Understanding the environment: co-evolution

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Introduction

Having observed the rapid growth and popular uptake of Wikipedia, this free course has been promoting an initiative called the "Earth Wiki" to combine the collective intelligence and experiences of everybody that has participated in the study of this course. You will be asked to bring your unique cognitive style and the wealth of experience you have gained into a concerted effort to systemically address issues of ecological sustainability and social justice.

This OpenLearn course provides a sample of level 2 study in Environment & Development

Learning Outcomes

After studying this course, you should be able to:

- use the insights gained from the study of this course to work collaboratively in developing a shared understanding of the Earth system and how we can establish a decent quality of life while remaining within the Earth’s carrying capacity.

1 Course outline

1.1 Aim

This section comprises a single major activity aimed at allowing you to express your unique abilities and all that you have learnt during your studies so far: you will be asked to contribute towards an online model exploring how we can live sustainably and equitably.

1.2 Readings

Reading 6.1 introduces you to a different emphasis in systems thinking and practice. Instead of analysing a situation in terms of objects you can focus on process – i.e. the processes that are going on within the system of interest as determined by the system's purpose. This shift in conceptualisation could be considered radical and revolutionary. Since the Enlightenment, our main aim has been to divide, categorise and label people and things. This 'objectification' has served us well in resolving simple problems (and created, or postponed the resolution, of more complex problems). Yet, identifying clear boundaries, and therefore objects, within complex and dynamic non-linear systems, especially when these concern human activities, is becoming increasingly challenging. And this comes at a time when we have known more about most issues than we ever did. Where exactly we insert boundaries amongst these flows to identifying objects (the systems themselves and their constituent components) is often more to do with personal values, worldviews and past experience, rather than rational thought.

Process management is therefore a fundamental aspect of systems thinking and practice, fundamental to using different modes of communication, including computer-based mathematical models, and fundamental to monitoring, evaluating and changing the impact we are having on Earth system processes. Readings 6.2, 6.3 and 6.4 focus on the role of information flows and feedbacks in determining behaviour. A key concept introduced in these readings is the role of information flows between natural and human systems, and how these could determine co-evolution and co-adaptation.

The 'humans-integrated-within-Earth-system-flows' model presented in this block may disconcert some individuals. But let us consider for a moment that we are indeed just 'temporary dynamic objects in our environment' with feedback flows of energy, matter and information amongst ourselves and with our surrounding environment. These interactions can therefore create positive or negative feedback loops, which can either sustain or undermine our own quality of life and the long-term viability of the Earth system as a whole. I attempt to expand on this point in the final reading, Reading 6.5 on co-evolution, concluding with the idea of a symbiotic and dynamic relationship between individuals, society, and the environment.

1.3 Activities

In Section 1 you learnt that individuals have distinct thinking styles and intelligences. From a reductionist point of view, one may label this fact as pejorative, but if one appreciates that there is a limit to our individual cognitive abilities, then allowing people to develop different traits is an advantage when we can find ways of constructively working together. In Section 2 you started to map out the intricate relationships across a range of scales which have combined to threaten the health and long-term viability of our social and natural systems. In Section 3 you explored a number of indices that are helpful for giving us an alternative non-economic assessment of our well-being and environmental impact. In Section 4 you expanded this static 'snapshot' into one which is underpinned by dynamic feedbacks. In Section 5 you explored how simple structures and feedback relationships can result in very different, and often unpredictable, behaviours over time.

Section 6 has a single major activity, Activity 6A, which attempts to integrate the range of concepts and skills that you have learnt during your study of this block. The challenge is to collaboratively create a shared dynamic understanding of the Earth system using a range of communication techniques. As we are dealing with a highly complex situation that is constantly changing, there is no expectation that this 'shared understanding' will ever be completed. Yet, the journey is more important than the destination: in engaging with this activity you will be developing your skills as a systems thinker and communicator which you can then apply to other highly complex and dynamic situations.

2 Section readings – Co-evolution

Reading 6.1: Systems thinking: the second step

It was noted in Reading 4.1 that the processes of **analysis** and **synthesis** in conventional thinking are based on the concept of an object. There the concept of **systems** was introduced as a set of interrelated objects. In this concept of a system it becomes important in the process of analysis to include both objects and their relationships. Other readings, in Parts 4 and 5, analyse natural systems, and investigate the understanding of behaviour resulting from synthesising objects and their relationships into a system. But this first step into systems thinking, looking at objects and their relationships, is limited in its usefulness.

During the development of systems thinking in the latter half of the last century, a number of people noticed that this object-based systems thinking did not work well when applied to human-activity systems. As a result the focus of the definition of system was changed to consider a system as an **input–process–output** structure, what I have called the second stage of systems thinking. This does not mean that the first definition is wrong but that it was incomplete. A system in the new definition is not characterised by attributes but by a **purpose**, that is if you take a snapshot at a point in time you can then contend that the system intends to produce more output from its input by a later time. The purpose encapsulates the relationship the system has with its **environment**, which was missing in the first definition.

The reasons for the limitations of object-based systems thinking were twofold. Firstly, in general, human-activity systems are far too complex to be able to define object components well. What objects would you include in a 'railway system' or 'education system'? This meant that, without realising it, different people were thinking of different systems and so could not come to agreement on their analysis. The problem was overcome by first defining the purpose of the system being considered. What purposes could you assign to the 'railway system' and 'education system'?

Secondly, in object-based systems thinking there is no reference to the environment of the system: remember the example of the lion in Reading 1.2. A lion in the zoo is not the same system as the lion in its natural savanna habitat, because the relationship between the lion and its environment is very different in the zoo to that in the natural environment. So whilst you might consider them exactly similar as objects, you cannot consider them exactly similar as systems.

Now, with the new system definition, when analysing the interior of the process boundary it is much more useful to do this in terms of **subsystems**, which themselves are systems, and therefore, also defined by their purpose. Here it is important not to confuse the system boundary with the process boundary. The system structure that we are now considering input–process–output does not have a clear boundary, and it cannot be differentiated from its environment in the clear manner that applies to an object. But what you can do is identify the process boundary, and this in the case of the lion is the same as the object boundary, since all lion processes take place inside the lion's skin, which is what you think of as the object boundary in this case.

What you gain by this change is that now you can analyse any system into its subsystems, and furthermore analyse subsystems into sub-subsystems, etc., and in reverse synthesise a system from its subsystems, etc. The processes of analysis and synthesis work with systems in the same sort of way that they worked with objects in conventional thinking.

Reading 6.2: An animal in its environment

Defining a system as an input–process–output structure enables a new look at the way in which ecologies work.

In Reading 2.1 a model of an animal receiving signals from its environment was developed – interpreting those signals, that is attaching meaning to them, and as a result choosing a course of action and then taking that action. It might be the smell of a predator, the sight or smell of fresh grass, the reaction of a potential mate to its approach, or of course as a human you can invent your own situation.

Whatever the situation you can see here that the animal can be viewed as a system, it receives input signals, processes them and this results in an output action (see Figure 6.1). The animal's relationship with its environment derives from the precise **roles** that result from the processes that are the sum of its **capabilities**. Those capabilities are the difference it makes to the environment, its **environmental footprint**.

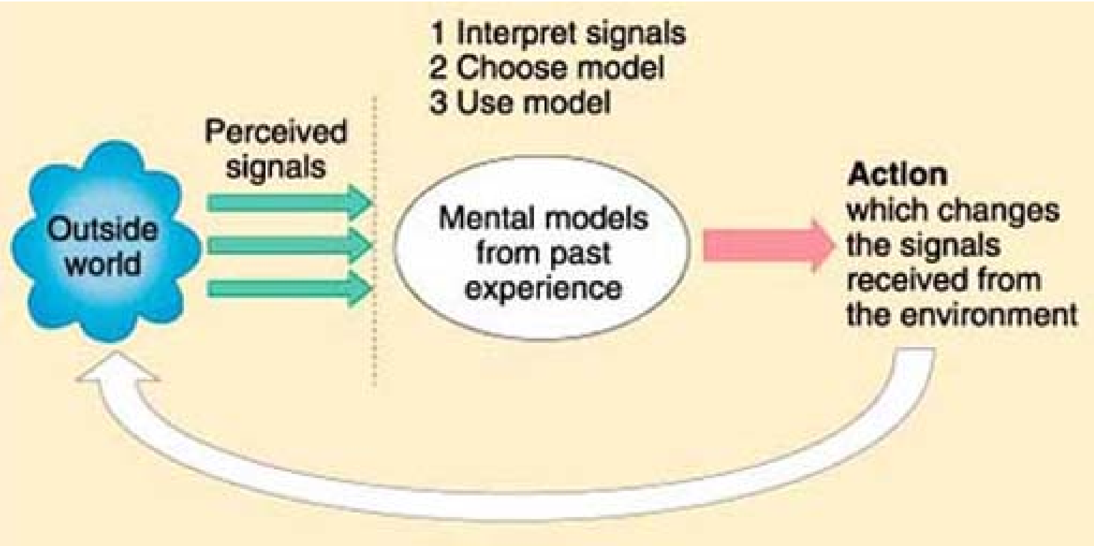

Figure 6.1 Managing the environment – perception to action

You can see now why it is that the lion in the zoo is a very different system to the lion in its natural habitat. The difference the zoo lion makes to its environment is very different to the difference the savanna lion makes to its environment. For example the first lion as a zoo attraction increases visitor numbers to the zoo, and thereby increases oil consumption and road congestion, sales of ice cream, etc., whereas the lion in its natural habitat is a force to be reckoned with as a predator, playing its natural role in that environment.

Whether the animal learns or not, whether it uses models built over the course of its lifetime, or models built in by its genetic inheritance, whatever the situation, the action taken has an impact on the environment of the animal, and change occurs. So here you can identify a feedback loop, the animal both responds to its environment and changes it. The change can be immediate and short term (e.g. a frog leaping to escape), or longer term (a bird building a nest) or perhaps something not immediately discernable (an animal in conjunction with others depleting their food source).

Having identified a feedback loop the question now arises whether the loop is a positive feedback loop or a negative feedback loop? This depends upon the action that is taken by the animal. For example in the situation of a male lion being faced by a rival for a mate, it may respond to an aggressive display signal with a further enhanced aggressive display signal, reinforcing the situation in a positive feedback loop towards an eventual violent clash. On the other hand, perceiving the superior size and weight of its opponent, it may instead respond with a submissive signal, building a negative feedback loop to avoid the violent clash and being disabled so that its ability to survive is impaired.

In either case, you can think of the person or animal attempting to manage its environment, in playing its allotted role in order to survive. Again, you can think of this in the short term or in the long term.

Reading 6.3: Control, regulation and cybernetics

The problem of controlling the steam engines of the industrial revolution brought into being the first machines that were controllers. Prior to that humans had always performed the function of **control** – the helmsman of the ship maintaining its course, the householder **regulating** the amount of material for the fire maintaining the warmth of the house, the owner regulating his factory, the magistrate regulating behaviour. The science of **cybernetics** arose from the Second World War where the problem of shooting down a fast moving aeroplane proved too difficult for the majority of gunners. Just as in the case of the steam engines, the task was beyond humans. Because human reaction times were too slow, a machine-based solution was required. The science of cybernetics arose from these beginnings, but it was soon realised that these regulation and control problems were common to different disciplines – engineering, business and management, medicine, psychology, psychiatry and, last but not least, the natural environment and ecology.

Whilst most of us are familiar with the idea of cybernetics connected with machines and robotics, the originators of the science of cybernetics did not think of it like this – they defined cybernetics as ‘the science of control and communication in the animal and machine’ (Wiener, 1948).

Any system will have some characteristic that you seek to control, usually some indicator will describe a characteristic, and there will be some desired value for the characteristic which you seek to achieve. In many cases this will be an output of the system. In order to perceive whether the characteristic or goal is or is not achieved you must have a means of sensing this, so the first essential component of a control system, is a means of sensing where you are. The signal from the **sensors** must be fed to some means of comparing where you are to where you want to be, the goal you wish to achieve, so the second essential component is a **comparator**. The comparator makes the comparison and must produce as a result a signal to a means of making an adjustment, an **actuator**. The actuator then is a means of effecting a change in the system to move it towards the desired goal. These three subsystems then are the essential components of a control system, together with some outside means of knowing what the ultimate goal might be (see Figure 6.2).

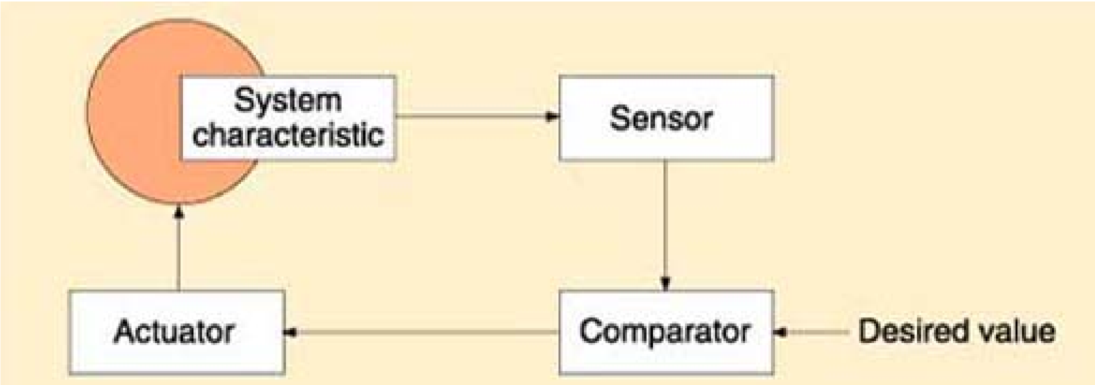

Figure 6.2 The basic elements of control (from: Kast and Rosenzweig, 1974)

Applying this to an animal managing its environment, you can see that the essential features are present. Figure 6.3 illustrates in simple form the animal managing its environment.

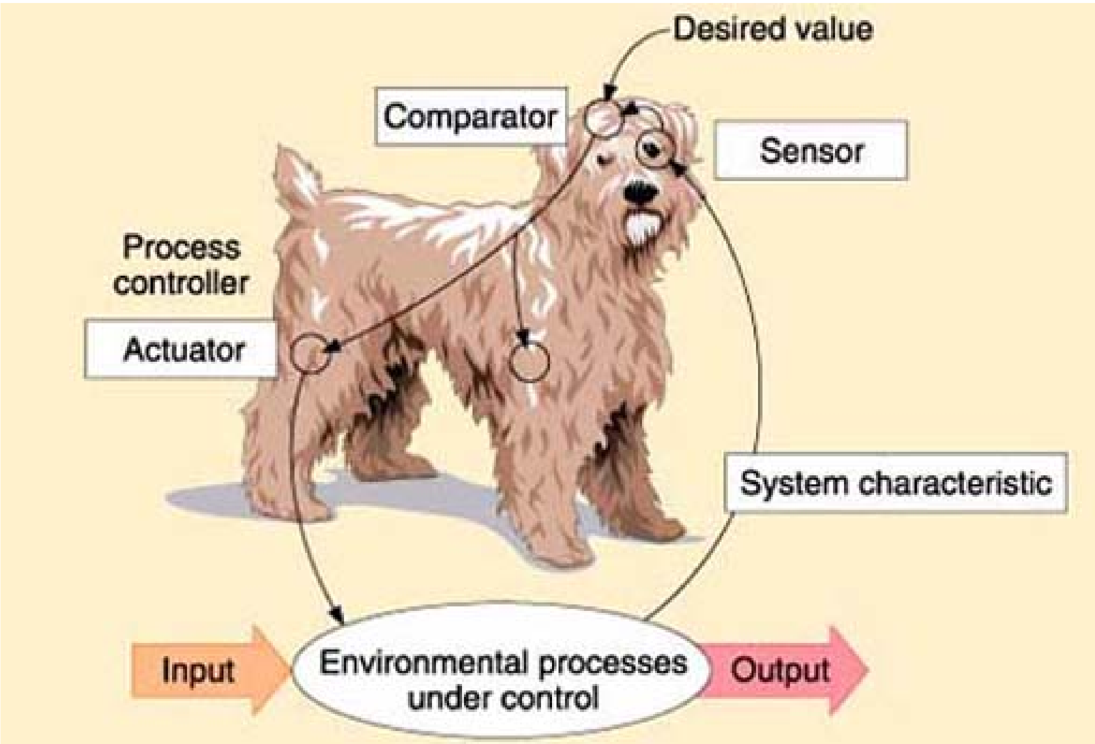

Figure 6.3 Control as a management feedback loop

The situation is of course much more complex than I am able to illustrate, but here I envisage the eye acting as a sensor, the brain acting as comparator, with a goal either built in by genetic structure, or as a result of prior experience, and the legs acting as actuators to change the environment.

Reading 6.4: Building shared models

In the early 1950s, Alex Bavelas (Bavelas, 1951) undertook some simple experiments which contain a number of important lessons. In particular he showed the way in which the shape of the system structure of communication affects the evolution of learning. Hierarchical **communication structures**, such as the typical organisation chart, are invariably faster at solving problems in very simple cases where no new learning is required, but once the problem situation becomes complex and there is a need to develop new learning, peer-based communication is invariably more effective. This seems an invaluable lesson in the world today which faces a multiplicity of complex problems.

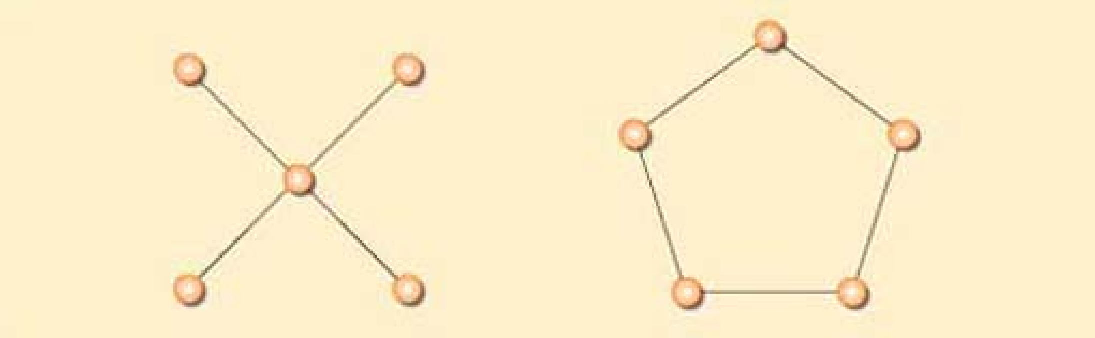

Figure 6.4 The Bavelas experiment

The experiment consisted of one group of five people arranged in a star configuration, and a second in a ring configuration (see Figure 6.4). They were provided with the means with which to communicate with each other in writing only. They were arranged so that they could write notes and pass them to the adjacent person or persons along the configuration lines, but could not communicate in any other fashion. They were not visible to each other. No communication could take place in the star configuration except through the central person, and no communication could take place across the ring, only around the line of the ring loop.

Each person in each group was given five marbles of different colours, such that only one colour was held in common by all the group members. The task for the group was to identify the colour held in common. Perhaps not surprisingly in all the trials the group arranged in the star configuration succeeded first, the central position being pivotal in that all the information could be gathered there and the problem solved at that position. Then the problem was changed in that marbles with ‘mottled, milky’ colours were substituted for the previous clear marbles with distinct colouration. This time the group arranged in the ring configuration succeeded first. Even more interestingly, it was found in repeated experiments, that in this situation the person occupying the central position of the star always gave up trying to understand the information being passed to him/her and started simply to guess the result. In the ring configuration in repeated experiments, the problem solving time reduced to that of the first experiment with clear marbles.

How do we explain these results? In the second case, it is clear that the problem becomes much more complex, the problem in either case cannot be solved without having a shared definition (**shared models**) of the colours. In the first case the uncertainty between the people in the groups about the definition of the colours is low, and there is sufficient shared understanding for it not to affect the problem solving. In the second case there is little shared understanding and it is difficult to achieve a common model – this can only be achieved with a great deal of communication. The volume of communication simply overwhelms the person at the centre of the star, and since they can no longer deal with it they give up and use an alternative strategy. In the ring group, the model is developed, and once developed, the problem solving time falls to the same as in the first case with the clear marbles.

Some further work on this scenario was carried out by Walter Lee and Paul Pangaro (Lee and Pangaro, 1993) from the point of view of information theory. They showed that, surprisingly, in information terms, the person in the centre of the star is operating sensibly from their point of view. They draw attention to the position of the CEO (Chief Executive Officer) who is in the centre of a much larger system configured as a star. Unsurprisingly, the CEO is not inclined to listen to the people around. The hierarchies of organisations are famous for communications only travelling in a downwards direction and nothing travelling up. Here you can see in a simple experiment the problem illustrated – to achieve communication you need to establish common models, common understandings, and to minimise the amount of communication necessary. The price you pay if this is not done is that of managers going their own way with little understanding of what is actually going on, to the detriment of the organisation.

Shared experience improves the relevance of messages simply because the sender understands (because he's been there) the recipient's concerns, values, prejudices and problems. The recipient, on the other hand, will perceive the sender's message as trustworthy because he knows (by virtue of previous collaboration) that the sender possesses that understanding. The Bavelas experiments indicated that the circle members trusted each other because each node knew that his partners (the adjacent nodes) were undergoing exactly the same experience. In the star configuration, by contrast, trust broke down precisely because everyone knew that the central node had a position and experience history that was qualitatively different from the peripheral nodes. (Of course, the peripheral nodes couldn't even trust each other because they couldn't communicate with each other.) The relevance of the messages, particularly of those from the periphery to the centre, was low simply because the peripheral nodes did not and could not appreciate the problems, pressures, and constraints facing the central node. Thus, messages sent during the noiseless case, that suggested improving the message-sending process by specifying the sixth colour that each node didn't have, were irrelevant to the situation faced by the central node, and would only make his job more difficult.

One way for a chief executive to establish common understanding is to surround themselves with people who share their view of the world. This is exceedingly common and does avoid the problem, but has consequences of its own.

So, because a message is formulated within a mindset, and framed within models contained within that mindset, achieving communication is not straightforward. Clearly one of the models that is important in this process is the model the source has of the destination mindset.

The message will be decoded, and the complexity unravelled, within the destination mindset using the models that are actually present. If these models are somewhat different the decoded message, then, may be very different from that intended. This raises the immediate question as to how common models develop, and here lies the importance of feedback, the return communication which creates a loop which will be seen to be a fundamental part of our modelling. In the ring group, the feedback loops between the participants functioned well so that gradually a shared model was formed. In the star group, because of the communication overload at the centre, this could not happen.

Reading 6.5: Co-evolution

In Readings 3.5 and 4.4, I introduced the connected ideas of **interdependence** and **homeostasis**. It can now be seen that homeostasis is just another aspect of regulation and control that was considered in Reading 4.4, in the situation where the parts of a system, the subsystems, act on each other to produce a stabilising effect. In this section, you have considered the animal managing its environment, but of course this perspective applies to any and every plant and animal in the environment. Taking a view from the outside of a particular ecological system you can consider each animal and plant as the component of a system. Each node takes inputs from a set of other nodes, processes those inputs, and provides outputs to a further set of nodes. All is dynamic. As one particular animal or plant modifies its environment, so its environment modifies the animal or plant in the feedback loop you have identified. So you must consider the environment managing the animal or plant, as much as the animal or plant managing the environment.

To survive, each system must continually adjust itself in order to maintain its particular role or roles in the ecosystem – it must maintain relationships that enable it to survive and prosper as an individual until it reproduces. The species must also maintain relationships with other species so that it may survive and prosper within the changing ecosystem.

There is no greater example of co-evolution than planet Earth. Just compare Earth's atmosphere with those of Venus and Mars. Earth has an atmospheric carbon dioxide concentration just above 0.03 per cent, while Venus and Mars have atmospheric concentrations of carbon dioxide of 98 per cent and 95 per cent respectively; and what about average surface temperatures? Earth 13 °C, Venus 477 °C, Mars -53 °C, and yet Earth is situated between Mars and Venus, and so you might expect a temperature around the mean of these two, around 265 °C. Four billion years ago, Earth also had an atmospheric concentration of 98 per cent carbon dioxide. Its surface temperatures were also extreme. So what happened? Life! Look at almost every component of the Earth system and you see the influence of life. Planet Earth has co-evolved with life. The Solar system, including the three planets above, was created about 4.6 billion years ago; evidence of the first living cells on Earth dates back to 3.6 billion years ago. These thrived in the carbon-dioxide rich atmosphere, but suddenly, about two billion years ago, a few bacteria evolved the ability to photosynthesise – to combine carbon dioxide, water and solar energy to create structural materials and food sources. The rapid proliferation of photosynthetic bacteria, radically transformed the atmospheric composition of gases to be dominated by nitrogen (78 per cent) and oxygen (21 per cent). Carbon was removed from the atmosphere and deposited as carboniferous rocks (the calcium carbonate skeletons of phytoplankton) and, to a lesser extent, as coal, petrol and gas. The high concentrations of oxygen in the atmosphere allowed the development of the ozone layer – a protective blanket shielding the Earth's surface from deadly levels of ultraviolet light. Living organisms were finally able to evolve on land. Almost everything that you come across – the air that you breathe, the water that you drink, the soil that you walk on – is there thanks to billions of years of co-evolution between living organisms and planet Earth: a life sustaining and promoting feedback relationship.

Rather than competition, the overriding message you get from living things around you is cooperation. Life has evolved increasingly complex mechanisms of sustaining itself in the face of environmental disturbance and change. Co-evolution is all about developing ever-increasing supporting feedback mechanisms. Are shared models of supportive co-evolution, rather than cut-throat competition, something we can learn from nature and transpose to human activity systems?

3 Section activities

Activity 6A: Modelling your shared understanding for a sustainable future

In this activity the aim is to integrate the various explorations you have engaged in so far (such as cause-and-effect models of emerging social/economic and environmental crises, your personal ecology, quality of life, ecological footprint index, system dynamics models) and create, using a range of communication and modelling approaches, the beginnings of a shared understanding of how various hierarchically-nested systems determine the flows of energy, matter and information in the Earth system. These flows and their feedbacks may be either maximising homeostasis or dragging us down towards collapse.

Developing a shared understanding does not imply achieving a singular mindset. This block has tried to demonstrate that we all have unique characteristics and that there are a multitude of paths to achieve the same objective – Costanza's Star Trek, Big Government and Ecotopia scenarios are all potentially 'sustainable'. Thus we need to strive to accept different perspectives and allow the emergence of creative ways to work through problems. However, the latter half of the block has focused on engaging with 'reality checks' to see whether any single approach is as sustainable as its associated rhetoric. I therefore hope that you can now see why I think the 'one size fits all' mechanistic, reductionist and no-limits economics model to resolving the major challenges we are faced with might not provide all the answers.

I would therefore like to propose that you begin this final activity by considering, together with your fellow course participants, the following question: 'Is it possible for humanity to define, arrive at and sustain an ecological footprint that is within the Earth's carrying capacity and simultaneously improves people's quality of life in a way which is fair?' There is clearly no ready-made answer, but engaging with this activity will certainly contribute towards an ongoing process of addressing this question.

Activity

The platform which we will be using for this activity is a wiki and associated discussion board. You can go to wiki here and instructions on how to use it can be found within the wiki itself. This wiki was started by the cohort of students on the 2008 T214 presentation and developed further by subsequent students. Now it's your turn to contribute according to the pointers that I provide (which arise from the learning outcomes for this course).

Open wiki now...

For the purposes of this activity I actually want you to limit your engagement to a maximum of eleven hours: one hour to initially explore the wiki in order to develop a 'big picture' view of it, how it works and where you could intervene (including discussions with co-participants); a couple of hours to research your initial contribution; and another couple of hours to put this into practice. This will be followed by a period of observation and evaluation, and, hopefully, one final iteration to take you up to the eleventh hour.

The limited amount of engagement time means that you have to be realistic in what you want to and can achieve. With such momentous activities, I always have the metaphor of the giant termite hills one observes in the tropics – microscopic living organisms individually adding even smaller pieces of earth to create highly sophisticated and gigantic structures. With hundreds of individual contributions you will be surprised to see how rapidly the process will develop. What you do need to keep in mind is that at the end of your process of engagement things need to be left in a state where others can pick up the process.

But for now please limit your engagement to the indicated timeframe – time management is also a useful skill to pick up. I am providing this warning here because this relatively open-ended activity could easily turn into a temporal black hole.

In the spirit of the 'star configuration' outlined in Reading 6.4, I would like you to contribute your own interventions and views on the collective process in a way that does not offend and upset others – something which can be so easily done in an online situation.

You should not be surprised if I now go on to recommend that you structure this process according to the four phases of the action learning process:

- Planning – what is the aim of your intervention? What activities do you think you will need to undertake in order to achieve it? How are you going to measure your progress? What assumptions are you relying on for your plan to be executed smoothly? What are your weaknesses and strengths? Who are you going to collaborate with and how are you going to manage this collaboration?
- Acting – each of the above questions will require certain actions to take place, either in creating the conditions for more information to be revealed about the situation and/or yourself, or in experimenting with certain interventions.
- Observing – this involves the simple task of recording the process and outcomes of the various actions.
- Evaluating – this should allow you to compare the models established in your planning phase with the resulting observations emerging from our actions. Have you got any closer to your aim? Were the actions, measurements, assumptions and collaborations appropriate? Was the original aim you set appropriate? Do you have the time to undertake another iteration in order to progress further?

To kick start your ideas, here are some different types of intervention you may wish to consider. You may want to:

- Engage in the process of analysis (exploring the detail) and synthesis (summarising the detail into the 'bigger picture' view) – in other words, illustrate the situation at a range of scales, from the local to the global, from the here-and-now to the long-term, from the personal to the transnational organisational scale. You could, for example, summarise some entries to a higher level, or, expand a particular entry into one or more subcomponents.
- Explore issues in both intuitive/emotive and rational/logical ways: solutions often emerge from a bit of creative thinking and are then validated by logic and facts – so don't be afraid to introduce some pretty wild ideas while being aware that these will need to be justified eventually. In particular, you may want to include both qualitative and subjective indicators (such as those determining one's quality of life), and quantitative and objective indicators (such as those characterising the biophysical status of our environment). You could, for example, develop a range

of quantitative and qualitative indicators which can be used to assess progress towards the activity's goal or one or more subcomponents of this goal.

- Promote an integrated verbal, visual and mathematical modelling approach, i.e. I would encourage you to look out for 'gaps' within the various wiki entries not only in terms of 'scale, knowledge gaps and missing links', but also in terms of model types, hopefully encouraging the full use of your multiple intelligences. NB you are not restricted to the verbal, visual and mathematical models introduced in this block, but I would recommend that you at least practice one diagramming technique.
- Explore the relationship between components, ideas, systems, etc, rather than only concentrating on describing these as isolated and independent entities. This implies clarifying the cause and effect relationship between components, and ultimately identifying positive and negative feedback loops. I acknowledge that this task may be limited by the functionality of the wiki. However, a lot can be achieved by simple restructuring of wiki pages and by the creation of webs of hyperlinks between pages.
- Distinguish between 'states' (i.e. temporary stores of energy, matter and information) and 'rates' (i.e. the processes which transform these states from one form into another).
- Propose how one could build dynamic models in order to develop a feeling for the behaviour of complex systems over time (NB this is optional in that there are no requirements for prior mathematical/programming knowledge and skills in this course – although it is possible to 'mentally simulate' dynamic behaviour by sketching a graph). At its simplest, tables showing change over time for particular 'states' could form the backbone of future dynamic modelling.
- Use the action learning framework to take ideas from the Earth wiki, actively experiment in the real world, and feed back to the wiki the results of these actions. We are not passive spectators helplessly glued to our television screens as the world collapses around us. As Mahatma Gandhi stated: 'Be the change you want to see in the world' (as quoted in Potts, 2003).

Answer

During the initial development of the Earth wiki, some participants struggled with the exercise and showed little evidence of constructive and cooperative working. Part of the problem was most certainly a result of the rather ambitious goals I had provided, the fact that people were starting from scratch, and the limited functionality of the wiki. Yet, I suspect that those individuals that struggled with the activity were those that had difficulties in taking the initiative to try to address some of the problems that emerged during its execution. Notwithstanding all that was said in this course about top-down hierarchical control by those in positions of power **not** providing the ideal conditions for solving complex problems, some still had the automatic expectation of needing to be told what to do, rather than implementing a ‘learning by doing’ approach to the activity.

I suspect that problems will still be encountered in this iteration. Systems thinking reveals one major insight: that blame cannot be attributed to a singular cause, whether this is an individual or an event. However, this does not mean that we can blame ‘the system’ as a whole for the difficulties either. Each participant within any system has a role to play, and we should take responsibility for the effects of our particular actions, including our inaction. We must certainly not be afraid to act and make mistakes, indeed, this is the only way in which we can learn.

You have now come to the end of this learning experience. Well done for getting this far!

If you have enjoyed any aspect of this course, it is most probably thanks to the constructive feedback from students, tutors and fellow course team members. Any difficulties that you may have had are my responsibility to address, so your feedback on any issues would be very much appreciated.

So, one final request. There is nothing better than receiving detailed feedback on particular aspects of your learning experience straight from participants. Now would be an ideal opportunity for you to summarise your experiences and feed them back to me, Andrea Berardi (a.berardi[at]open.ac.uk).

Conclusion

This free course provided an introduction to studying Environment & Development. It took you through a series of exercises designed to develop your approach to study and learning at a distance, and helped to improve your confidence as an independent learner.

Glossary

action learning
: The process of undertaking the steps of planning, acting, observing and evaluating in order to understand and engage with a complex situation.

actuator
: In the control model, the part of the system that can effect a change.

analysis
: A method of understanding something by dividing it into parts and making sense of the parts.

attributes
: The properties of a thing that identify and characterise it.

balancing feedback
: Feedback that dampens change. Also referred to as 'negative feedback'.

boundary
: The line or region which distinguishes what is in a system from the wider environment around it.

capabilities
: The capacity of an element of a system to affect the wider system.

change
: Modification of system structure and/or processes.

channel
: In the Shannon–Weaver model of communication – the medium or link through which a message is sent.

chaos
: A situation which shows no predictable pattern of organisation and/or behaviour.

closed system experiment
: Where an experimental system has to function without any exchange of energy, matter and information with its environment.

communication
: The exchange of meaningful information – an important mode of learning in humans, through which experiences can be widely shared.

communication structures
: The organisation of communication channels, such as the organisational chart in a company.

comparator

In the control model, a comparator compares the output of a process against a goal such as an indicator.

concept

A coherent idea abstracted from practical situations.

control

Control refers to the function of a system which regulates its outputs or maintains it within certain bounded behaviour. Control can arise from within or without a system.

culture

The explicit and implicit social rules that shape the way people behave.

cybernetic optimisation

Action by a system initiated in order to achieve a particular goal which causes some change in the environment towards achieving that goal. The change in the environment is fed back to the system via information/energy/material flows which in turn changes the way the system then behaves: stronger action if the goal has not been achieved; or the cessation of action if the goal has been achieved.

cybernetics

The science of control from the Greek word for the steersman of a ship.

delays

Where the feedback in a system takes a significant time to reappear as an input. This can have a profound affect on the dynamics of the system.

diagramming

A formal approach to visual modelling using a range of techniques for exploring the organisation of information in two dimensions, e.g. on paper or on a computer screen.

difficulty

Bounded problem with a limited timescale, clear priorities, limited applications. It can be treated as a separate matter, with a limited number of people involved who know what needs to be done, know what the problem is and know what a solution would be (contrasted with **mess**).

diversity

A measure of the degree of differences between things – for example the number of different species in an ecosystem, or the different types of businesses that a pension fund has invested in.

ecology

The study of the relationship amongst living organisms and between these and their environment.

ecosystem

The organisation of species and their surrounding environment into a self-sustaining whole.

eight intelligences

Howard Gardner's theory that there are eight different ways in which people develop, communicate and put into practice their understandings.

emergence

Higher-level properties emerge from systems of lower-level components in such a way that the high-level properties could not be predicted from knowledge of the components in isolation.

environment

In systems terms, this refers to those factors outside of a system with which it interacts or which affect how it operates.

environmental footprint

The impact of something (such as a person, a city or a sports event) on its environment. Subcategories of an environmental footprint include ecological, water and carbon footprints.

epistemology

A study of the way we know what we know (how knowledge arises out of a combination of beliefs and facts), its history and its limits.

equifinality

When a system always ends up in a single final state, whatever its starting point.

equilibrium

When system components do not show any apparent change in quality and quantity.

extinction

The permanent and irreversible disappearance of a lifeform.

feedback loop

Where an input of a system is affected by one of its outputs – for example in communication when communicating with someone who is communicating back.

flows of energy, matter and information

This refers to the way that systems interact with their environment and amongst its components – for example a system could be closed in terms of matter, but open in terms of energy. Some components provide other components with energy, matter and/or information.

group think

The tendency for individuals to fall in with the thinking of those with whom they are closely associated, even if they might individually disagree.

hard complexity

Complexity that arises from the dynamics of a situation, where the presence of large numbers of feedback loops and/or **variables** makes prediction difficult.

hierarchy

The nested nature of systems: systems encompass **subsystems** while simultaneously being part of **supra-systems**.

homeostasis

The dynamic equilibrium through which living systems maintain the conditions for their ongoing existence.

indicator

A characteristic of a system which is used as a measure for control.

information

Matter and/or energy which is not of direct use by a living organism apart from having the potential to change the organism's behaviour – for example, the triggering of moths' reproductive behaviour resulting from a full moon.

information and communication technologies

Technologies that allow the recording, storage or sharing of information.

input–process–output

A process-based way of looking at what a system is, concerned with defining a system by what it does rather than the objects it is constituted from.

interdependence

The way that different system components (such as organisms in an ecosystem) play roles that supports other components which in turn support themselves.

internalised model

A model developed by a living system in order for it to cope with its environment without constantly sensing it. It may only be detectable implicitly through the living system's behaviour.

interpersonal intelligence

The ability to empathise with others by recognising their intentions, motivations and desires. Professions which require a high level of this intelligence include educators, psychologists and politicians.

intrapersonal intelligence

The ability to recognise one's own intentions, motivations and desires. Professions which require a high level of this intelligence include poets and artists.

kinaesthetic intelligence

The ability to coordinate one's movements. Individuals which require high levels of this intelligence include athletes, craftspeople, musicians, dancers, surgeons and painters.

learning

The capacity to change or create internalised models in response to experience.

learning cycle

A sequence of steps that describe the different aspects of learning. There are a number of different types of learning cycle, such as Kolb's learning cycle. Many of them feature observation, evaluation, planning and action, or their equivalents.

linear sequential thinking

Thinking based on a precise sequence of information that goes into greater and greater detail.

linguistic intelligence

The ability to use a coherent narrative to communicate and organise thoughts. Professions which require a high level of this intelligence include lawyers, writers and actors.

logical–mathematical intelligence

The ability to investigate issues deductively and recognise/work with numerical patterns. Professions which require a high level of it this intelligence include software programmers, engineers and scientists.

mathematical communication

Mathematical communication uses quantification (numbers and functions) to share or highlight experience.

mathematical models

Models where the essential dynamics of a situation are represented through numbers and mathematical patterns.

mental models

Essentially the same as internalised models, but referring specifically to humans.

mess

Unbounded problems or sets of problems with: a longer, uncertain timescale; priorities which are called into question; uncertain, but greater implications. It can't be disentangled from its context, and more people are involved who don't know what needs to be known, who aren't sure what the problem is, and don't see 'solutions' (contrasted with difficulty).

metaphor

The use of an unrelated word or phrase to represent and model another object or situation. For example, the term 'war on terror' depicts the process of addressing a particular criminal activity as a military intervention.

models

Simplified representations of reality which have a purpose.

Modes

(of delivery) Medium or type of communication.

multiple intelligences

The idea that there is more than one way of solving problems – for example right and left brain thinking or Gardner's eight intelligences (linguistic/logical-mathematical/musical/kinaesthetic/spatial/interpersonal/intra personal/naturalist-ecological).

musical intelligence

The ability to recognise pitches, tones, rhythms and compose these into recognisable patterns. Professions which require a high level of this intelligence include composers and musicians.

naturalist intelligence

The ability to appreciate ecological **interdependence**, including the nested nature of our society within the greater Earth system.

negative feedback

Feedback which operates to reinforce **stability**. Also called balancing feedback.

network

The organisation of components as a system which facilitates the flow of information, matter and/or energy.

object

A discrete entity, or one that is perceived to be so. Used to categorise **flows of energy, matter and information**. This is especially relevant when these manifest levels of structural and/or process stability. For example, a stone or a flame can be objectified because their material composition, energy levels and capacity to convey information are stable enough over time for categorisation.

open systems

A system which exchanges energy, matter or information with its environment.

oral communication

Verbal communication through sound.

organism

A living system with a distinct boundary which distinguishes it from its environment.

overshoot

The point where one or more of a system's components are using resources over the rate by which these can be replenished. The inevitable consequence of overshoot is the collapse of the component(s), and the potential collapse of the system as a whole if at least one particular component is playing a vital role in system processes.

positive feedback

Positive feedback reinforces change.

process

The way in which information, matter and/or energy flows through, and are modified by, a system's components.

purpose
: An anticipated outcome that directs system structure and processes.

quality of life
: Quality of life indicators widen attention beyond monetary wealth to health and happiness.

quantitative (mathematical) models
: Models where the essential dynamics of a situation are represented through numbers and mathematical patterns.

rates
: The measures of changing system component quantity or quality relative to time.

receiver
: The means by which communication is received.

reductionist thinking
: Thinking based on the idea that a thing can be characterised by the attributes of its components.

redundancy
: Multiple complementary components or functions such that removing one instance does not result in system failure because the others can keep going. For example, the removal of one kidney out of the two will still allow the individual to continue a healthy life.

regulating
: Taking control of something.

relational logic
: Reasoning based in the relationships between things which are disciplined, rule-bound and repeatable so that decisions are defendable and explainable.

relationship
: Interaction between components within a system.

resilient
: Able to cope with stresses and shocks by recovering readily.

resistant
: Able to cope with stresses and shocks by not being affected much in the first place.

roles
: The typical functions that system components carry out - for example a species in an ecosystem.

selective perception
: A phenomenon where people pay attention to things they are familiar with or to evidence that supports views they already hold.

sensors
: The means to detect signals or a change in state. In the control model, a sensor monitors the outputs of a process.

shared models
: A common interpretation that enables effective communication.

sign graph diagrams

A diagram that represents the operation of causality in a system's dynamics.

simplification

A model is a simplification of reality that does not pay attention to all the aspects of a situation, but is relevant to understanding and engaging with the situation.

soft complexity

Complexity that arises from a lack of certain information about a situation – for example when there are intractable differences in the way that a situation is perceived by those involved in it.

spatial intelligence

The ability to recognise visual patterns and relationships. Professions which require a high level of this intelligence include artists, designers, and taxi drivers.

stability

Unchanging system structure and/or processes, usually applied in situations where the system's environment is changing.

status

A measure of a system, its structure, processes and/or components with the aim of identifying change or stability.

stocks

In a model, a quantity of something that can increase or decrease.

subsystems

Components of a system, which are themselves systems.

supra-systems

The systems within which your particular system of interest is nested within.

survival of the fittest

Continuation of a particular component within a system which through competition and cooperation can access enough resources to maintain itself or replicants of it, while other components become extinct through lack of resources.

synthesis

Trying to understand something by considering its relationship to other things. Also the process of making a whole out of parts.

system dynamics

The study of the patterns of feedback in complex systems.

system dynamics diagrams

A **diagramming** methodology used in **system dynamics** modelling.

system performance

A comparison between the behaviour of a system as detected through an indicator and what is expected.

systems

An interconnected and interdependent set of components with coherent organisation, often characterised by nested subsystems, emergent properties, communication, and control which is dynamic, adaptive and self-preserving.

systems thinking

A style of thinking that balances rational and intuitive, synthetic and analytic, thinking.

technique

Standardised and formal approaches for executing certain tasks.

thinking trap

A learned and/or biological limitation in the way that we model and act in the world which does not result in the best outcome for addressing a particular problem.

tipping point

This is where small changes within a system result in no notifiable overall change until a certain threshold is reached, after which the system changes radically, and sometimes, irreversibly. A simple example of a tipping point is the boiling of water – very little happens as the water temperature rises, but once the 100°C threshold is reached, there is a sudden transformation of liquid water into vapour.

transmitter

The means by which communication is sent.

unit of measurement

A standard measure in which something is quantified.

variables

Independent and distinct factors which influence the rate of change of a stock's level as represented through a system dynamics diagram.

verbal models

Models where a situation is described in written or spoken words.

viability

The capacity for ongoing existence.

visual communication

Visual communication uses two-dimensional pictures, three-dimensional objects and spatial representations to communicate experience.

visual models

Two or three dimensional forms where a situation is described through graphical symbols and spatial relationships.

written communication

Written communication uses written words to communicate experience.

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