Complexity uncovered

By Sharon Varney

Who is this for?

If you're new to complexity, this paper will help you find your way around the field. It provides a high level map by outlining some of the interpretations of complexity in an organisational context. It includes a guide to key complexity terminology and signposts where to go for more information.

What is this thing called complexity?

First of all, there is no single theory of complexity. Complexity theories emanate from a number of strands of the natural sciences. While a number of research centres are focusing on complexity within a management, business and social arena, this is still a developing field of study.

Interpretations of complexity

Depending on who you read, the term 'complexity' can be **interpreted pretty broadly**. Margaret Wheatley's Leadership and the New Science, considers how chaos theories, complex adaptive systems (CAS) theory and quantum physics might apply to leadership in organisations. Or it may be applied **very particularly**, as in Ralph Stacey's complex responsive processes (CRP) theory of organisational dynamics.

It may be **taken as a metaphor** or an analogy which challenges our pre-conceived ideas of how we might work together in organisations. Or it can be **applied literally** as many academics are researching now.

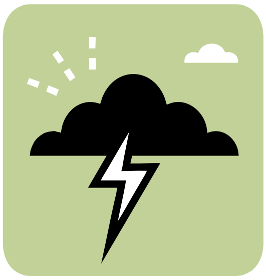
Often, when we use the terms chaos and complexity in everyday life, we mean something rather different to the academic definitions. **Chaos** is often considered synonymous with things being hectic, messy, out of control. However, the mathematician's view of chaotic systems shows patterning and order, over time.

Complexity is often used to mean difficult or convoluted; a problem where the answer is not obvious. However, a better word to use here might be complicated. Complexity science focuses on how patterns emerge from the myriad of interactions between people and comes from the notion of things being intertwined.

So, we can see that the boundaries to what is and isn't 'complexity' are somewhat unclear and ambiguous. In short, it means different things to different people. While the academics are exploring these areas of interest from a theoretical perspective, as practitioners, we're also asking similar questions.

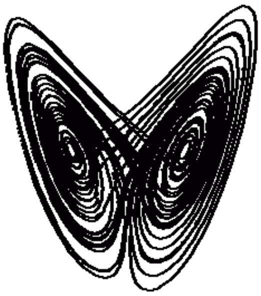
The language of complexity

Language is important in understanding complexity. Below is a short guide to some of the key terminology. As the concepts are explored, I also ask questions and make conjectures about how this might apply to learning in complex organisations. You may well add your own.



Chaos theory

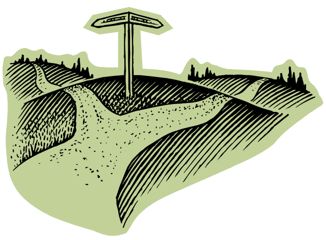
Chaos theory is often partnered with complexity in the literature, but is different. It comes from mathematics and is concerned with non-linear dynamic systems, such as weather systems. The behaviour of chaotic systems often appears to be random, but is not. In fact, chaotic systems have pattern and boundaries that become apparent over time after many, many iterations. Order appears as those coherent forms take shape through computer modelling.



Attractors and strange attractors

These terms come from chaos theory. Attractors describe a particular state of behaviour to which a system is drawn. An important feature is that it can 'flip' the behaviour of a system from one pattern to another.

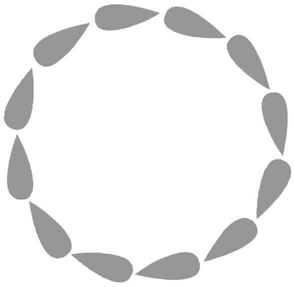
Attractors and other concepts from chaos theory tend to be used in a metaphorical sense in thinking about organisations. Their mathematical nature does not lend them to more literal applications. However, this notion of attractors has caught the interest of those thinking about organisational behaviour. We might think of values as operating like attractors, holding our behaviour within an invisible boundary (Wheatley 1997) or our mental models.



Bifurcation points

Simply put, bifurcation points (also from chaos theory) could be considered as "forks in the road", each leading to a different future (Morgan 1997). However, although forks in the road offer a limited number of choices for the traveller, bifurcation points are not simply either/or choices, they may signify a point at which an *infinite* number of possible states is theoretically possible. Importantly, a system can make sudden, huge and unpredictable leaps at these points and it can't go back.

In terms of learning, this might cause us to think about the potential value, or otherwise, of trying to predict learning outcomes and seeking to take a linear approach to reaching them.



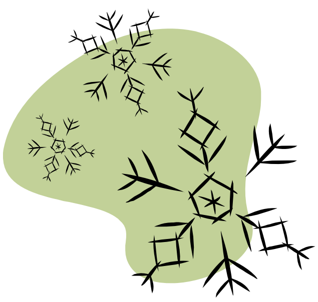
Boundaries
Chaotic systems have boundaries – not ones set by external observers – but integral to themselves. As Wheatley explains: "The boundary lives within the system, becoming visible as it explores its space of possibilities. The order is already present; it has now become discernible" (1999, p118).

In terms of learning does this mean that learners need to explore their own boundaries for development? If so, how can we help them explore their personal possibility space? If we include a broader diversity of people, could that help to naturally extend the boundaries for the group as a whole and enlarge the possibility space for learners to explore?

Dissipative structures
When a system spontaneously self-organises to produce something new (typically at the edge of chaos), it takes energy to keep it in that new state and it is, therefore, known as a dissipative structure. Stable (equilibrium) structures require little energy to maintain and considerable energy to change them. This is reversed in a dissipative structure, which needs little to change it and considerable energy to keep maintain its new state (Stacey 2000).

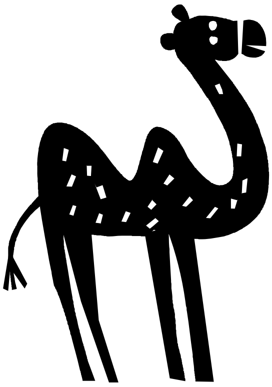
In learning terms, the concept of dissipative structures suggests that we may need to support emerging new ideas and new ways of working, as they take less energy to undo.

Edge of chaos
Sometimes referred to as 'far from equilibrium'. Two descriptors of a system on the edge; not a completely random one, but one more likely to fall under the influence of other attractors. Dana Zohar (1997) differentiates between "at the edge", used in chaos theory to describe the border between order and chaos, and "on the edge" or "over the edge" which imply a precipice that you can fall off.



Fractals
Fractals describe any object, natural or man-made, which is created from repeating patterns evident at many levels of scale (Wheatley 1999). Precise measurement can be difficult, as each small portion of the fractal can be viewed as a reduced-scale replica of the whole, but the overall pattern is clear.

Fractals have intrigued many people in mathematics, computer science and art. Their patterning is what makes them interesting to artists and causes me to wonder if there are repeating patterns in organisations and learning?

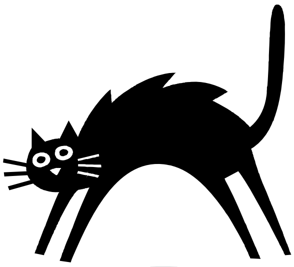


Non-linearity

In linear systems, a large effect requires a large cause and small causes can be safely overlooked, as they tend to have negligible effects. Conversely in a non-linear system, "the slightest variation can lead to catastrophic results” (Wheatley 1999) as there is no visible relationship between the strength of the cause and the consequence of the effect.

The old adage of the straw that broke the camel’s back is one way to understand this. The first few straws, even the first few thousand, have no noticeable effect on the camel. However, when the camel’s system is pushed to the edge of chaos by the weight of the straw, just *one* extra (a small cause) could effect the whole system to collapse; breaking the camel’s back.

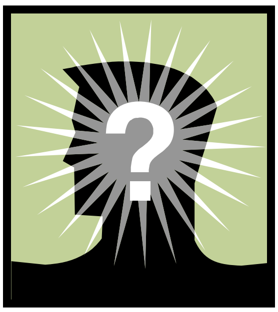
In learning terms, this might mean that we cannot accurately predict outputs (the learning) from a set of inputs. This implies that we cannot engineer learning. It also means that there may be *unintended consequences* from our actions. As no part is insignificant we might want to consider, as developers, how might we be more vigilant and really notice what is happening within and around us?



Paradoxical behaviour

Paradoxical behaviour signifies a key difference between chaos theory and systems theory which forms the basis of learning organisation theory (Stacey 2000).

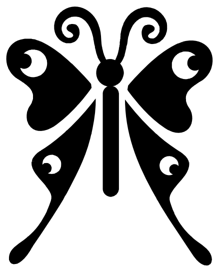
In complexity thinking, the message for practitioners is *not* to try to resolve tensions and paradoxes, but to think 'both and' rather than 'either or'. For example, in designing a learning event, do we make it *either* structured *or* unstructured? What if we made it *both* structured *and* unstructured, *at the same time*? Holding open a paradox like this, means not resolving the tension between the 2 options.



Possibility space

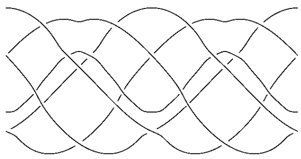
Possibility space comes from the mathematical concept of "search space" where solutions to equations can be displayed graphically in 3 dimensions (Battram 1998).

Imagine possibility space as a grid. The concept is that we will first explore those possibilities in the areas adjacent to our position (the adjacent possible). When we choose a path, new possibilities will open up to us in those spaces around our new position (Kauffman discussed in Mitleton-Kelly 2003). This does not limit our learning, as the space of possibilities is infinite, but it does somehow suggest that there are some (in fact many) paths that are more likely than others.



Sensitivity to initial conditions
The patterns inherent in chaotic systems are not random, as previously discussed, but are determined by the exact starting conditions. This is known as sensitivity to initial conditions and is often explained by the 'butterfly effect' where a small change, like a butterfly flapping its wings, could have a huge impact on weather systems in another part of the world (through a series of small, incremental changes).

Due to the sensitivity to initial conditions, it is not possible to predict how a non-linear system will evolve because minute differences can be amplified to produce huge effects. This has important implications for the notion of 'best practice' in learning. What is 'best' in one specific context may not work in another.



Complexity theories

In common with chaos theory, complexity is concerned with non-linear, dynamic behaviour. Key principles are self-organisation and emergence. Here we find that patterns and order appear through local interactions in a way that is not determined or controlled.

Autopoiesis
From biology, Maturana and Varela coined this term to expound their argument that the ultimate aim of living systems is to produce themselves (discussed in Morgan 1997). They strive to maintain their identity by subordinating all changes to it in circular patterns of interaction. The snake biting its tail, the 'ouroboros', is sometimes used to signify the self-referential nature of autopoiesis.

Writers are divided as to whether autopoiesis is relevant to organisations. However, as a metaphor, the notion of self-referencing to our own identity may be interesting in relation to learning. For example, might leadership development be about helping people to grow into their personal identity as a leader?

Co-evolution
Stuart Kauffman's work at the Santa Fe Institute considers how different species co-evolve together in an ecosystem to co-create their environment. This is very different to the idea of reacting to their environment (central to Darwinian theories of natural selection) and highlights the self-referential nature of ecosystems.

An organisation might be considered to be a social ecosystem, where various constituent parts evolve together as they are connected and interdependent (Mitleton-Kelly 2003). She questions how the rate of co-evolution within and between teams can be improved and points out clear associations with learning and knowledge transfer.

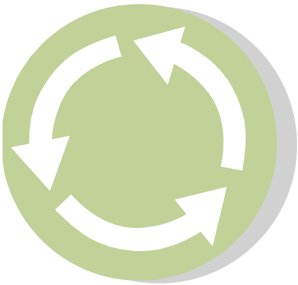
Complex adaptive systems (CAS)
CAS differ from 'whole system' theories, such as chaos, by concentrating on local interactions between individual agents (Stacey 2000). Examples of complex adaptive systems might be a flock of birds, human brain, human being, or an organisation. In each, of prime importance, is the way individual agents adjust their behaviour to others in accordance with simple rules. Complex behaviours arise and patterns evolve. Order emerges at the level of the whole system. There is no architect: nobody who sets the pattern for the whole system.

CAS theories have been developed in relation to computer simulations, with complicated algorithms existing as the defining 'rules'. This had led some variations on CAS as related to human interactions.

Complex Evolving Systems (CES)
At the London School of Economics' complexity research group, they prefer to consider human systems as complex *evolving* systems (CES). CES may include discussion on autopoiesis, dissipative structures, chaos theory and path dependence (Mitleton-Kelly 2003).

Complex Responsive Processes (CRP)
Ralph Stacey prefers the term complex responsive processes (CRP) for describing human organisation. He finds the word "adaptive" insufficiently active to describe the way people relate to each other in a continuous flow of responses, and that "system" is too mechanistic for humans. In addition, CAS has come to be interpreted as one where individuals are the agents; supporting cognitive theories of the primacy of the individual over the group. Stacey disagrees. In complex responsive processes, therefore, agents are "themes that organise experiences of relating. The individual person and the group are simply different aspects of the one phenomenon, namely relating" (Stacey 2000).

These various interpretations of complexity are still being explored in relation to organisations and to learning. However, they do agree that there is no architect, so the practitioner role may be more helpfully understood using another metaphor. In organisations we might imagine that we collectively create our rules of engagement through our interactions. If so, is the role of the developer to help remove any barriers that may interrupt these interactions?



Connectivity and Interdependence
These are key principles of complexity and mean that behaviours of any individual may affect related individuals, but will not necessarily have an equal or uniform impact. The effect of these behaviours varies with the state of each related individual at that particular time (Mitleton-Kelly 2003).

For example, the impact of a new team member depends on what they can bring to the team and what the members of the team are willing and able to accept. Mitleton-Kelly points out that they need to allow space for the new person to make their contribution. What actually happens is unpredictable (variable over time and in different contexts), as it is co-created through the detailed interactions of those involved.

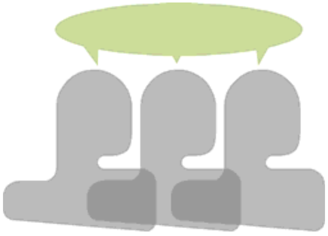
Emergence
"In complex systems no one is ever in a position to control or design system operations in a comprehensive way. Form emerges. It cannot be imposed, and there are no end states" (Morgan 1997, p272). New patterns emerge through spontaneous self-organisation and they cannot be imposed.

This notion challenges the idea that we can plan or architect change, even with the best intentions. As part of the interactive process, our intentions as developers can help to shape outcomes, but there will *always* be unexpected outcomes too.

Path dependence
A term from economics which challenges conventional economic theories. Brian Arthur (discussed in Mitleton-Kelly 2003) has claimed that theories of supply and demand are flawed as they concentrate on stabilising forces known as negative feedback. They ignore positive feedback, which may amplify the effects of small economic shifts.

For example, the dominance of VHS video-recorders over Betamax came from small changes, which led to outlets stocking increasingly more VHS-format tapes. Technology clusters are another example, as development of one new technology encourages the associated technologies. Path dependence is the increasing pull of a new technology in attracting or enabling those further developments.

So, could there be a path dependence related to learning in organisations? In my experience, learning certainly seems to breed learning. Those people who have participated in a learning event are more likely to ask for further development opportunities for themselves and others.



Spontaneous self-organisation
A system must have sufficient internal complexity (connectivity) and sufficient diversity for spontaneous self-organisation to happen. This can lead to "fundamental structural development (novelty) not just superficial change" (Stacey 2000, p276).

Connectivity and diversity are important for learning and may be achieved by both breadth and depth. Having large enough groups with a good mix of people is one way. Traditionally we have looked for small homogeneous groups so we can target learning. This may work for skill development, but could limit the amount of learning that may be gained. Another way to achieve diversity may be through depth, by peeling off another layer, getting underneath issues presented.

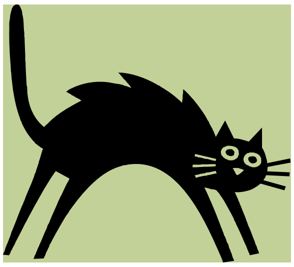
Quantum physics

Participation is a key concept in quantum physics. Some physicists believe that the universe is entirely participatory and we create the present and the past by what we choose to look for (Wheatley 1999).

This participatory nature of the universe, where material objects do not exist separately to our awareness, can be a little hard for most of us to grasp. Participation is not a new concept in learning, but this does, in my view, put a rather different slant on it.

Fields
Space is not an expression of emptiness between particles of matter, as understood in Newtonian physics, but is filled with invisible fields; thought to be the basic substance of the universe. Fields are non-material and invisible, though visible in their effect e.g. magnetic and gravitational fields. They are understood to exert influence and particles may come into being where fields intersect for temporary and fleeting moments.

We can conceive of fields as forming connections and relationships across space even though they are non-material. As a metaphor, we may imagine learning as a field, some invisible force that cannot be seen in itself only in its effects. Can we enrich some spaces with more learning fields and, if so, how?



Role of the observer
Schrödinger's cat is placed inside a closed box with solid walls. A device is set to trigger the release of food or poison, with a 50% probability of each at any one point in time. When the trigger goes off we would expect the cat to meet its fate and to discover that fate when we open the box. Not so said Schrödinger. With nobody watching, the cat is only a probability wave and is therefore *both* alive and dead until someone observes it. It is the act of observation, he argues, that determines the cat's wave function and makes it alive or dead (from Wheatley 1999).

In terms of learning, it must mean that, as developers, we are *never* an independent observer, and always an active participant in co-creating what happens through our continuous interactions.

Drawing it all together

So, taken as a whole, what does this all mean? There are a number of views.

Arthur Battram counsels us to **think differently** in order to navigate complexity. Think relationships, think community, think network, think pattern management he tells us (Battram 1998).

Margaret Wheatley's advice is to **search for a simpler way** because the universe is inherently orderly (Wheatley 1999). Is this a hint to those involved in developing organisations to back off a bit? Have we just over-complicated things?

Eve Mitleton-Kelly recommend staying out of the content and offering **enabling frameworks** or infrastructures that work on a multi-dimensional level e.g. cultural, social, technical conditions (Mitleton-Kelly 2003). This approach gives some clear guidelines for those involved in developing organisations: don't over-design, don't over-control and don't intervene too much, as this can all be counterproductive. Do allow for the interaction of people (individuals, teams etc.) to encourage co-creation. Do allow space for the exploration of possibilities in both a metaphorical and a physical sense.

Ralph Stacey (2007) suggests that we stop thinking of managers (or developers) as objective observers and start thinking of them as participants in complex responsive processes. He advises us to **re-focus attention** on:

1. the quality of participation
2. the quality of conversational life
3. the quality of anxiety and how it is lived with
4. the quality of diversity
5. unpredictability and paradox.

Still others offer that we need a greater appreciation of **wholeness**. This may be connecting the mental, emotional and spiritual aspects of our human selves (Dana Zohar 1997). Or it may be thought of as appreciating the wholeness of nature. Recognising that, in living systems, everything is in everything; the whole is in the parts and the parts are in the whole (Peter Senge et al 2005).

Reference and further reading

Battram, A (1998), *Navigating Complexity*, The Industrial Society, London

Isaacs, W (1999), *Dialogue and the Art of Thinking Together*, Doubleday

Mitleton-Kelly, E (2003), *Ten Principles of Complexity & Enabling Infrastructures*, http://www.psych.lse.ac.uk/complexity/publications.html (accessed 02/08/07)

Scharmer, C (2003), "Presencing: Illuminating the Blind Spot of Leadership" http://ottoscharmer.com/ (Accessed 02.08.2007)

Senge, P et al (2005), *Presence*, Nicholas Brearley Publishing, London

Stacey, R (2000), *Strategic Management and Organisational Dynamics*, Third Edition, Pearson Education Ltd, Essex

Stacey, R (2003), "Learning as an activity of interdependent people", *The Learning Organization*, Volume 10, Number 6, pp325-331

Stacey, R (2006), *Complex Responsive Processes in Organizations: Learning and Knowledge Creation*, Routledge, London

Stacey, R (2007), Strategic Management and Organisational Dynamics, Fifth Edition, Pearson Education Ltd, Essex

Wheatley, M (1999), *Leadership and the New Science*, Berret-Koehler Publishers Inc, San Francisco

Zohar, D (1997), *ReWiring the Corporate Brain*, Berrett-Koehler Publishers Inc, San Francisco