the parts interacting with each other. *(Gharajedaghi & Ackoff, 1985)*

Different systems thinkers have different definitions. Most include the following:

A system is a discernible ‘whole’

- consisting of interacting parts
- that are organised for a purpose
- have regulated relationships
- and give rise to emergence
- etc.

Biomatrix systems theory has its own definitions. It distinguishes different types of systems (i.e. web, entity and activity systems, as well as artefacts) and has a definition for each.

Emergence

Emergence is explained by the famous systems saying: “The whole is greater than the sum of its parts as new properties emerge at the level of the whole.”

Emergence is a synergistic outcome at the level of a whole that is co-produced by the parts and environment of a system. Put more simply, emergence arises from the interaction of a system with its parts and its environment. It consists of properties or characteristics of the whole that are not inherent in the parts, analogous to one plus one is three.

For example, the interaction of hydrogen and oxygen atoms with different temperatures and pressures gives rise to different emerging states, such as the fluidity of water, the solidity of ice or the gaseousness of steam. Or, the interaction of my and your unique knowledge can give rise to new ideas that neither of us had before.

Co-production

Systems thinking emphasises that everything in the universe is co-produced.

The development of a system is co-produced by other systems in its outer and inner environment and by itself. *For example, a person’s life is co-produced by the functioning of the cells in the body, by external circumstances and by the person’s own efforts. The development of an organisation is co-produced by the contributions of each of its staff members, by its own systems, by conditions in the market, contributions by its stakeholders and by planetary conditions, amongst others.*

Likewise, any situation or issue (*e.g. a car accident, a building project*) has several, if not many, co-factors that bring it about. Also the problems experienced by a system are co-produced. *For example, a societal problem such as an underperforming education system is co-produced by many co-factors which are often problems in themselves. Ackoff coined the term “mess” to describe a system of interacting problems.*

Not only is a system co-produced, but it also co-produces the systems it interacts with. Thus, systems mutually co-produce each other. They continuously emerge from this co-production.

By asking “**What else** is co-producing the problem?” one shifts into systemic problem analysis mode. Or by asking “**What else** could we do to improve this situation?” one shifts into a more systemic developmental mode.

In a problem situation, not every co-factor is necessarily a problem in itself. Sometimes the solution in one area can create a problem in another area. *For example, the more successful a person is in completing a project, the bigger the workload might get.*

Systems thinkers also distinguish between a **necessary** cause and a co-factor. Even if a cause is necessary to create a condition, it is typically not sufficient to bring about the effect but requires additional co-factors to be effective. *For example, the HIV virus causes a disease complex referred to as AIDS. The virus per se cannot cause the disease unless it enters a body (involving co-factors like contaminated needles or unprotected sex) and opportunistic diseases (e.g. exposure to infectious diseases) are involved.*

Note on terminology: Other terms that are used to describe *co-production* are *co-causation* or *multiple causation***.** The words that are typically used to describe the contribution of a system to a change in another system are *co-factor*, *co-cause* or *co-producer*.

(Dis)Synergy

Synergy is defined as the interaction or cooperation of two or more systems to produce a combined effect, greater than the sum of their separate efforts. Thus the concept of synergy is a combination of both co-production and emergence.

Emergence can be desirable (synergistic) or undesirable (dis-synergistic). *For example, a team can co-produce conflict and chaos (dis-synergy) or harmony and creative output (synergy), depending on the nature of the team interaction.*

Synergy arises from parts working together to produce desirable emergence for the whole. Synergy has win / win built into it, because synergy is only present if the co-producing parties are satisfied with the shared outcomes.

By comparison, **dis-synergy** refers to undesirable outcomes for the co-producing parties and other impacted on stakeholders. It often implies a lose / lose for all parties concerned. It typically arises if a system acts to promote its own interest at the expense of others or at the expense of the larger whole. *For example, the finance crisis arose from behaviour induced by maximising self-interest which created problematic outcomes at the level of the larger whole, the society*. Although, in the short-term, this strategy may benefit the part, in the long term, the part suffers together with the whole. *Like cancer, it will die when the body dies. When the economy collapses, so will the banks.*

Systems thinkers (e.g. Ackoff and Gharajedaghi) point out that optimising the part tends to sub-optimise the whole. One should optimise at the level of the whole (i.e. optimise the 'we').

Impact

Another way of explaining co-production is that systems impact on each other.

Chains of impact

As one part of a system (as described by a co-factor) changes, its interaction with its connecting systems will change and elicit a response in them. Often this implies that they will also change.

Thus a change set in motion in one co-factor ripples on through to others. A systems dynamics model (like the one in the visual summary section) allows one to trace this rippling of change from one co-factor to another. Forrester, Meadows, Senge and Gomez, amongst others, have popularised systems dynamics models.

In interaction with the impacted on co-factor, the change takes on a new form. There is emergence, making the impacts of change largely unpredictable.

Circular impacts

The ripples of change are also likely to return to the co-factor from which change originated, co-producing change in that system yet again. Thus systems also co-produce themselves.

If the return change is direct, one speaks of **circular causation**. It means that two systems impact on each other directly (illustrated by the orange arrows in the systems dynamics model in the visual summary section). *The famous example is that of the chicken and egg which give rise to each other.*

Circular causation can involve **vicious circles** (*e.g. I hit you, you hit me back*) or **virtuous circles** (*e.g. I am nice to you and you are nice to me*).

Analysing impacts

One can analyse the nature of the impact according to:

- nature of impact: The impact produces more change in the impacted on system (positive feedback) or limits it from changing (negative feedback) – this will be discussed in more detail in module 3 in the context of different types of governance
- time aspect of impact (i.e. the impact occurs in the shorter or longer-term)
- strength of impact (e.g. the impact is strong or weak)

Change potential of co-factors

Besides observing how change flows through the system, systems dynamics models also reveal the action potential of each co-factors. One can distinguish between active, passive and critical co-factors:

- Active co-factors are those that create change in others. They tend to have arrows going out of them.
- Passive co-factors are those that are impacted on by others and change as a result, but do not have a strong action potential to change others. They are co-factors that have arrows pointing at them, but not from them.
- Critical co-factors are those with lots of arrows going in **and** out. The significance of critical co-factors is that the outcome of an intervention is often unpredictable, because of the ripple effect of the impact coming back to it via others.

Note on terminology: In the context of a systems dynamics model the term *impact* can be replaced with *feedback* and *feedforward* and the term *co-factor* is typically referred to as *variable*.

Additional reading

It is useful to read the following sections of *Biomatrix: A Systems Approach to Organisational and Societal Change (*3rd edition*):*

Essence of systems theory: Section 1.2 (pages 6-11)

Exercises

Exercise: Emergence

Identify three to five of the biggest problems you have in your case study.

Notes:

- The more problems you find, the more ideas you will later generate for the design of your case study.
- Be as specific as you can. Any person should be able to understand what you mean when reading each of your problems. *For example, "communication problem" is not acceptable. It does not explain the nature and reason of the problem (e.g. is there too little communication, an overload of it, wrong messages, delays, or what?). By comparison, a problem like "the boss does not provide strategic information that impact on our work" is quite clear.*

Problem 1	
Problem 2	
Problem 3	

Exercise: Co-production

Identify three to five co-factors for **each** of the problems identified in the previous exercise.

A co-factor is often a problem. It can however also represent a success for the co-producing system. *For example, a co-producing factor of the educated youth unemployment problem is improvement in the pass rates of matriculants. Or, the more successful you are in completing a project, the bigger your workload might get.*

Notes:

- Do not use keywords but a sentence or part sentence for each problem co-factor.
- Be as specific as you can. Any person should be able to understand what you mean when reading each of your co-factors.

Problem 1:	Co-factor 1.1:
	Co-factor 1.2:
	Co-factor 1.3:
Problem 2:	Co-factor 2.1:
	Co-factor 2.2:
	Co-factor 2.3:
Problem 3:	Co-factor 3.1:

	Co-factor 3.2:
	Co-factor 3.3:

Exercises: Impact

Exercise: Impact between co-factors

Draw the mutual impacts between eight to ten of your problems and problem co-factors.

Use all your problems identified earlier and add a few problem co-factors to make up the eight to ten problems / co-factors. Arrange them in a circle and draw the impact between them.

Impact means that if one problem / co-factor changes, it will cause a change in another problem / co-factor. If there is a direct impact between two problems / co-factors, draw an arrow, with the tip towards the impacted on problem / co-factor.

We suggest that you only work with **direct** and **strong** impacts. Because indirectly and weakly, everything impacts on and thereby co-produces everything else, as illustrated by the famous "butterfly effect" from chaos theory (i.e. if a butterfly flaps its wing, it can co-produce a tornado). Nevertheless, for the practical purpose of this exercise, we suggest that you do not draw an impact arrow between co-factors that seem to have only an apparently **weak** impact on each other.

Work "round robin":

- Start with problem / co-factors 1 and ask if it directly and strongly impacts on problem / co-factors 2. If yes, draw an arrow from 1 to 2. If no, don't draw an arrow. Then ask if it impacts on problem / co-factors 3, then 4 etc. till 10.
- Continue with problem / co-factor 2 and its impact on problem / co-factors 1, 3, 4, 5, etc., followed by problem / co-factor 3 and its impact on problem / co-factors 1, 2, 4, 5, etc. until you covered all.

This exercise yields a systems dynamics model of your problem.

Exercise: Circular impacts

Identify circular impacts amongst your co-factors (i.e. two variables that have an arrow pointing from and to each other, like the two orange arrows between the pupil's and teacher's motivation.)

Identify one vicious circle and one virtuous circle associated with your case study.

Exercise: Action potential of variables

Identify the most active, the most passive and the most critical co-factor(s).

Self-reflection

What is the relevance of the following concepts and their application for your case study?

- emergence
- co-production
- (dis)synergy

- impact

Contextual reflection

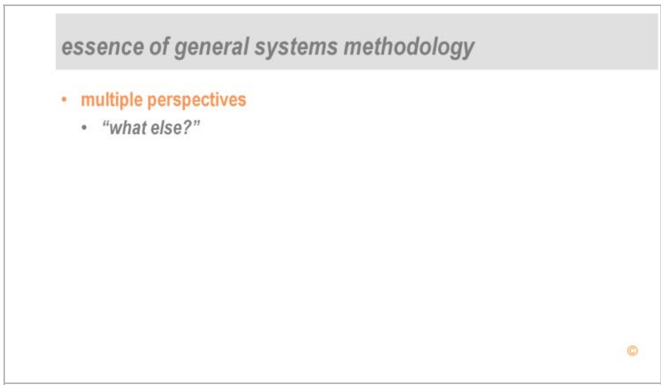
Choose a recent event in environment relevant to your case study (e.g. a new development in your personal environment, or a political development in your nation or on the global scene) and comment on it from the perspective of the following concepts:

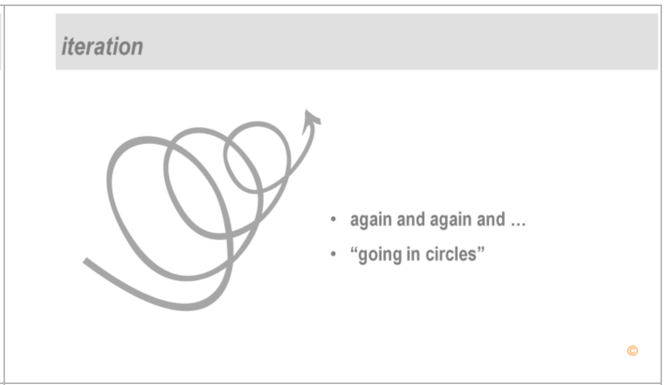
- emergence
- co-production
- (dis)synergy
- impact

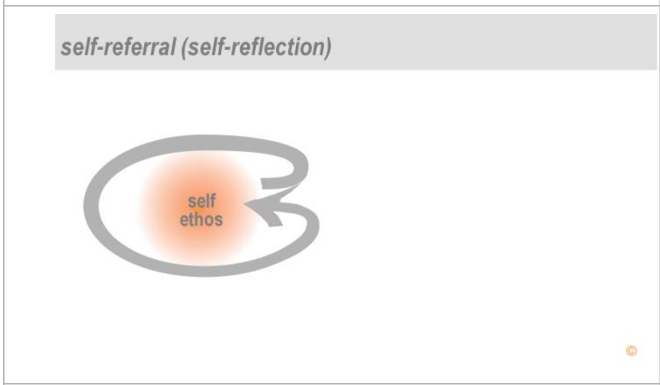
Can you identify a not previously considered problem or problem co-factor associated with any of the concepts? If yes, add it to your list of problems and problem co-factors.

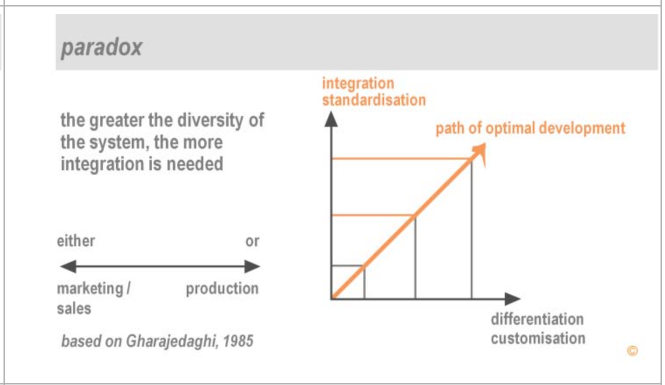
Essence of systems methodology

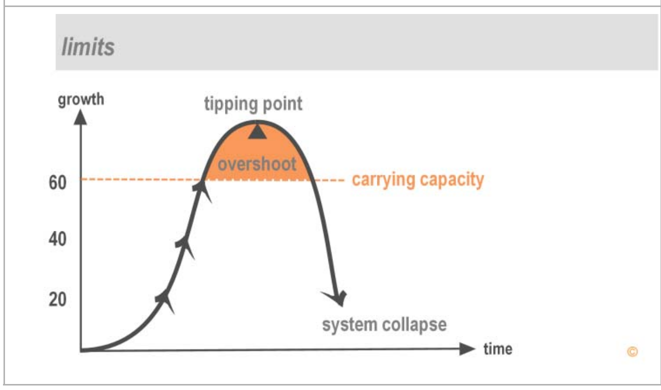
Visual summary

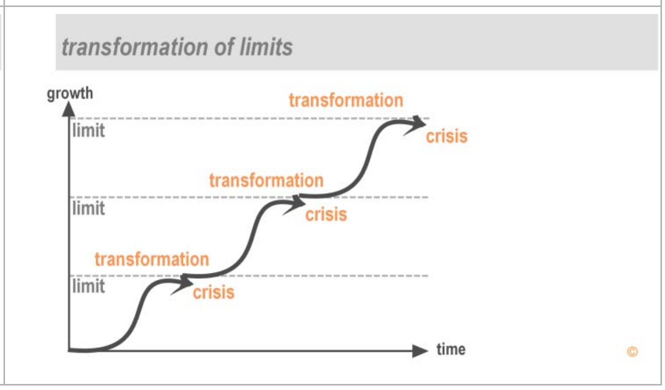












Summary of theory

Multiple perspectives

The co-production of every system, issue and situation implies that different stakeholders are involved. *For example, the development of a person depends on the contributions of different stakeholders in the external environment (e.g. parents, teachers, peers, society, media), internal stakeholders (e.g. genetic predisposition, health of body) and personal co-factors (e.g. motivation, self-development and learning, deliberate lifestyle choices and actions to implement them).*

Each stakeholder represents different functional perspectives.

The more perspectives are considered, the more thorough a problem analysis or the more creative a development strategy for the system under consideration will be. The question "What else?" prompts this.

The issue of multiple perspectives arises repeatedly in systems thinking in different ways, as for example in the context of connectivity to stakeholders and the multi-dimensionality of activity systems.

Multiple perspectives are also generated through iteration.

Iteration

Iteration means to work on an issue or repeat an action again and again.

Working iteratively is a principle of systemic behaviour. It is a purposeful way of ensuring continuous improvement and learning *(e.g. learning a sport or an instrument through repetition)* as well as deliberately aligning stakeholders in a synergistic manner. *For example, deciding to make a building alteration involves discussing the project with various stakeholders and based on their input, making changes to the plan, until it is finalised.*

Likewise, change interventions in an organisation or in society require iteration in order to align stakeholder interests and take on board new stakeholders that were missed in previous rounds. As a rule of thumb: the larger a project and the more diverse the interests of the stakeholders, the more iterations will be required. Also, the more stakeholder inputs are received and incorporated in the shared project, the more synergistic it is likely to be.

Another reason why iteration is systemic behaviour is that as change is initiated in one point in a system, it ripples through the system and into systems in the inner and outer environment, creating emergence in every new interaction. Thus, the effect of an intervention is unpredictable and one needs to change and fine-tune the ripples until they are settled and stakeholders are (reasonably, if not fully) satisfied.

Thus, iteration is not inefficiently doing the same thing over and over again or "running in circles". It is moving towards shared outcomes, albeit not necessarily in a step by step or predictable manner.

Iterations can occur between stakeholders representing the whole system (*e.g. the organisation as a whole*) and its parts (*e.g. different parts of the organisation*), between a system and its environment, between short-term and long-term considerations, between identifying problems and designing solutions, amongst others.

Iteration alternates convergent with divergent phases of intervention. Fine-tuning change is a convergent phase, while new stakeholders could open up a divergent phase, giving rise to new change not previously considered. However, ultimately, the iterations will stop and the system and its stakeholders will settle into a routine behaviour again, until the next change is required.

Self-referral

Self-referral means linking the issue one is dealing with to oneself. It implies thinking what the issue under consideration means to oneself, how it affects the self, what one knows about it, feels about it, how it compares to one's past experience, what it could mean for the future, and so on.

In the context of thinking, self-referral involves self-reflection. It is the basis of learning and conscious decision-making. It also creates meaning, promotes self-development and self-awareness.

In a systemic context, it closes loops between systems / co-factors / issues and the self.

In a group context, self-referral implies relating the issue to the "self" of the group. *For example, a team may discuss a project from the perspective of the organisation (i.e. what it means for us as an organisation). Discussions in parliament are an example of self-reflection by society. Editorials and readers' letters in the media are also reflections for the collective.*

Self-referral is an essential tool for deliberate planning and decision-making, as well as learning.

Self-reflection is the most effective way of changing culture (societal, organisational or personal).

Paradox

The dictionary defines paradox as a seemingly self-contradictory or absurd statement which is nevertheless founded in truth. In a system, paradox implies that the system is guided by or aims to achieve seemingly contradictory values. *An example is freedom versus security. The more security is required, the more freedom needs to be curtailed and vice versa.* Paradox is resolved dialectically, by dealing with each value contextually. Often different values are relevant in different contexts or are located in different parts of the system and can therefore be met by the containing system. *For example, one can develop a system that maximises both freedom and security in their relevant contexts.* Thereby either / or is transformed into as well as.

Paradox can also span levels, such as between the system and its external / internal stakeholders, between different parts of the system, between a part of the system and the system as a whole, between different stakeholders of the system, etc.

There is also an inherent paradox in each system, namely that of integration *(e.g. we are one team)* and differentiation *(e.g. we are each a unique member of the team).*

Limits

Because every system is part of other systems and contains other systems, it is limited by the possibilities inherent in those other systems. *For example, the amount and quality of grazing land limits the number of animals that can be sustained by that land. The physiology of a person imposes limits on how much he / she can work or how long he / she can stay awake. The current climate change issue is the result of exceeding the limits of the level of greenhouse gases that would sustain current weather patterns.*

The limits are also referred to as carrying capacity, which is a measure for the amount of growth and development a system can sustain.

Exceeding carrying capacity (i.e. overshooting it) can lead to the collapse of the system.

Sustainable development implies staying within the limits of carrying capacity of the containing and contained systems.

Transformation

If a system wants to grow and develop beyond the limits (i.e. carrying capacity) inherent in the self as well as the containing and contained systems, it has to either extend the limits or - if this is not possible – it has to transform itself. *For example, to extend the production of food beyond the current carrying capacity of the available land, one can either get access to more land or if the limits of the available land are reached, one needs to use the land differently to achieve higher yields. This requires development of the system (e.g. from subsistence to industrial agricultural* *production and later to information age agriculture). Or, if one gets stuck in career limits, one needs to transform oneself in order to move onto a different level of career development, one may have to "reinvent" oneself. If an organisation hits carrying capacity issues through for example an obsolete product, service or systems that cannot cope with a too rapid growth, it needs to transform itself.* (This is what the *Biomatrix Organisation Transformation Programme* assists with.)

Additional reading

It is useful to read the following sections of *Biomatrix: A Systems Approach to Organisational and Societal Change (*3rd edition*):*

General systems theory and methodology (pages 12-17)

Self-reflection

What is the relevance of the following concepts and their application for your case study?

- multiple perspectives
- iteration
- self-referral
- paradox
- limits
- transformation

Contextual reflection

Choose a recent event in environment relevant to your case study (e.g. a new development in your personal environment, or a political development in your nation or on the global scene) and comment on it from the perspective of the following concepts:

- multiple perspectives
- iteration
- self-referral
- paradox
- limits
- transformation

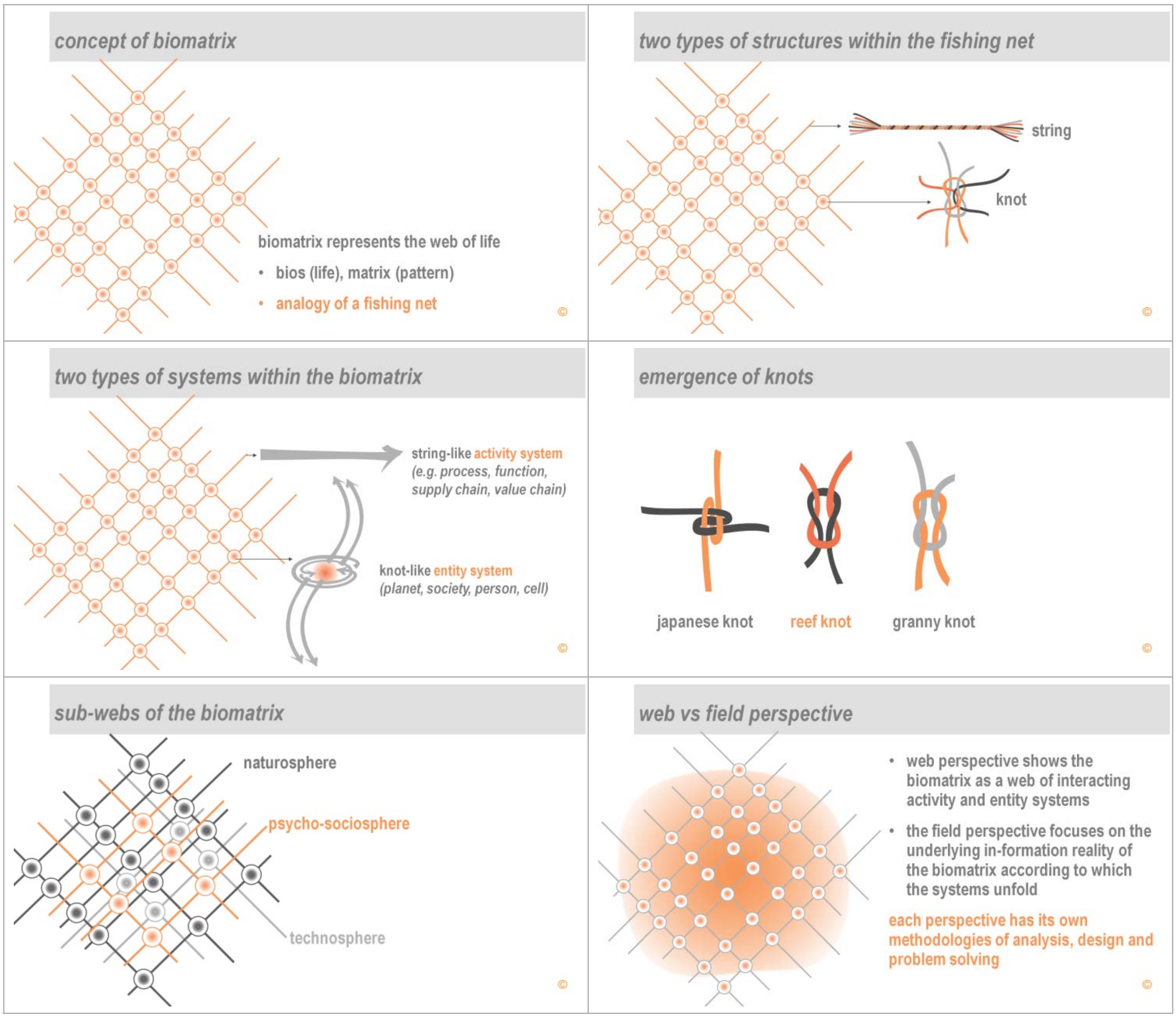
Can you identify a not previously considered problem or problem co-factor associated with any of the concepts? If yes, add them to your list of problems and problem co-factors.

Part 3

Overview of Biomatrix and General Systems Theory

Key concepts of Biomatrix systems theory

Visual summary



Summary of theory

Concept of biomatrix: biomatrix as a web system

Biomatrix represents the web of life. The word is derived from the Greek *bios*, meaning life and *matrix,* meaning pattern or womb. It thus means pattern of life or how life is organised.

The whole biomatrix can be regarded as one gigantic system, the universe.

Biomatrix systems theory is a theory of how the biomatrix and its systems are organised. It is also a worldview that views and interprets the phenomena that we observe in physical reality.

Two types of systems within the biomatrix

Biomatrix systems theory uses the analogy of a fishing net to illustrate a fundamental principle of organisation of the web of life, the distinction of different types of systems. Analogous to the fishing net which consists of knots and threads, the web of the biomatrix consists of string-like activity systems and knot-like entity systems.

Activity system

Activity systems are the “thread-like” systems within the biomatrix. They represent an activity (or a process or movement). Unless we deal with a random activity (*e.g. like an accident*), the activity is likely to be purposeful and governed accordingly. We therefore define an activity system as a purposeful process that is structured and governed to achieve its aim.

Activity systems connect entity systems with each other. *Examples are a production activity system that connects the producer to the customer; an eating system that connects the body with its cells; or thinking which connects the person with him/herself.*

An activity system can be a project or a function. It also refers to a supply or value chain.

Project

A project is an activity system that is discontinued when its outcome is achieved, *as for example a building project or an education assignment.*

Function

A function is an inherent part of an entity system. It provides a service (i.e. a function) without which the entity system cannot live or would be incomplete, *as for example the circulatory or breathing functions of the body, or the production, marketing or finance functions of an organisation.*

A function is ongoing and exists as long as the entity system to which it belongs (i.e. the entity system of origin).

Supply and value chain

Activity systems link up with each other to form a chain of activity systems, *as for example an industry supply chain*. The whole chain can be regarded as one overarching activity system.

Likewise, an activity system consists of a chain of sub-activity systems. *For example, the business process (or business activity system) of an organisation is likely to consist of a production, marketing / selling and delivery sub-activity system.*

The term supply chain emphasises the continuity of outputs from one activity system as input to the next. The term value chain emphasises that value is added within each link of the chain.

Entity system

Entity systems are the knot-like systems within the biomatrix. A knot in the web consists of patterned threads. Likewise, an entity system is a **pattern** formed by its interacting activity systems.

The same threads can give rise to different knots with different emergent properties *(e.g. compare the properties of a Japanese knot, a reef knot or a granny knot in the figure in the visual summary).* Likewise, by interfacing the activity systems of an entity system in new ways, one can change the qualities of the entity system.

Analogous to the knot which consists of patterned thread, an entity system is defined as a whole that consists of a field of interacting activity systems. *Examples of such "knot-like" entity systems are the planet, a society, an organisation, a family, a person, an organism, a cell and an atom. In a social context, entity systems are often referred to as stakeholders.*

Sub-webs of the biomatrix

The biomatrix consists of three sub-webs

- **naturosphere** (nature's systems)
- **psycho-sociosphere** (human systems)
- **technosphere** (technological systems)

The activity and entity systems within the three sub-webs display the same generic organising principles of the biomatrix. At the same time, the systems of the three sub-webs also differ in terms of their functioning due to the degree of choice: the systems of the naturosphere and technosphere are characterised by relatively fixed functioning, while the human psycho-sociosphere is characterised by a larger degree of free will.

The systems of the three sub-webs interact and co-produce each other. Thus, all systems have characteristics derived from the three sub-webs. This is referred to as multi-dimensionality (for more detailed explanation see the later section on *Multi-dimensionality).*

Field perspective of the biomatrix

The analogy of a fishing net also illustrates another organising principle, the "space" behind the net. The physical reality of the net exists within space.

Research in physics suggests that this space is not "empty", but that space / time interact with matter. More recently it is hypothesised that it contains in-formation. This is also supported by other scientific disciplines (quantum physics, evolutionary biology, cosmology and consciousness research) and called different names.

Accordingly, Biomatrix systems theory postulates that there is an in-formation field underlying the web of the biomatrix and each of its systems. It contains the in-formation that determines the form and functioning of each system.

The term in-formation (a term coined by D. Boehm) refers to that type of information that in-forms, meaning that puts form into things. *For example, the values and aims of a person or organisation are in-formation, as it guides their development. By comparison, the information on a bank statement, price list or pamphlet explaining a product is information, not in-formation.* Information does not transform the system. In-formation does (we will explore this in detail in the sections on ethos in the following modules).

The information fields form a containing hierarchy, whereby the in-formation field of a species is shared by all members of the species. However, within this field there are variations making each member of the species unique. *For example, all humans share in-formation, making them equal and the same in some ways. And each person is unique according to its personal in-formation* *field. Likewise, a market (e.g. the financial product market) shares the same fundamental ethos. Within it, each bank and even each branch within a bank has its unique and distinctive features.*

The biomatrix as web versus field

The biomatrix is both a web of interacting activity and entity systems and an in-formation field, analogous to light which is both wave and particle.

The dual nature of light implies that an observer arrives at different sets of qualities and laws for light as particle and light as wave. Likewise, the dual nature of the biomatrix as web and field gives rise to different organising principles, as well as methodologies of analysis, design and problem (dis)solving.

Each set is a partial truth. Together, these different sets make up a greater truth that gives more insight into the phenomenon of light and biomatrix.

Additional reading

It is useful to read the following Sections of *Biomatrix: A Systems Approach to Organisational and Societal Change (*3rd edition*):*

The web of the Biomatrix (pages 21-47)

Exercises

Exercise: Two types of systems

Identify the activity (activities, functions) and entity systems (stakeholders) associated with your case study.

Activity systems	Entity systems

Self-reflection

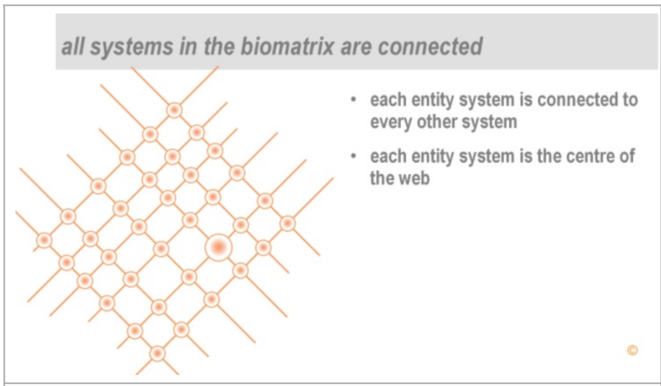
What is the relevance of the following concepts and their application for your case study?

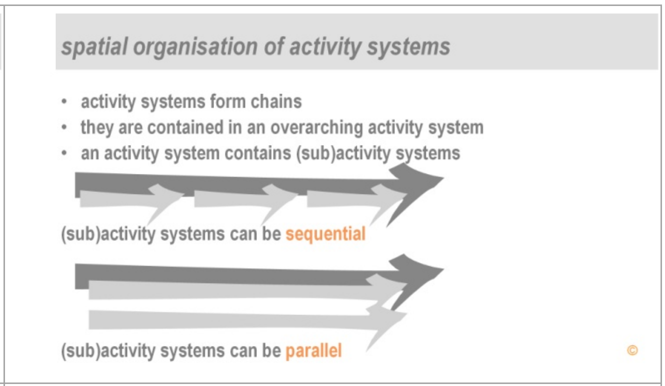
- The biomatrix as a web system
- Activity system
- Entity system
- Sub-webs of the biomatrix
- Field perspective of the biomatrix

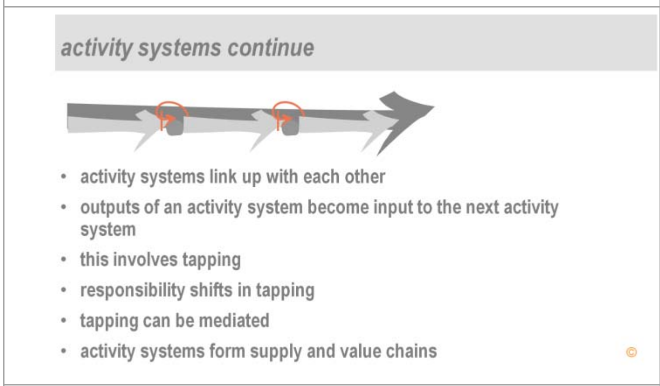
Can you identify a not previously considered problem or problem co-factor associated with any of the concepts? If yes, add them to your list of problems and problem co-factors.

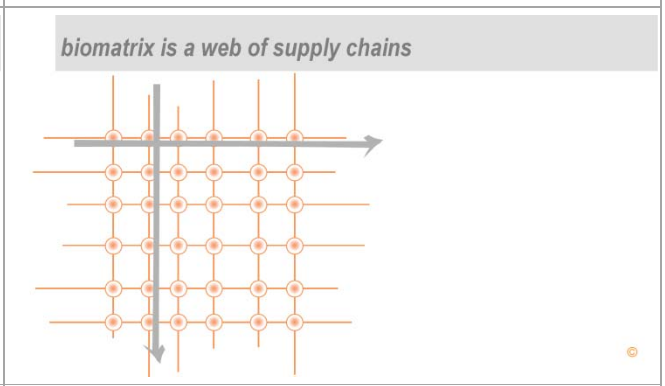
Organisation of the biomatrix in space: Activity systems

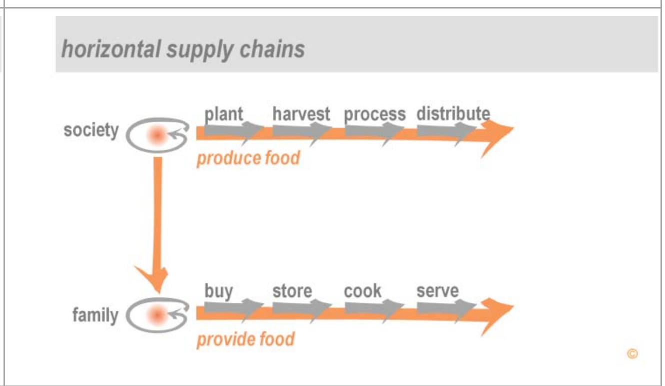
Visual summary

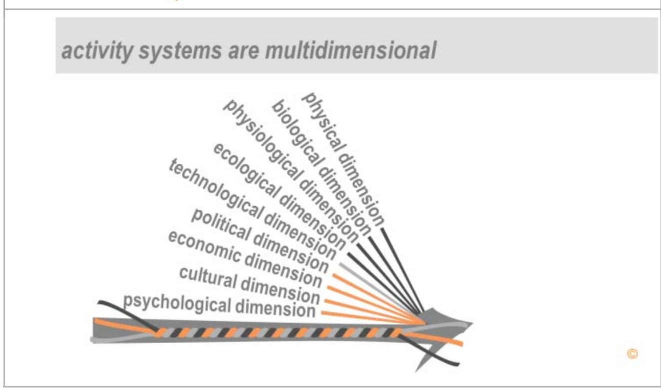












Summary of theory

All systems in the biomatrix are connected

As illustrated by the fishing net, the threads link all knots with each other. Likewise, within the biomatrix the activity systems connect all entity systems with each other. Thus, all entity systems are connected to each other via their own activity systems, which link up with those of other entity systems.

The connectivity continues so that ultimately, every entity system is connected – directly or indirectly – to all other entity systems. Put differently, every entity system is the centre of the biomatrix.

The systems to which the system of focus is directly linked are typically referred to as stakeholders.

Through this connectivity, systems can exert direct or indirect influence on each other.

By aligning with other, like-minded systems, one can increase one's influence outward.

Managing outward is one of the core competencies of leadership.

Activity systems form chains

Activity systems form a chain of activity systems. On the one hand, each activity system links up with activity systems of other entity systems. *For example, a person's learning activity links up with the teacher's teaching activity on one end and the neural activities of the brain on the other end.*

On the other hand, an activity system can be broken down into a chain of sub-activity systems. *For example, the e-learning activity system of this programme consists of the sub-activities of watching the video of the whole module, then watching the first section again, reading the manual of the section, doing the exercise and self-reflection of that section, and follows the same sequence of activities for the next sections.*

The output of one activity system continues as input to a connecting activity system. This connectivity involves tapping (depicted by the orange arrows in the visual summary section). The output of one system is tapped by the next.

Responsibility shifts in the tapping interface. If conflict occurs in tapping, this needs to be mediated (this will be explored in more detail in module 3).

Note on terminology: A chain of activity systems is typically referred to as a supply chain or a value chain. The term supply chain emphasises that the work done by the activity system supplies goods or services to the connecting activity system. The term value chain emphasises that the work of the activity system adds value within the chain (this will be explored in more detail in module 3).

The biomatrix is a web of supply chains

Activity systems link up with each other to form horizontal and vertical supply chains.

Vertical supply chains run across levels *(e.g. from society to the individual or the individual to his / her cells)* and horizontal ones run along levels *(e.g. from one business, staff member or person to another).*

Most supply chains are a mixture of vertical and horizontal. *For example, the management education activity system between the organisation and the individual staff member can be extended "upstream" with an activity called "education programme development" or "curriculum development" and the supplying entity system is a consultant or a university. It could be extended "downstream" with an activity system called "learning" associated with the brain or neurons of the learner.*

The biomatrix can be viewed as a web of interacting supply chains.

Activity systems are multi-dimensional

The biomatrix consists of three sub-webs, the web of nature (the naturosphere), the web of technological processes and artefacts (the technosphere) and the web of social systems (economic, cultural and political systems).

Analogous to a string that is comprised of intertwining threads, the systems of the biomatrix interact and co-produce each other, in-forming each other. This implies that each system reflects the others in some way. Systems theory refers to this as multi-dimensionality. The following list gives some generic dimensions associated with each sub-web:

Dimensions of the psycho-sociosphere

- psychological (thinking, feeling, spirituality, etc.)
- cultural (ethics, aesthetics, knowledge, etc.)
- economic (resources, production, exchange, etc.)
- political (governance, control, relationships, etc.)

Dimensions of the technosphere

- technological entities and processes

Dimensions of the naturosphere

- ecological (water, air, soil, organisms, etc.)
- physiological (organs, cellular functioning, etc.)
- biological (cellular functioning)
- physical (molecules, atoms, sub-atomic particles, etc.)

Each issue, situation and system is multidimensional. *For example, the biomatrix e-learning activity system reflects most of the dimensions listed above. We have designed it with psychological considerations in mind (e.g. to make it as easy for the user as possible). We considered the ethics, aesthetics and knowledge aspect in its design and delivery. There are cost implications as well as political considerations (e.g. our Organisation and Societal Transformation Programmes involve personal interaction with our client organisations, while our programmes do not; also much thought was given to the design of the controls and governance built into the programmes). The online delivery and data integration requires many technological processes and we also looked at the physiology of brain / mind functioning and how this affects learning. By replacing face to face delivery with e-learning we also reduce our carbon footprint considerably, as we reduce our travel.*

Exercises

Exercise: Identify connecting entity systems

Demonstrate that your case study is directly connected (i.e. “upstream” and “downstream”) to entity systems (stakeholders).

Upstream entity systems (stakeholders)	Downstream entity systems (stakeholders)

Exercise: Identify external connecting activity systems

Identify the connecting activity systems associated with your case study.

Activity systems typically connect to upstream activities of suppliers and downstream activity systems associated with customers / clients. This is referred to as a supply chain.

Upstream activity systems (of suppliers)	Downstream activity systems (of clients)

Exercise: Identify your sub-activity systems

Your own case study can be broken down into sub-activity systems. Identify the sub-activities of your case study.

Sub-activity systems of your case study

Self-reflection

What is the relevance of the following concepts and their application for your case study?

- connectedness of systems
- chains of activity systems

- multi-dimensionality of activity systems

Contextual reflection

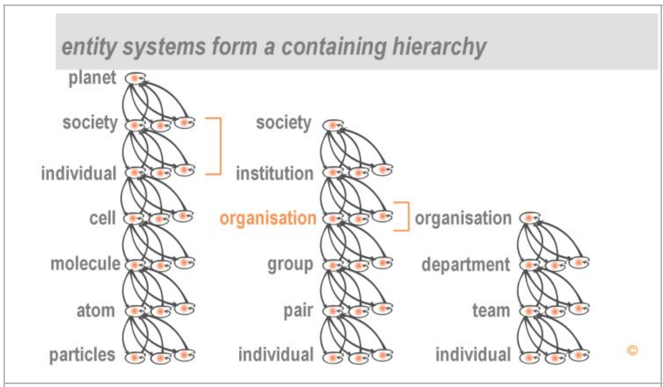
Identify a recent national or international event (not related to your case study) in which the following concepts played a role and comment on them:

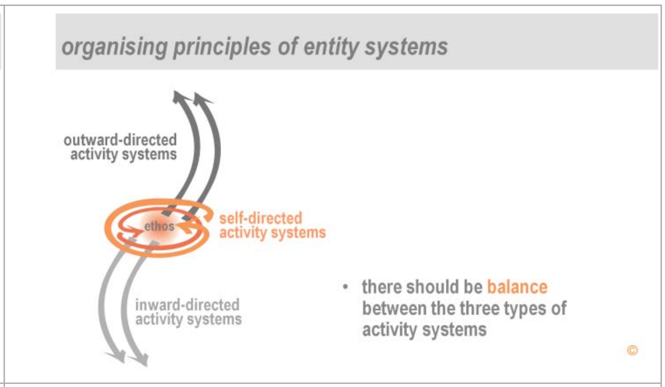
- connectedness of systems
- chains of activity systems
- multi-dimensionality of activity systems

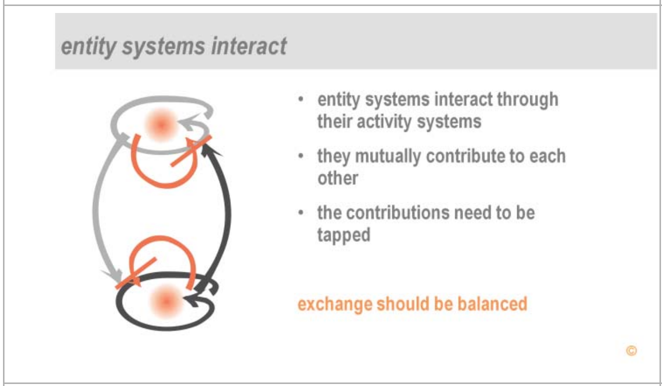
Can you identify a not previously considered problem or problem co-factor associated with any of the concepts? If yes, add them to your list of problems and problem co-factors.

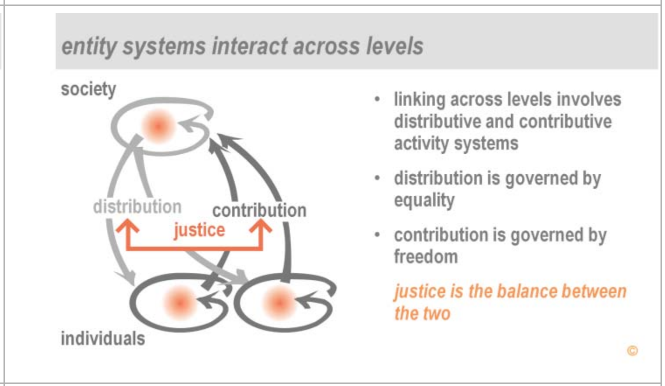
Organisation of the biomatrix in space: Entity systems

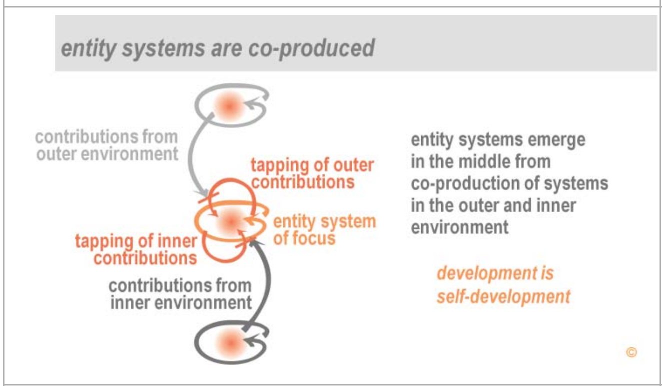
Visual summary

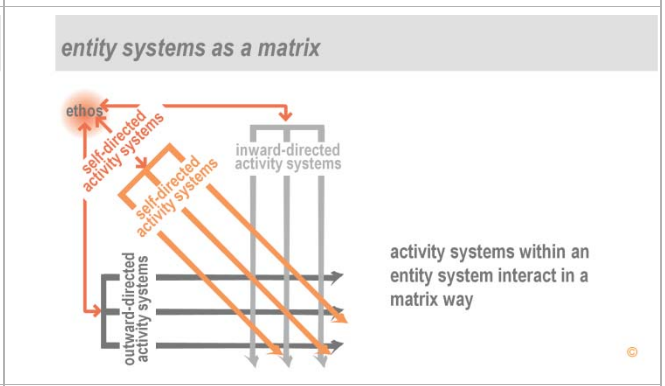


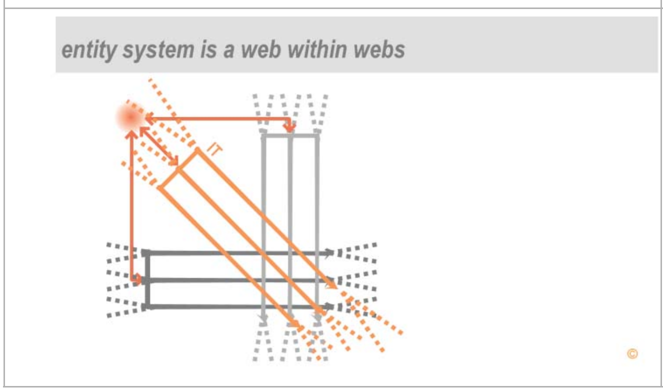


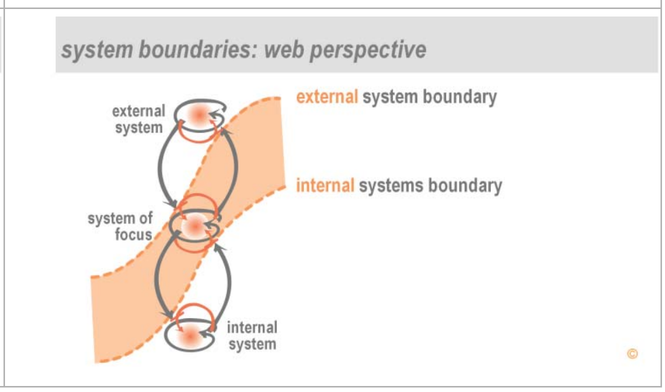


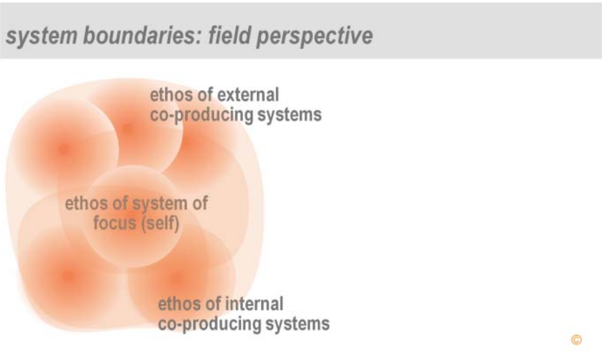












Summary of theory

Entity systems form a containing hierarchy

Entity systems contain other entity systems and are contained by other entity systems.

A containing hierarchy is not a control hierarchy in the sense of the traditional top down hierarchy of the industrial age. Rather, control in the containing systems hierarchy flows out – in, in – out, and self – self.

Nature has evolved a generic containing systems hierarchy. On our planet these include societies (of humans and other species), individuals, cells, atoms and particles, amongst others. Each of these systems, which are wholes in their own right, marks a level in the systems hierarchy.

Between those levels other levels can be inserted, as *for example an organisational and a family level between the society and individual level.*

Likewise, there are levels within levels. *For example, there are levels within an organisation (e.g. board, functions, sub-functions, etc.).*

Some learners are initially confused about the issue of levels, especially distinguishing between the inner level and self. *For example, if the body is the "self", then the cells are located at an inner environment, as are the atoms and particles on even more inner levels. At the same time, the body also has its own levels, like organs and their parts. However, these levels "belong" to the body. The organs and their parts are inherent to the body. They belong to the self of the body and are not independent systems in their own right, as each of the cells in the body is. The cells come and go as they populate the parts of the body. In an organisational context, the function of HR manager, for example, belongs to the organisation. It is an inherent part of it. The person filling the role, however, belongs to the inner environment of the organisation.*

Entity systems have a three-fold organisation

An entity system is a field of interacting activity systems. It is greater than the sum of its activity systems. It is an emergence.

A knot in a net shows threads going out, threads coming in and threads winding around itself. Likewise, an entity system has activity systems that connect it with the outer environment, the inner environment and with itself. Thus, entity systems have a **three-fold organisation**.

The directedness of the activity systems is determined by their purpose, not necessarily the flow of their substance. *For example, the purpose of breathing is to supply the inner environment of the* *body with oxygen. It is therefore an inward directed activity system, even if its substance (air and its composites) flow in and out of the body. Nutrition, stress management and sleeping are other inward directed activity systems of a person, while work, parenting and voting are outward directed activity systems. Learning, playing, self-reflecting are self-directed activity systems.*

Incomplete entity systems (like artefacts) do not have three types of activity systems. They typically lack inward-directed (*e.g. self-maintaining*) and self-directed (self-reflecting) activity systems. However, with artificial intelligence and in some bio-technologies even artefacts may soon become living entity systems in their own right.

Entity systems interact with each other

An entity system is connected with other entity systems in the outer and inner environment via its activity systems.

They offer contributions to each other. These need to be tapped by the recipient system in order for interaction to happen (tapping is illustrated by the orange arrows in the visual summary section).

In the context of the social systems hierarchy, the inward-directed contributions from society to the individual, for example, are typically referred to as distributive activity systems. The contributions made from the inner to the outer level, as for example from the individual to society, are typically referred to as contributive activity systems.

Examples of distributive activity systems are the provision of education, transport, healthcare and other services by society to its individual members. Examples of contributive processes are the work contributions of a person, the raising of children as members of society, voting, etc.

Distributive activity systems are governed by the value of equality (i.e. equality of access); the contributive ones are governed by freedom (*e.g. freedom of expression*).

Ideally, contributive and distributive processes are balanced (i.e. balance of exchange and give and take). If some systems take without contributing, the balance will be disturbed, some systems will apparently prosper at the expense of others and there is likelihood of damage to both types of systems.

Entity systems are co-produced

Each entity system is co-produced by its outer environment, inner environment and by itself.

Entity systems in the outer and inner environment offer contributions (i.e. in form of matter, energy and information). These are tapped (or not) by the entity system of focus. Thus, the state of an entity system develops across three levels: those of the outer environment, inner environment and the level of the self (or system of focus). *For example, one person takes advantage of (i.e. 'taps') talent offered by the inner environment (e.g. genetic predisposition, previous experience) and supporting opportunities offered by the outer environment (e.g. education) to develop. Another person may have similar opportunities from the external and internal environment but does not utilise them, having a different emergent development.*

Thus each entity system emerges "in the middle" from the opportunities inherent in the outer and inner environment and how they are being tapped.

Tapping can be passive (i.e. of opportunities that are present) or active (i.e. the deliberate seeking out of opportunities to tap). If the environment does not present opportunities, the entity system can seek them out deliberately. It is not a passive victim of circumstances. Thus, whatever the nature of the environment, the entity system is ultimately responsible for its own development.

The contributing systems that co-produce an entity system are from all spheres of the biomatrix (i.e. the naturosphere, psycho-sociosphere and technosphere) and all levels, from the planetary to the sub-atomic levels.

Entity system as a matrix

The activity systems within an entity system interact with each other. This occurs frequently in a matrix manner. *For example, the bloodstream in the body interacts with every cell in the body, carrying nutrients to each cell within each function and also distributing their in-formation to other functions.*

In an organisational context, the three-fold composition gives rise to a three-fold matrix structure. This allows an optimal interaction between the different activity systems.

This is discussed in more detail in the *Biomatrix Organisation Transformation Programme*.

Entity system is a web within webs

Each of the activity systems within a matrix is part of its own supply chain. It therefore connects the entity system with other entity systems in the outer and inner environment in a very function specific way.

This is discussed in more detail in the *Biomatrix Organisation Transformation Programme*.

Boundaries between entity systems

By looking at an entity system from a web perspective, its boundaries are clear. They are where the outputs of each of its activity systems are tapped by other systems in the outer and inner environment.

From an ethos perspective, the boundaries between entity systems are fuzzy and overlapping. It is not always clear where one entity system starts and another ends.

Interacting ethos is synergistic. New ideas arise from the interaction of the ideas contributed by the interacting entity systems. It is difficult to allocate ownership to them.

Exercises

Exercise: Containing hierarchy of entity systems

Your case study is part of an entity system (i.e. the entity system of focus). Describe this entity system in the context of the containing entity systems hierarchy.

Outer outer containing entity system	
Outer containing entity system	
Entity system of focus	

Inner contained entity systems	
Inner inner contained entity systems	

Exercise: Three-fold organisation of entity system

Is your case study an outward, inward or self-directed activity system of the entity system of focus?

Name two or three other outward, inward and self-directed activity systems of the entity system of focus.

Outward-directed activity systems	
Inward-directed activity systems	
Self-directed activity systems	

Self-reflection

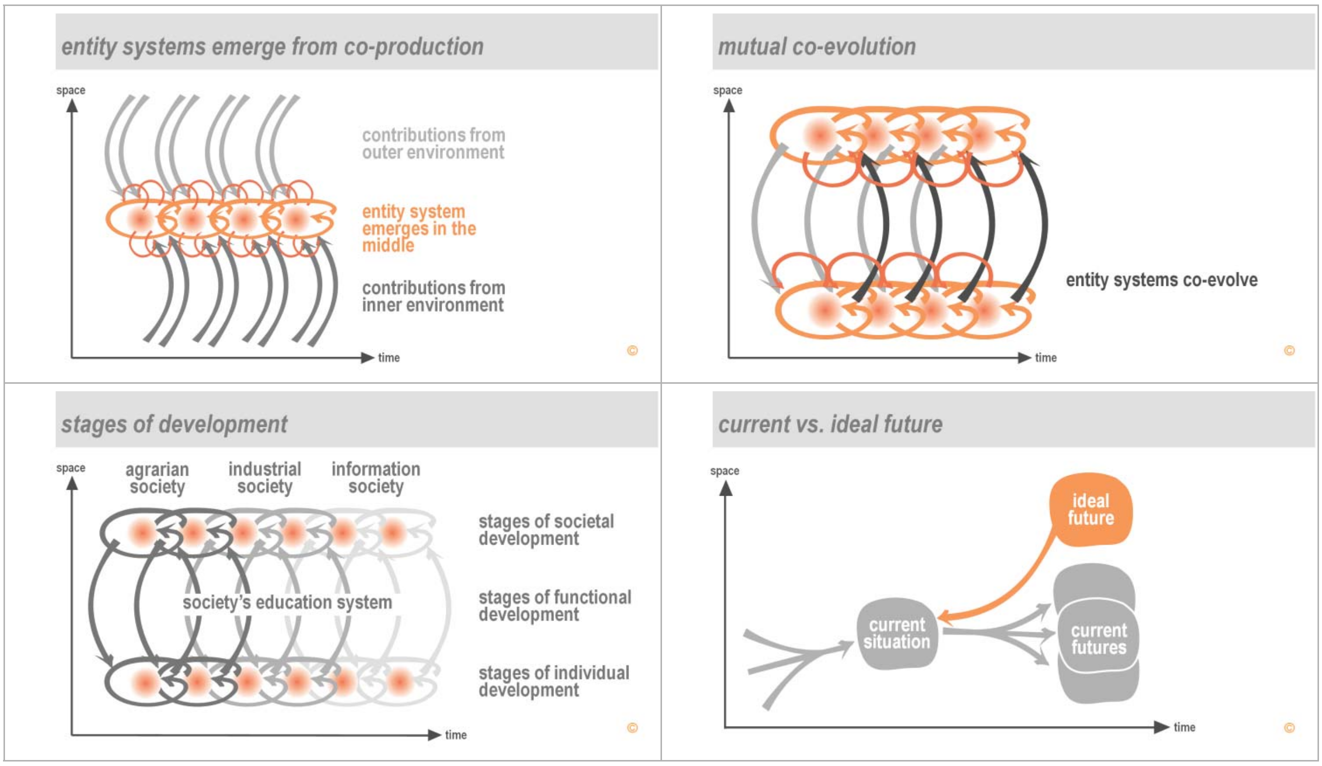
What is the relevance of the following concepts and their application for your case study?

- Containing hierarchy of entity systems
- Three-fold organisation of entity system
- Interaction between entity systems
- Co-production of entity system from three levels
- The entity system as 3-D matrix
- The entity system as web within a larger web
- Boundaries between entity systems

Can you identify a not previously considered problem or problem co-factor associated with any of the concepts? If yes, add them to your list of problems and problem co-factors.

Organisation of the biomatrix in time

Visual summary



Summary of theory

Co-evolution of systems across levels

Entity systems at different levels co-evolve with each other.

Entity system evolution as emerging middle

On the one hand, an entity system changes over time through contributions from the outer and inner environment and its response to it. It emerges “in the middle” from the interaction with the outer and inner environment.

For example, the development of a child emerges from the co-production by its inner genetic predisposition, the opportunities in the outer environment and by the motivation and effort of the child him / herself.

Mutual co-evolution

On the other hand, the entity system also offers contributions to entity systems in its outer and inner environment. These contributions change in accordance with the system’s own development and if tapped by the other entities, also co-produce their development. Thus, entity systems at different levels co-evolve with each other.

In accordance with its own evolution, the child makes contributions based on its learning to the family and later the work place, changing them in turn.

Since adapting to a changed environment is a necessity for the survival of all entity system, they have to mutually adapt to each other. This is the underlying reason for co-evolution across levels.

Stages of development

In the course of the co-evolution, the qualities of the interacting systems change and one can detect distinct stages of development.

For example, one can observe that in the course of history societies and their individual members have co-evolved from a hunting / gathering to an agrarian, industrial to an information society. Likewise, one can distinguish stages of development in every profession, in the life of a person and organisation.

Current versus ideal future

Systems have a current and ideal future.

Current futures

A current future is derived by projecting the current situation and current behaviour of the system into the future. Unless deliberately changed, current functioning *(e.g. habits, policies, strategies and structures)* persist. The current functioning has momentum that propels the system into a current future.

A current future is determined through forecasting the current momentum. Depending on assumptions concerning the interaction of the system with its environment (i.e. assuming likely / possible changes in systems structure and behaviour in response to likely / possible changes in the outer and inner environment of the system) one can forecast a range of alternative current futures.

Ideal future

The ideal future is a vision of an ideal state of the system that is deliberately designed and chosen by the system itself. It resides in conceptual space.

It serves the purpose of inspiring the system to develop strategies that could lead it towards that future. In the course of moving towards the ideal future, a system transforms itself.

The ideal future is especially relevant in systems with a large degree of choice regarding their functioning. Unlike systems in nature which have evolved relatively fixed functioning that is described by the laws of nature, social systems have a greater freedom to develop in ways of their choice. Since there is no law of nature prescribing *for example, a person's career, marriage or a society's education system*, these systems must decide for themselves *what is a desirable career, marriage or education system*.

If a system does not design an ideal future to strive towards, it will continue with what is familiar, i.e. a current future.

Self-reflection

What is the relevance of the following concepts and their application for your case study?

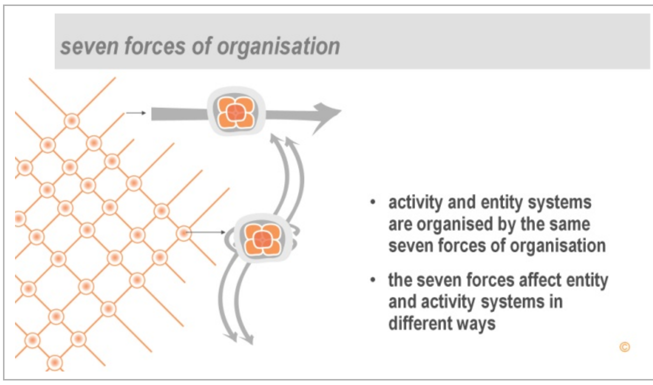
- co-evolution

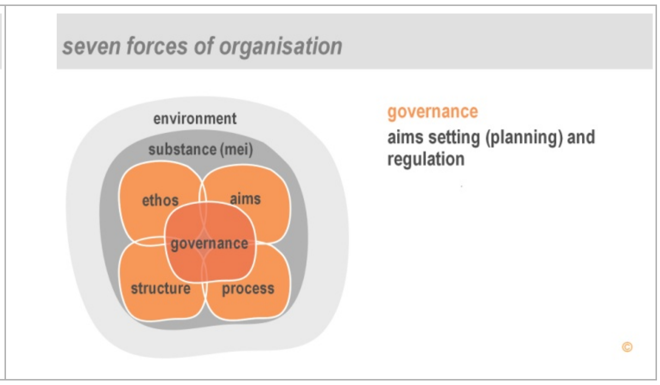
- stages of development
- current versus ideal future

Can you identify a not previously considered problem or problem co-factor associated with any of the concepts? If yes, add them to your list of problems and problem co-factors.

Overview of seven forces of system organisation

Visual summary





Summary of theory

Seven forces of system organisation

There are seven forces of organisation that operate within the biomatrix and its systems. In interaction, they determine the unfolding of the form and functioning of a system.

Analogous to the number of sides which make up every dice, every system is co-produced by seven forces of system oranisation. These are

- substance / mei (**m**atter, **e**nergy, **i**nformation)
- environmental relations
- ethos
- aims
- process
- structure
- governance

These forces interact and co-produce the unfolding and functioning of the biomatrix and each of its activity and entity systems.

As one of the seven forces changes, the others will change too, co-producing change in the system as a whole. *This can be illustrated by the analogy of Rubik's Cube: as one changes the colour of one side of the cube, the other sides change, as does the appearance of the cube as a whole*.

Each of the seven forces is generated by specific principles of organisation. They will be discussed in detail and applied to your case study in the following modules.

In summary, each of the seven forces refers to the following:

Substance / mei

As far as we know, the substance of every "thing" in the universe is matter, energy and information. They form the substance of what we observe as physical reality.

They always occur together and form an interacting field which we refer to as **mei**.

In an organisational context, substance refers to resources and components, such as human, material, technological, knowledge and financial resources / components.

Environment

A system exists within an outer and inner environment.

As the environment changes, the system has to change accordingly, if it wants to survive within the changed environment.

Ethos

Ethos is the field of in-formation which resides at the core of an entity system and guides it's unfolding.

In social systems ethos is referred to as culture.

Any system within the biomatrix (i.e. anything we observe) comes into being through in-formation by an ethos.

Analogous to the DNA in the organism, the ethos of a system contains the guiding values, principles and rules that in-form the development of the system.

Aims

An aim is a point in time-space that a system wants to attain.

Activity systems have a single, overarching aim.

Entity systems have multiple aims (*e.g. a mission describes what the entity system wants to do for its external stakeholders, internal stakeholders and for itself)*, while activity systems have a single overarching aim.

Process

Process is flow of substance (i.e. of matter, energy and information or mei).

As substance (mei) flows through a (sub-)activity system, it gets processed or transformed. *For example, foodstuffs are processed to become a cake*

Structure

Structure refers to a stable configuration or a stable pattern of (inter)action of substance (mei).

Structure within an activity and entity system differs:

- The structure of an activity system refers to its configuration of the acting and support substance (e.g. how a production line is configured). In business process redesign we typically restructure (i.e. rearrange the workstations) to make the processing (i.e. work flow) more efficient.
- The structure of an entity system refers to the pattern of interaction of its activity systems. This is typically referred to as organisational structure.

Governance

Governance within an activity and entity system differs:

- Governance of an activity system involves aims setting and regulation.
- Governance of entity systems involves self-referral (e.g. managing, planning, decision-making, considering diverse interests and balancing them, influencing external stakeholders through leadership, amongst others).

Additional reading

It is useful to read the following sections of *Biomatrix: A Systems Approach to Organisational and Societal Change*

Seven systems aspects of organisation (pages 47-108)

Self-reflection

What is the relevance of the following concepts and their application for your case study?

- seven forces of organisation
- substance / mei (matter, energy, information)
- environmental relations
- ethos
- aims
- process
- structure
- governance

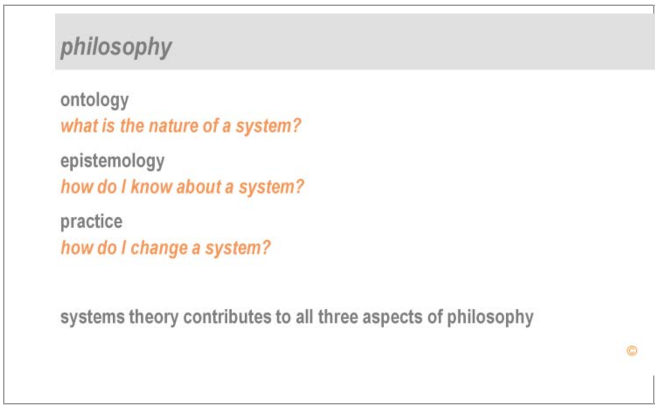
Can you identify a not previously considered problem or problem co-factor associated with any of the concepts? If yes, add them to your list of problems and problem co-factors.

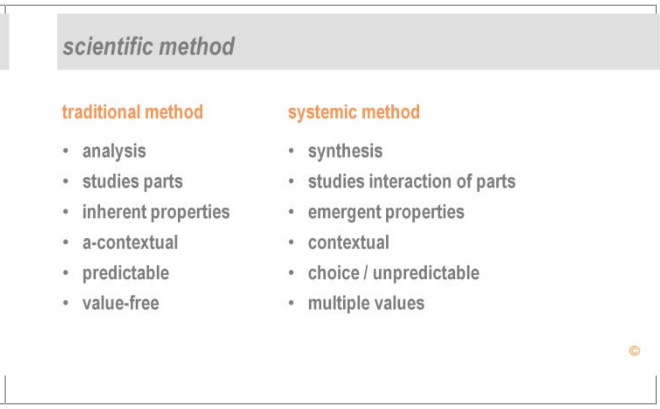
Part 4

Philosophy of systems theory

(Please skip this part if you are not interested in philosophy).

Visual summary





Summary of theory

From a philosophy of science point of view, systems thinking represents an extension of the current scientific paradigm.

It deals with those aspects of reality that cannot be understood by analysis alone but that require an understanding of the unique emergence that arises from the interaction of a system with its changing environment.

Self-reflection

How could the philosophical considerations of system thinking be relevant to you and your case study?

Next module

Module 2 on *Systemic Problem (Dis)Solving* explains the theoretical difference between problem solving and problem dissolving and outlines the methodology of problem dissolving through Ideal System (Re)Design.

The module will

- create an understanding of the nature of systemic problems as compared to inherent problems
- generate understanding of the difference between problem solving and dissolving
- generate skills in systemic problem (dis)solving
- help (dis)solve personal, functional and organisational problems
- make individuals more innovative and creative
- generate innovative ideas for the learner and his / her context.