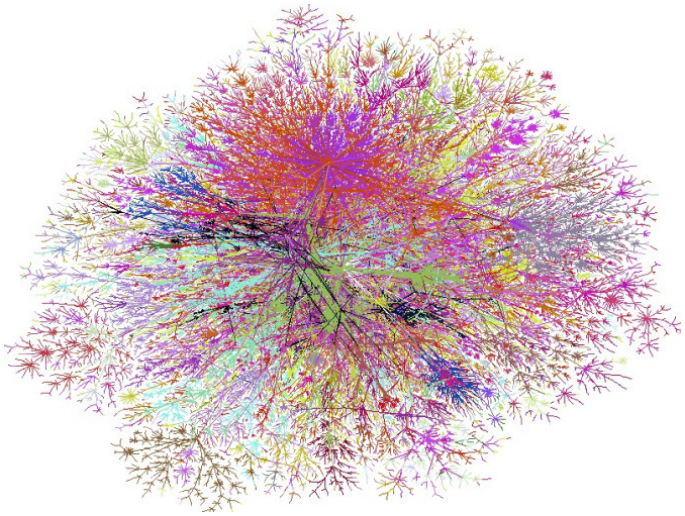
Complexity Theory



Complexity is one dimension of every project; complexity theory helps understand the social behaviours of teams and the networks of people involved in and around a project. The ideas apply equally to small in-house projects as to large complicated programs - 'complexity' is not a synonym for *complicated* or *large*.

There are four basic dimensions to every project[1]:

- Its inherent size usually measured in terms of value;
- The degree of technical difficulty in creating the output;
- The degree of uncertainty involved in the project; and
- The complexity of the relationships ('small p' politics) both within the project team and surrounding the project.

Interestingly, whilst all of these factors impact on the degree of difficulty associated with successfully managing the delivery of the project, the Project Manager can only significantly influence, as opposed to manage, the last two elements. Reducing the degree of uncertainty and enhancing the relationships with and between project stakeholders (including the project team).

The difference between how complicated the work is and complexity theory is that managing complicated work (ie, work with a high level of technical difficulty) is achievable by implementing appropriate systems such as quality management and configuration management. The consequences of technical difficulty are definable, predictable and manageable with the right people. The essence of complexity theory is that the future is inherently unpredictable.

Highly complex (extreme) projects require a high level of expertise in stakeholder engagement to deal with the uncertainty. This type of project cannot be fully planned because the scope and requirements evolve over time (requiring iterative planning); but political and commercial pressures require as much certainty as possible 'upfront'.

Understanding Complexity Theory

Complexity theory has become a broad platform for the investigation of complex interdisciplinary situations and can be defined as the study of how order and patterns arise from apparently chaotic systems and conversely how complex behaviour and structures emerge from simple underlying rules. Some of the ideas appear directly relevant to understanding project management from a relationship perspective.

The first idea is from the early days of 'chaos theory'. The ***Tipping Point*** describes the way natural systems can absorb influences with minimal (or predictable) change until the 'tipping point' is reached and then there is a sudden catastrophic change. This idea is particularly relevant when thinking about 'culture change' in a

[1] For more on ***project size and categorisation*** see: https://www.mosaicprojects.com.au/WhitePapers/WP1072_Project_Size.pdf

network. The social network can absorb a lot of pressure to change and targeted individuals may change whilst under direct 'pressure' but the 'cultural norms' prevail and there is little real change until the 'tipping point' is reached, then there is a sudden shift to a new set of 'cultural norms' and people retaining the 'old ideas' are seen as being out of touch. It is impossible to predict the 'tipping point' until it has been reached at least once.

The idea of ***Nonlinearity*** builds on from this. Nonlinearity suggests that you can do the same thing several times over and get completely different results. Small differences may lead to big changes whilst big variations may have minimal effect. The 'butterfly effect' describes the situation where minute changes in the starting condition can have major and unpredictable consequences in non-linear systems. Importantly, all human relationships are non-linear.

The complete unpredictability of Nonlinearity is counteracted by the idea of ***Strange Attractors***. Strange attractors are most easily thought of as recurring patterns that have quasi-predictable features. The behaviour of dynamical systems in nature (eg, the weather) has a degree of predictability. However, dynamical systems can follow a number of qualitatively different attractors depending on their initial starting condition and the effect of external influences (see: ***Simulating complexity*** at the end of this paper).

This brings us to the concept of ***complex dynamical systems***. These systems are continuously both receiving and transmitting 'energy' to their environment, eg, a cyclone; at the detail level they are in 'chaos' but overall are a quasi-predictable 'system'. After a period of time transferring energy, these systems reach a point of irreversible change (bifurcations) where the outcome is inherently unpredictable.

Self-organising systems are complex dynamical systems that appear capable of self-organisation and exercising choice in a manner that makes them inherently unpredictable. Feedback loops contained within the system ensure that 'rich patterns' are produced and the system itself behaves in its own unique way. Importantly, how the system will behave cannot be determined by studying its parts. These ideas apply to shoals of fish, ant colonies and human social groups. As these self-organising systems go about their daily business, they are continually exchanging energy and matter with their environment. This allows them to remain in a state that is far from equilibrium and allows spontaneous behaviours and new patterns to emerge in response to stimuli; 'living on the edge of chaos'.

Complex adaptive systems are self-organising systems that have the capacity to learn from their experience. This 'system description' appears to relate very closely to a project team, living on the 'edge of chaos'; responding and adapting to its surroundings (ie, the project's stakeholders) and learning (or creating new knowledge) as it advances. These ideas offer a new set of insights on the management of projects; the key strand of research into complex adaptive systems that this paper will focus on is the concept of the ***Complex Responsive Processes of Relating*** (CRPR).

CRPR puts emphasis on the interaction among people and the essentially responsive and participative nature of the human processes of organising and relating. ***Organisation is an emergent property of many individual human beings interacting together through their complex responsive processes of relating***. They use 'language' in conversations to simultaneously transfer information and ideas, negotiate social status and develop power relationships. The 'actors' intentions, choices and actions / reactions are influenced by and influence their conversations as they operate within the dynamic of their daily interactions with other people. The process of 'organising' is the human experience emerging from the interactions between actors who are all continual forming intentions, choosing and acting in relation to each other as they go about their daily work together implementing the project.

The future seen from this perspective is therefore under perpetual construction by the movement of the human action itself. Consequently, the actors, interactions and emerging organisation are located in a specific context (the organisation's social network, culture and 'project team') and are oriented towards an 'unknown future' (the project outcome) that the group is in the process of continually creating (or working to

achieve). In this context, the intended (or planned) future needs to be differentiated from the actual future that unfolds over time[2].

Managing within complexity

Without becoming experts in complexity theory, project managers can adapt to work within complexity. Some of the key ideas to use in your work include:

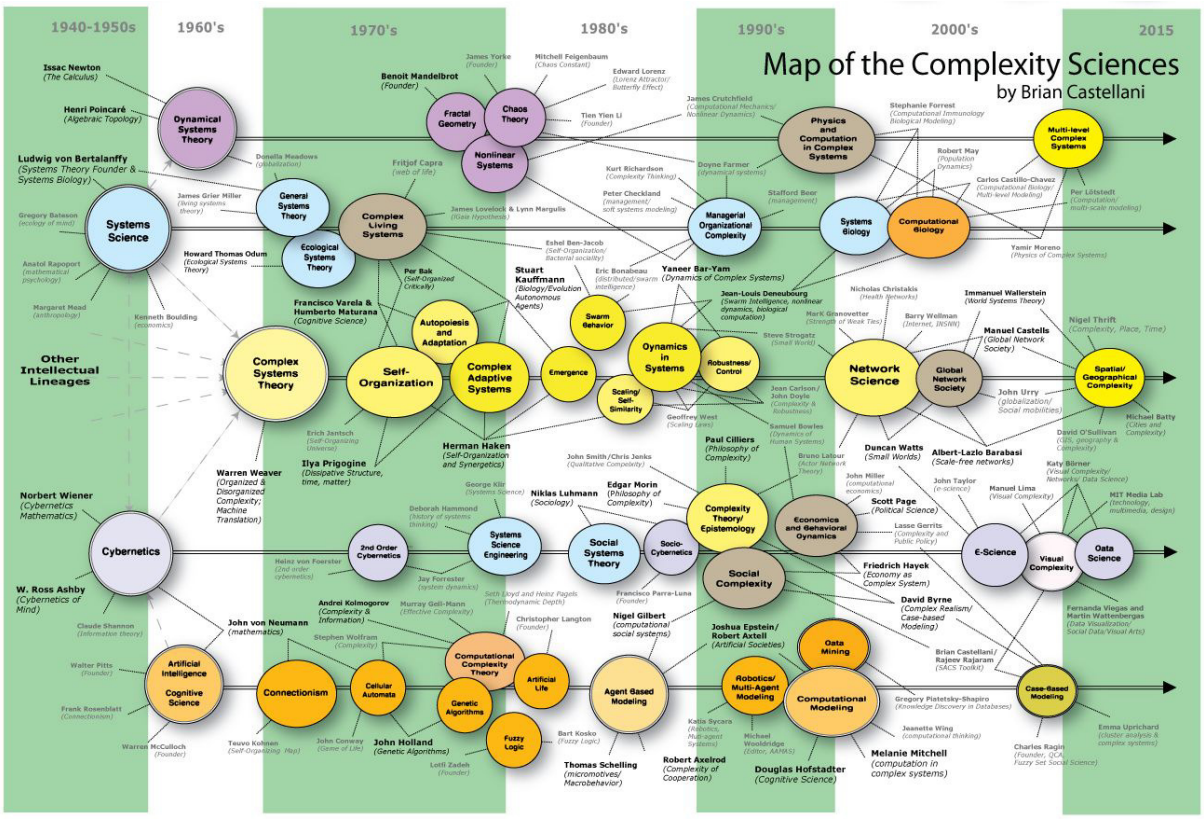
Embrace the assumptions of complexity:

The four key assumptions within complexity are:

- All elements of a situation are interconnected.
- Partial knowledge is all that is available.
- Individual perceptions, thoughts and emotions are as important as actions and events.
- Outcomes are probable, not certain.

You cannot predict or absolutely control the future, pretending you can, may feel more comfortable but is ultimately far more dangerous than accepting a degree of unpredictability and being prepared for the unexpected.

Understand the science of complexity is complex:



For a readable version see: https://www.art-sciencefactory.com/complexity-map_feb09.html

[2] Complexity theory is discussed in more detail in ***A Simple View of 'Complexity' in Project Management:*** https://www.mosaicprojects.com.au/PDF_Papers/P070_A_Simple_View_of_Complexity.pdf

Complexity studies are themselves complex, adaptive, multi-faceted and emergent as the diagram above demonstrates. We do not have precise or definitive solutions!

Take a whole system perspective:

A broad 'whole system' perspective helps you define trends, overall priorities and opportunities. Avoid becoming overloaded with information and distracted by detail. If you lead your team effectively[3] they will be motivated to look after the details.

Understand the three types of complexity:

The three types of complexity require quite different approaches:

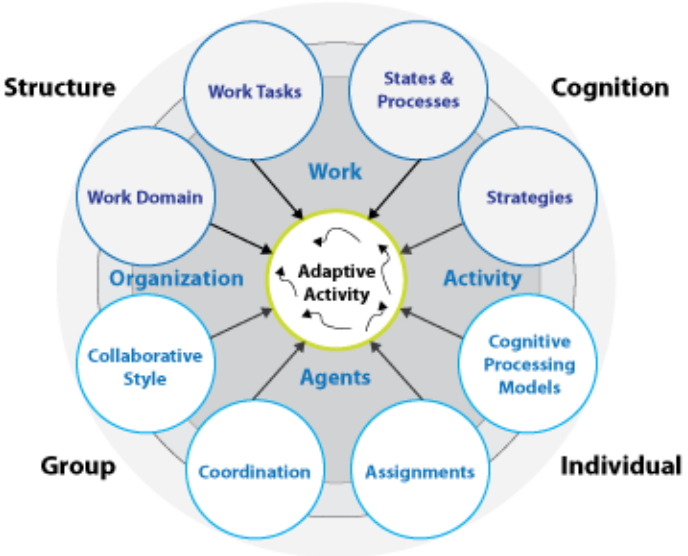
- Structural complexity deals with the practical issues around the number of stakeholders, their allegiances and alliances and the practicalities of consulting and communicating with them. This type of complexity requires a management response to ensure adequate resources are available to manage the issues.
- Socio-political complexity deals with the attitudes and expectations of the stakeholders and how they are likely to react to a project or a change and to each other. This type of complexity is rooted in relationships and perceptions and requires effective leadership and communication to optimise outcomes.
- Emergent complexity deals with changing events and the unforeseen or unknowable. Dealing with this aspect of complexity requires an entrepreneurial approach based in flexibility and an awareness of the emerging opportunities as well as reacting to emerging problems - many emergent situations combine opportunities as well as threats.

Beware of assumptions and perspectives (including yours):

Careful examination of the implicit assumptions and perceptions we all take for granted is needed. Seek diverse perspectives and apply disciplined thinking to make sure your own perceptions and assumptions are not part of the problem.

Dig for the dynamic drivers:

The real drivers of most situations are hidden. Key factors include thoughts, perceptions and individual motivations playing out through the network of actors in and around you project team. These factors are frequently 'the cause of the cause of a problem' and can be remarkably subtle and intricate whist being pervasive and difficult to change. Some of the factors that will influence each activity include:



[3] For more on ***leadership*** see: https://www.mosaicprojects.com.au/WhitePapers/WP1014_Leadership.pdf

Understand the power of emergence:

Complex situations are constantly evolving in unpredictable ways. An iterative approach based on making a decision, taking action, reviewing the outcomes and deciding on the next set of actions based on what has actually happened will move the project towards its intended goal. This cycle needs to be played out across multiple fronts to achieve the best outcome. This agile approach to managing means the final goals may be different to the initial expectations because all of the stakeholders have leaned new information along the journey.

Emergence is defined as *'the arising of novel and coherent structures, patterns and properties during the process of self-organization in complex systems*[4]*'*. The common characteristics of an emergent state are:

1. Radical novelty (features not previously observed in systems);
2. Coherence or correlation (meaning integrated wholes that maintain themselves over some period of time);
3. A global or macro "level" (ie, there is some property of "wholeness");
4. It is the product of a dynamical process (it evolves); and
5. It is "ostensive" (it can be perceived).

The challenge is you cannot predict the emergent state until after it emerges.

Summary

Complexity theory suggests that the creation of a successful project outcome will always be an uncertain journey, but the path to success or failure can and will be influenced by the actions and attitudes of the actors within and around the project team. The key element is how effectively the project team uses its social network to gather the resources (knowledge and support) needed to create success.

These ideas are closely linked to Stakeholder theory[5], which suggests that a project is only successful if its key stakeholders perceive the project to be successful. An obvious part of this requirement is the delivery to the stakeholders of a 'useful deliverable', in an appropriate way, that includes elements of the 'right output' at the 'right time' for the 'right cost'; but none of these factors are absolutes. Project success is created by effectively managing the stakeholder's expectations to align with what is reasonable and feasible for the project to achieve. Managing the stakeholder's expectations takes place through the relationships that exist within project's larger 'social network' and is 'complex'. The emphasis for successful project managers is shifting to a focus on influencing, motivating and leading the people who can make projects successful.

Simulating Complexity – Chaos Theory

The element of chaos theory of interest is the temporal behaviour of a system[6]. A system consists of parts that interact and most business/project systems have many interdependent parts, including human beings and even the environment. This makes it conceptually and practically difficult to pin down the behaviour of a

4 Definition developed by economist Jeffrey Goldstein.

5 For more on ***stakeholders*** see: https://www.mosaicprojects.com.au/WhitePapers/WP1007_Stakeholder_Cycle.pdf

6 For more on ***systems thinking*** see: https://www.mosaicprojects.com.au/WhitePapers/WP1044_Systems_Thinking.pdf

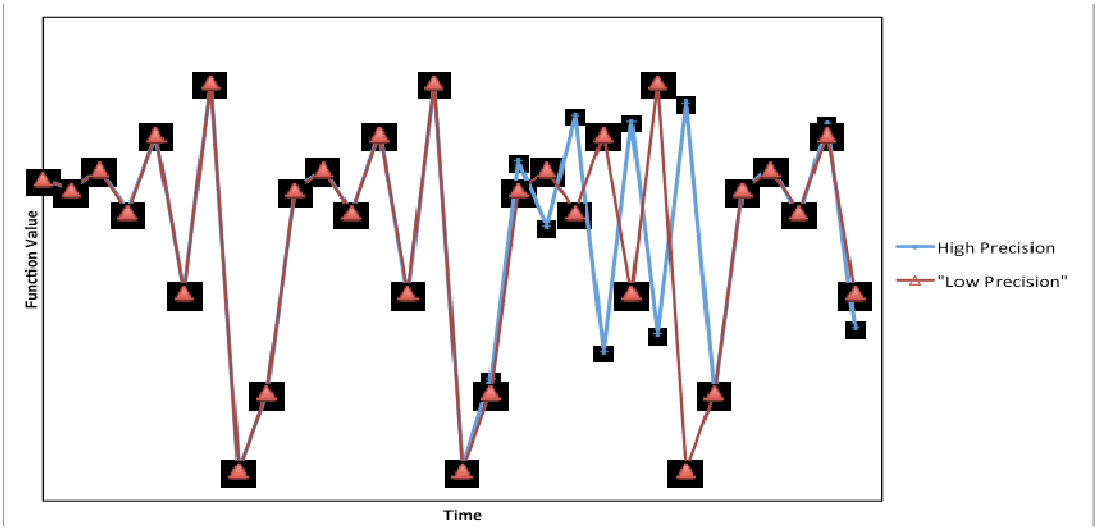
system under all operational conditions. It is the nonlinear elements in the system that may cause unexpected behaviour, no matter how well we characterized the system initially. A sudden change in a nonlinear system may give rise to ***chaos***, but chaos is only one type of behaviour exhibited by nonlinear systems.

It is relatively easy to simulate chaos in excel using a simple formula. An example is

$$x_{t+1} \leftarrow 1.9 - x^2_t$$

This is an iterative (or difference) equation, meaning that for any time-step in the future, we use the previous value of the equation, generated at the previous time-step as the value of the time dependent variable to generate the next value. The equation is nonlinear because it is quadratic in the time dependent term x_t^2.

The graph is erratic, there is no obvious pattern or cycle; but the graph was generated by a deterministic equation, not by some random (stochastic) process. Simply by changing the precision used by Excel to calculate the chart, differences can appear, and then disappear (then reappear later). This simple system is also extraordinarily sensitive to the initial start value; minute changes can cause significant variation.



More complex formula in more sophisticated tools can generate fascinating charts……

In many circumstances, chaos is a deterministic process that arises in non-linear systems. If an appropriate model can be developed, short term predictions can be very accurate but the nature of the system makes the prediction of long-term behaviour meaningless. And we cannot discover the history of a chaotic system by looking at the system in its current state – mathematically such a system has equations that are noninvertible.

Managers must deal with knowing that their team is a system that will behave chaotically in a certain circumstance. Being sensitive to this fact is an important start!

Key papers on Complexity Theory:

1. ***A Simple View of 'Complexity' in Project:***
   https://mosaicprojects.com.au/PDF_Papers/P070_A_Simple_View_of_Complexity.pdf

2. ***Risk Management and Complexity Theory - The Human Dimensions of Risk***:
   https://mosaicprojects.com.au/PDF_Papers/P072_Risk_and_complexity.pdf

3. ***Scheduling in the Age of Complexity***:
   https://mosaicprojects.com.au/PDF_Papers/P089_Schduling_in_the_Age_of_Complexity.pdf

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