Enabling effective learning in catchment management agencies:
Research Report

Report to the
Water Research Commission
and
The Department of Water Affairs and Forestry
on the project
"A philosophy and strategy enabling learning for good ecosystem governance"

by

DJ Roux[1], K Murray[2] and E van Wyk[3]

[1] International WaterCentre: Africa, Water Research Node, Monash South Africa
[2] Insight Modelling Services CC
[3] Natural Resources and the Environment, CSIR

WRC Report No. 1689/1/09
ISBN 978-1-77005-896-5
Set No. 978-1-77005-861-3

November 2009

This report forms part of a series of two reports. The other report is *Enabling Effective Learning in Catchment Management Agencies: A Philisophy & Strategy* (WRC Report No. TT 421/09).

EXECUTIVE SUMMARY

Background

This work arose out of perceived need for basic guiding concepts for enabling effective learning within catchment management agencies. This report describes the thinking and learning that took place during the development of the learning philosophy and strategy which are captured in WRC Report No. TT 421/09.

The formal objectives of the study were:

- To further develop and refine a philosophy and set of principles that will enable the establishment of appropriate learning environments for good ecosystem governance;
- To develop a strategy that implements this philosophy in a chosen Catchment Management Agency; and
- To facilitate roll-out and initialise implementation of the strategy in the chosen Catchment Management Agency.

These objectives were achieved. The outcomes are captured in this report and the complementary report, WRC Report No. TT 421/09.

This work further develops that of Roux et al. (2007), which developed learning principles for organisations with a mandate for ecosystem governance. The challenges faced by such organisations are significant. They include:

- Complexity with its inherent emergence and unpredictability;
- Change;
- Information overload;
- Significant decision making that affects people's lives and livelihoods;
- Threats to sustainability of the organisation; and
- Multidimensionality.

The abilities of a learning organisation with a mandate for ecosystem governance can therefore be summarised as follows:

The organisation must be able to acquire, create and transfer knowledge in ways that allow it to practice good governance of a social-ecological system in a sustainable manner, transforming itself if necessary to do so. This requires it to be able to deal with (a) multi-dimensional problems, (b) the associated complexity (and hence uncertainty), (c) change in all aspects of the social-ecological system, (d) information overload, (e) decision making that may have far-reaching consequences, and (f) predictable and unpredictable threats to its ability to achieve its mandate in an on-going way.

Learning principles

The appropriateness of the learning principles developed by Roux et al. (2007) was re-assessed in light of the above required abilities of a learning organisation. In particular, the assessment considered the following two questions:

1. **Correctness**: Are these principles the correct (essential) ones?
2. **Sufficiency**: Is the set of principles sufficient (equivalently, are all the important principles captured)?

A careful analysis of methods for answering these questions was carried out. It concluded that no practical approach was possible that could help answer these questions unequivocally. However, various approaches could be adopted to raise confidence in their correctness and sufficiency.

Some principles were refined (by improving their definitions), two new principles were added and others were considered but not adopted. A thorough exercise was then carried out that systematically identified the outcomes of, first, applying each learning principle and, secondly, not applying it. This process specifically raised confidence in the general appropriateness of the new set of principles.

Reputable literature was also carefully analysed to establish the extent to which the principles were aligned with the recommendations of such authors. This suggested that the current set of indicators is well aligned with much that the respective authors suggest is required for learning organisations. An interesting and relevant perspective is that the current set of principles goes beyond what these authors suggest is important. Specifically, the two principles of transdisciplinarity and adaptability are both regarded as essential for learning organisations with a mandate for governance of social-ecological systems. It is hypothesised that the literature may be more focused on "traditional" business environments, not the more demanding environments of governance of social-ecological systems.

Overall, therefore, the assessment of the principles suggested that they are appropriate considerations for learning organisations.

Indicators and learning audits

A series of indicators and a "learning audit" questionnaire was developed to explore in more depth the degree to which an organisation is a "learning organisation" and the degree to which it applies the learning principles.

A total of 27 indicator statements were chosen for the eleven learning principles with a maximum of 3 indicators per principle. Based on the above six essential abilities of a learning organisation, a similar series of indicator statements was developed to enable assessment of the degree to which ability exists in the organisation. An additional nine indicators were formulated to address certain enabling objectives, for example data processing, information processing and leadership. This series of indicators therefore went well beyond just the learning principles.

An analysis of the degree to which these indicators were aligned with the recommendations of reputable authors suggested good alignment.

A single audit of the unit within SANParks responsible for the greater Kruger National Park was undertaken. This group was chosen because it is generally perceived as a learning organisation. Eight people were interviewed in seven separate interviews (in one interview two people were interviewed together). For present purposes (i.e. development and refinement of indicators), this learning audit was extremely useful.

The execution of the learning audit with SanParks was a useful exercise in the following respects:

- It facilitated an in-depth examination of individual learning principles within a specific organisation;
- It added a degree of practical reality to the principles; and
- It strengthened links with the organisation.

Notwithstanding the usefulness of the exercise, the degree to which the exercise was quantitative was thought to be inappropriate and excessive. It was also felt that there was too much emphasis on individual principles and specific outcomes, and the measurement thereof. Instead of assuming that each principle should be applied within an organisation (albeit to different extents), each

should rather be regarded more loosely as “touchstones” to be suggested, tried and tested, and even discarded if appropriate. The general rigidity of the questionnaire, its indicators and the associated principles and outcomes was also considered inappropriate. By its nature, the “learning audit” approach does not necessarily fully account for the inevitable complexity (i.e. emergence and unpredictability) in such an organisation.

Accordingly, this quantitative “learning audit” approach was not continued.

Complexity

The philosophy upon which a strategy for learning organisations should be based is firmly grounded in a number of general frameworks. One important framework is complexity. This chapter presents a description of complexity for those who may not have been exposed to the concept.

A distinction is made between complicated (consisting of many interconnecting elements) and complex (involving, in particular, emergence and unpredictability). Organisations, ecosystems, social systems and overall social-ecological systems are all regarded as complex systems.

Complex systems have specific characteristics or properties, for example:

- Self-organisation and emergent properties;
- Near-neighbour interactions;
- Feedback;
- Unpredictability; and
- Nesting.

These characteristics were examined specifically in the context of learning organisations and a series of strategy principles distilled:

- **Influence, don’t control**: *Self-organising systems, by definition, can’t be controlled*.
- **Focus on a few critical rules**: *Only a few rules are necessary for emergent properties*, e.g. *empathise and internalise*.
- **Monitor, monitor, monitor**: *Complex systems with emergent properties that have positive reinforcing feedbacks can cause very rapid change*.
- **Expect the unexpected**: *Complex systems are unpredictable*.
- **Acknowledge the past**: *In a self-organising system the present depends intimately on the past*.
- **Don’t get too comfortable**: *A system is most adaptable on the edge of chaos*.

These formed the basis of a few extra learning ideals that specifically ensured the learning philosophy captured in the Philosophy and Strategy report (Roux et al., 2009) specifically took account of complexity.

The practicalities of mathematical complex systems were also explored to achieve a greater depth of understanding. This included a very superficial development of mathematical models for the law of supply and demand (recognised as an example of a complex system) and the production of a visual presentation of “zebra stripes”.

Conclusions and recommendations

The following summarise the conclusions drawn from the work:

- This work, as captured in this and the complementary report (WRC Report No. TT 421/09), has addressed the three original objectives of the project.

- The general environment in which catchment management agencies currently operate, and will operate in future, is very demanding from many points of view.

- This demanding working environment will place specific demands on those catchment management agencies which explicitly choose to place emphasis on appropriate learning. It cannot be simply be business as usual.

- The nature of learning and its underlying principles is such that it is difficult to be categorical about anything. It is particularly difficult to be quantitative.

- Equivalently, it is difficult to rigorously test whether the proposed learning principles are correct (i.e. the essential ones) or sufficient (i.e. they are all captured). Nevertheless, those subjective tests that can be performed (like comparing them with the recommendations of reputable workers in the field) have given reason for confidence in their appropriateness.

- The proposed learning principles are at a very low-level enabling level in the sense of the kind of guidance a policy might provide. Their guidance is very general and therefore strategies that may make them operational might vary considerably from one situation (and catchment management agency) to the next.

- The new business ethic will demand a special human-centred sensitivity to change and a tricky balancing of the inevitable short-term demands of the social-ecological system with the optimum long-term strategies that will ensure an appropriate level of sustainability.

- Complexity theory has much to offer the water resource manager. Probably its most important role will be to provide a justification for the kind of management mindset that is required, especially in acknowledging the inevitability of surprise. However, it also suggests how complex systems should be managed, namely that constructive emergent behaviour should be managed with gentle persuasion, not command and control.

The following recommendations are made:

- It is strongly recommended that the basic concepts of complexity theory be understood by water resource managers.

- Because a water resource governance and management mindset must acknowledge surprise, or equivalently, unpredictability, it is strongly recommended that strategic adaptive management be considered as an appropriate framework within which to develop sound learning practices. It has been developed specifically to cope with the uncertainty associated with decision making.

- The nature of learning is such that it is recommended that monitoring of learning-related progress (e.g. in a strategic adaptive management context) be more qualitative than quantitative.

- It is recommended that this and the complementary report (WRC Report No. TT 421/09) be distributed directly to at least (a) the DWAF Institutional Oversight directorate, (b) all current DWAF regional offices, and (c) all existing CMAs and proto-CMAs.

- Because of the fundamental nature of sound learning to the effectiveness of a CMA, it is recommended that it be explicitly captured in any CMAs catchment management strategy.

- The nature of the work undertaken in this project was of a fundamental nature leading to a general philosophy and strategy. It is therefore recommended that this work be continued by a phase which makes these practically operational for at least the Inkomati CMA.

ACKNOWLEDGEMENTS

The production of this report was jointly funded by the Water Research Commission and the Department of Water Affairs and Forestry.

The authors wish to thank the following people for their contributions during the project.

Reference Group

Harry Biggs	SANParks
Jaqui Goldin	African Water Issues Research Unit (AWIRU)
Eiman Karar	Water Research Commission (Research Manager)
Thembi Khosa	SANParks
David Malobo	DWAF: Transformation
Mario Marais	Meraka Institute, CSIR
Jerry Methula	DWAF: Institutional Oversight
Barbara Schreiner	Pegasys Consulting
Marius Ungerer	University of Stellenbosch Business School
Francois van Wyk	Rand Water
Petrus Venter	DWAF: North West Province

Other contributors

Eustathia Bofilatos	DWAF: Institutional Oversight
Andrew Deacon	SANParks
Linda Downsborough	Rhodes University
Llewellyn Foxcroft	SANParks
Rina Grant	SANParks
Navashni Govender	SANParks
Brian Jackson	Inkomati Catchment Management Agency
Judith Kruger	SANParks
Tsakani Maphophe	Inkomati Catchment Management Agency
Tshiamo Matabane	DWAF: Institutional Oversight
Sizile Ndlovu	CEO Inkomati Catchment Management Agency
Rob O'Donoghue	Rhodes University
Mark Pascoe	International WaterCentre
Danie Pienaar	SANParks
Freek Venter	SANParks
Etienne Wenger	Communities of Practice Consultant
Derek Weston	DWAF: Institutional Oversight

CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: BACKGROUND

This chapter presents the objectives of this work and describes the context of the work.

1.1 INTRODUCTION

Managing water resources is complex and multi-disciplinary. Decisions are often based on insufficient or uncertain data and information. Water resources are also in a state of continuous change and subject to unpredictable changes. Adaptive management (a necessary condition for good ecosystem governance) that balances robustness and flexibility is therefore essential. Only learning organisations can achieve this.

Learning organisations are skilled at acquiring, creating and transferring knowledge and, importantly, adapting their behaviour when necessary on the basis of new knowledge. This work develops basic guiding concepts for enabling effective learning within catchment management agencies in particular. This report describes the thinking and learning that took place during the development of the learning philosophy and strategy which are captured in another report (Roux et al., 2009).

This document is structured as follows:

- This chapter describes the general learning context.
- Chapter 2 describes an assessment and refinement of the underlying learning principles, originally published by Roux et al. (2007).
- Chapter 3 describes the development and application of a questionnaire for a "learning audit". This was applied to SANParks. While much was learned from this process, the general approach of using a questionnaire was discontinued because it was generally felt that it was overly (and inappropriately) quantitative.
- Chapter 4 describes complex systems, provides many examples, and explores how the concept is relevant to organisations with a mandate for ecosystem governance.
- Chapter 5 describes the overall outcome of the work, drawing conclusions and providing recommendations.

1.2 OBJECTIVES

The formal objectives of this work were as follows:

- To further develop and refine a philosophy and set of principles that will enable the establishment of appropriate learning environments for good ecosystem governance.
- To develop a strategy that implements this philosophy in a chosen Catchment Management Agency.
- To facilitate roll out and initialise implementation of the strategy in the chosen Catchment Management Agency.

1.3 THE NATURE OF THE PROBLEM

1.3.1 Introduction

Before embarking on the development of a philosophy and strategy it is important to have clarity on the following:

- The general mandate of the organisation for which they are developed,
- The current realities in the targeted organisation, and
- The abilities of such an organisation that will enable it to carry out its mandate.

These are described in the following sub-sections. In effect, these comprise the assumptions upon which this work is based.

1.3.2 Organisational mandate

This work further develops that of Roux et al. (2007) which developed learning principles for organisations with a mandate for ecosystem governance. We assume the same mandate in this work.

Ecosystems are complex in themselves. However, good governance of such systems involves more than just the ecosystems. It must consider the complete associated social-ecological system, including individuals, organisations and institutions in private and public sectors. Governance also implies a participatory approach, not just bland “involvement”.

1.3.3 Current realities

The South African National Water Act (No. 36 of 1998) is regarded as one of the most progressive in the world with the mandate for its implementation entrusted to the Department of Water Affairs and Forestry (DWAF). However, South Africa is a country with scarce fresh water resources and demanding imperatives for social and economic change. Sustainability and equity are core principles and often in tension in practice.

DWAF is currently in the process of creating catchment management agencies (CMAs) in an effort to devolve water resource management to the lowest practical level. Although the CMAs have a degree of autonomy in their choice of staff, they will inevitably rely on existing DWAF staff to some extent. Because of this autonomy, it is not possible to evaluate accurately the likely realities in future CMAs. However, their relationship with and dependence on DWAF will mean their future reality will be influenced by DWAF. DWAF currently faces a wide variety of challenges. These are described in the following paragraphs.

DWAF shoulders daunting responsibility (as ultimately the CMAs will). Decisions they make affect people’s lives and livelihoods, now and in the future. The sustainability of the very water resources upon which society depends can be sensitive to both action and inaction. There is the every-present challenge to promote appropriate water resource use, a dynamic characterised by uncertain outcomes over space and time, both short- and long-term. Adaptable and anticipatory sense and response mechanisms are essential.

The challenges relating to DWAF’s and CMA’s external environments are significant. The social-ecological systems the governance encompasses exhibit the traits of complex systems (Gunderson and Holling, 2002; Walker et al., 2006). At the complexity core is unpredictability (see Chapter 4). Frequently decisions have transdisciplinary dimensions, ranging from using, for example, well-established scientific understanding of ecosystem functions to ethical issues of

rights of access to those ecosystems. By their very nature most social-ecological system components also change, whether they be ecosystems, climate, social and cultural systems, or economic, political, and legal systems. They can change daily, seasonally, over decades, and sometimes unexpectedly. The final and equally demanding burden is the burgeoning volume (and almost frustrating ready availability) of data, information, and knowledge.

Institutional decentralisation and devolution of responsibility will ultimately place catchment management agencies at the "coal face" of local and regional water resource management. Expectations are high because water is such a cross-cutting resource. Both vertical (transdisciplinary) and horizontal (multidisciplinary) integration will be necessary.

Governance and management of social-ecological systems relating to water resources is therefore a particularly challenging environment in which to consider notions of learning.

1.3.4 Essential abilities

In essence the tasks facing an organisation with a mandate for ecosystem governance are complicated (has many interacting components) as well as complex (i.e. involves emergence and uncertainty). They necessarily require wide-ranging skills, experience and knowledge.

Managing the physical, chemical and biological dimensions of ecosystems requires considerable knowledge depth in a wide variety of natural sciences and engineering disciplines. However, practising good governance requires knowledge that spans social, economic, political, legal and ethical dimensions. This is partly because social and economic systems influence, and are influenced by, ecosystems. Politicians are mandated by legislation to manage ecosystems in particular ways. However, they are also heavily influenced by their constituencies. Ethics and basic human values, on the other hand, are either embedded in such legislation (like in "sustainable development") or require *ad hoc* interpretation in specific circumstances.

Furthermore, superimposed on this multi-dimensionality, is the phenomenon of change. An organisation must be able to adapt to change that is not only rapid but perpetual (Schein, 2004).

The organisation with a mandate for ecosystem governance is therefore faced with increasingly enormous amounts of data and information (both relevant and irrelevant, and these change as well). Nevertheless, the irony is that there is often insufficient information to make risk-free, or even low-risk, decisions. It must solve complex cross-discipline problems, make decisions that affect the daily lives, and often livelihoods, of ordinary people and the long term sustainability of the very ecosystems upon which they depend. It must make decisions that balance short-term desperate needs and, often conflicting, long-term optimum needs. It has a significant responsibility to its stakeholders and knows it will be held accountable.

To achieve its mandate the organisation must know a lot about many aspects of social-ecological systems, in their broadest possible sense. It must keep pace with new approaches, data, information and knowledge. It must learn what to learn and learn it quickly. It must be able to solve complex problems, minimise risks associated with decision-making and learn and grow effectively when things go wrong (as they will do). Furthermore, it must ultimately be sustainable in the face of all these challenges. This requires a dedicated team of people with special talents who can work and act together efficiently and effectively.

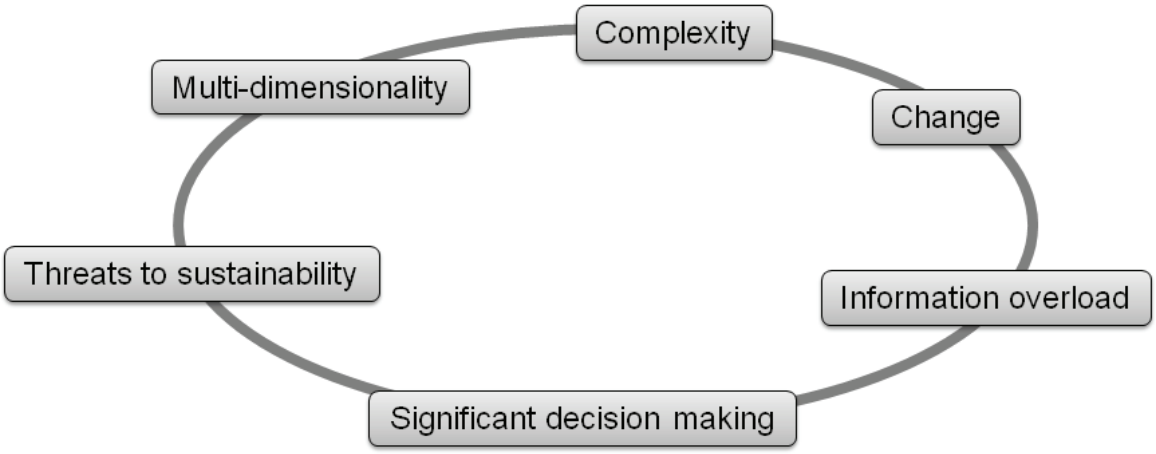


Figure 1 : The challenging realities of ecosystem governance or management.

In essence, each challenge (see **Figure 1**) requires a specific ability. Each of these abilities is an essential pre-requisite for a learning organisation with a mandate for ecosystem governance or management. These are, generically, the ability to:

- Deal with complexity;
- Deal with change;
- Deal with information overload;
- Deal with significant decision making;
- Deal with threats to sustainability; and
- Deal with multi-dimensionality.

We therefore can summarise the abilities of a learning organisation with a mandate for ecosystem governance as follows:

The organisation must be able to acquire, create and transfer knowledge in ways that allow it to practice good governance of a social-ecological system in a sustainable manner, transforming itself if necessary to do so. This requires it to be able to deal with (a) multi-dimensional problems, (b) the associated complexity (and hence uncertainty), (c) change in all aspects of the social-ecological system, (d) information overload, (e) decision making that may have far-reaching consequences, and (f) predictable and unpredictable threats to its ability to achieve its mandate in an on-going way.

This forms the basis of the explorations into organisational learning- and knowledge-related issues described in the following chapters.

CHAPTER 2: LEARNING PRINCIPLES

This chapter describes an assessment and refinement of the underlying learning principles.

2.1 INTRODUCTION

The principles proposed by Roux et al. (2007) were based on the assumption that an organisation with a mandate for governance of a social-ecological system is better equipped for this task if it is a learning organisation. More specifically, the principles comprise ideals and values that should be strived for in order to enhance the nature and extent of learning appropriate for organisations with such a mandate.

This chapter assesses the appropriateness of these principles in some depth. It redefines a few principles, adds a few and considers others.

2.2 PRINCIPLE VALIDATION TESTS

2.2.1 Correctness and sufficiency

Roux et al. (2007) make the following claim:

*"Good ecosystem governance requires **positively persistent** and **adaptive** people with a culture of **empathy** for other knowledge systems and levels. Their knowledge must be **transdisciplinary**, moulded by a **common future focus**, acquired by **patiently engaging their prior knowledge** and **learning by doing** in an environment of **social knowledge sharing**."*

This is essentially a narrative summary of the nine formally-defined principles (indicated in bold) they propose will enable "a more appropriate learning process for good ecosystem governance".

The following two questions arise:

1. **Correctness**: Are these principles the correct (essential) ones?
2. **Sufficiency**: Is the set of principles sufficient (equivalently, are all the important principles captured)?

It is doubtful that a simple test could be devised to answer either of these questions. However a few general approaches could be investigated aimed at improving confidence that the proposed set of principles is satisfactory. The following sub-sections describe these approaches.

2.2.2 "Principles and outcomes" test

This test involves answering two questions for each principle:

1. What is achieved when this principle is properly applied?
2. What happens when it is not applied?

This exercise can only test correctness, not sufficiency. The degree to which the two questions can be convincingly answered may give at least some context and a little more depth and justification for the importance of each principle. This is particularly so if they can be related directly to the realities challenging organisations responsible for ecosystem governance (identified in Section 1.3.4: Essential abilities). This is by no means an objective test. On the contrary, it is necessarily somewhat subjective and reflects, at present, the combined reference (knowledge) systems of the authors.

In effect, this exercise attempts to establish a relationship between a cause (the principle) and an effect (ability to deal with some challenging reality).

It is useful to consider generically how scientists establish cause-and-effect relationships in systems. Assume the "system" is an ecosystem. The scientist wishes to establish whether a particular anthropogenic activity, say large-scale agriculture, – the possible cause – may be responsible for declining fish diversity – the effect. To establish the relationship convincingly, the scientist must demonstrate that a *mechanism* exists relating the cause to the effect. This will typically be based on a hypothesis (based perhaps on experience and a suspicion of a possible mechanism).

For example, the scientist may first establish that the agricultural activity involves the use of a pesticide. If this is confirmed, the scientist establishes that a mechanism for that pesticide to enter the local aquatic ecosystem. Excessive rainfall and therefore runoff may be confirmed. A literature survey confirms that the particular pesticide is extremely toxic to the same fish species now apparently no longer present in the water resource. The scientist then establishes that there is a likely exposure mechanism of the fish to the pesticide (for example, the pesticide is known to accumulate in sediments and the fish is a benthic species). A final experimental investigation establishes that the fish, grown in a cage in the water resource, contain elevated levels of the pesticide. A convincing argument can then be presented that the agricultural activity is likely to have caused the observed decrease in numbers of that particular fish species. A *mechanism* linking the cause to the effect has been established.

It is clearly more difficult to use physical-system investigations to rigorously establish cause-and-effect relationships in organisations of people. However, in order to "test" as rigorously as possible whether the principles are appropriate (i.e. correct) for creating the necessary abilities for ecosystem governance, these "What happens if …?" questions were answered in a systematic and mechanistic format.

The principles and their expected outcomes are captured in Section 2.6: Principles and outcomes.

2.2.3 "Reputable literature" test

Another test of correctness (only) is to provide justifications for each principle, based explicitly on reputable literature, that support its inclusion. That is, directly reference other reputable authors who have said the same, or basically the same, thing. Furthermore, if these justifications are peer-reviewed and agreed to by national and international experts this would add further confidence that the chosen principles are the correct ones. However, the evidence remains empirical.

A comparison with some relevant literature is described in Section 2.7: Reputable literature test.

2.2.4 Organisational audit test

In principle, one could choose a series of organisations, rank them on a scale of degree of success as a learning organisation (using indicators that are entirely independent of the chosen principles) and test (audit) the degree to which those organisations apply the chosen principles.

Figure 2 shows what conclusions may be drawn for three scenarios:

1. All the principles are applied.
2. Some are applied, others are not.
3. None are applied.

This analysis assumes that some quantitative measure of whether an organisation is successful at learning can be developed. For the current analysis, the organisation is simply ranked as unsuccessful or successful.

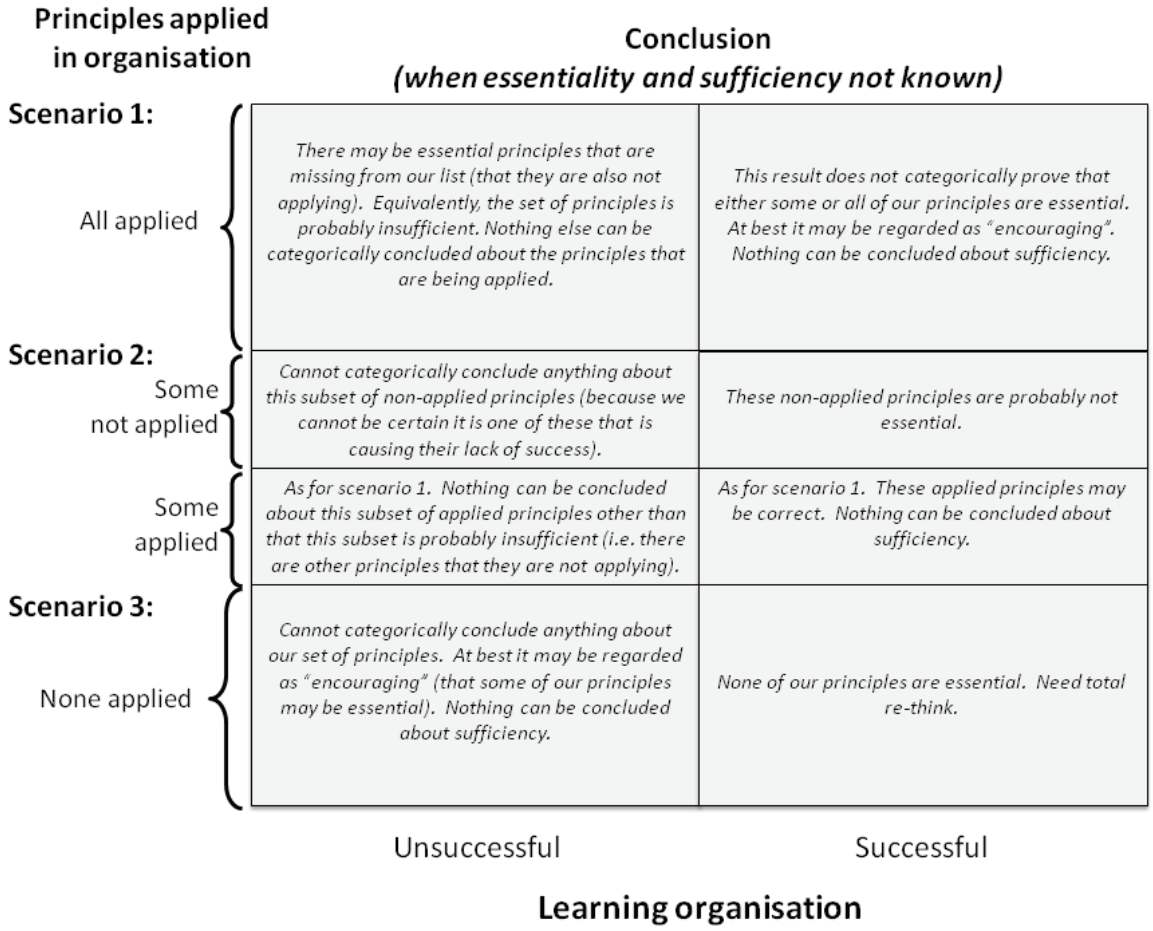


Figure 2 : Testing principles: When essentiality and sufficiency are not known.

Generally speaking, the figure suggests that such an analysis may not provide a useful test of the proposed principles. The analysis is deliberately rigorous, looking for instances in which categorical conclusions can be drawn.

If it were possible to independently establish the essential nature of all or some of the principles, this would result in slightly different conclusions being drawn for the various scenarios. These are captured in **Figure 3**.

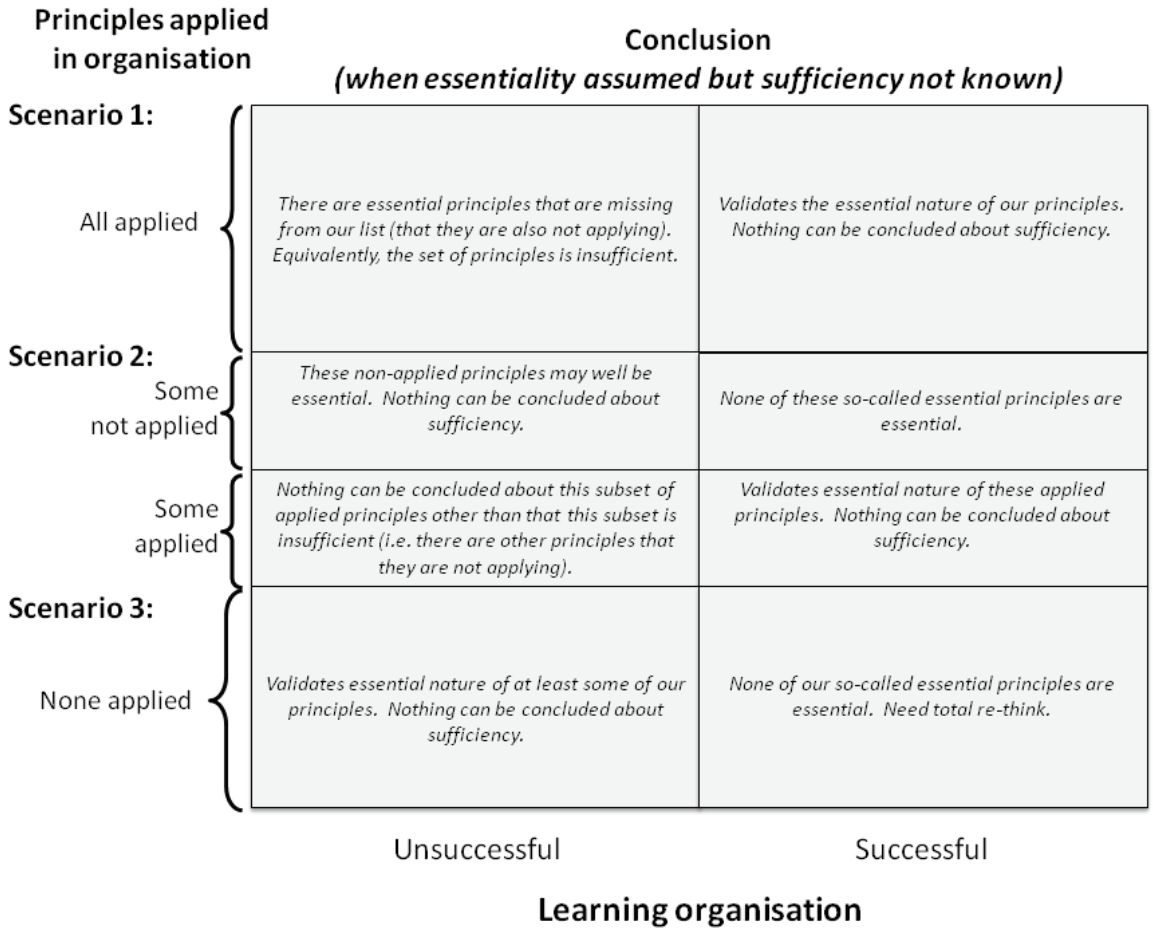


Figure 3 : Testing principles: When essentiality is known but sufficiency is not known.

Again generally speaking, the figure suggests that this analysis will also not necessarily provide a useful test of essentiality and sufficiency of the proposed principles.

Given the complex time-consuming and uncertain nature of carrying out this test properly, it is not recommended that this approach (of rigorous analysis) be adopted to formally establish essentiality or sufficiency. Other approaches, if any, should rather be used.

This analysis is not suggesting that audits of organisations should be not carried out. However, the results should not be analysed in the above manner.

2.3 REFINEMENT OF PRINCIPLES

2.3.1 Introduction

The more in-depth considerations of the principles in this work have resulted in an improved understanding of some of the principles. Accordingly, some definitions have been modified, new principles have been added and some deleted. These, and their motivations, are presented in the following sub-sections.

2.3.2 Prior knowledge engagement

The original definition (Roux et al., 2007) was as follows:

"Prior knowledge engagement" strives to ensure that knowledge creation acknowledges, monitors, is tailored to, interacts with, adapts to, and builds on what learners already know."

The terms "*is tailored to, interacts with,"* were considered superfluous. For example, "*is tailored to*" is equivalent to "*adapts to*". Similarly, "*interacts with*" is equivalent to "*adapts to, and builds on*". A shortened definition was therefore adopted. This appears in Section 2.6: Principles and Outcomes.

2.3.3 Adaptability

The original definition of the adaptability principle (Roux et al., 2006) was not considered to be sufficiently accurate:

"Adaptability" strives to ensure that learning processes adapt to the learners and that the learners themselves learn to adapt to and handle change.

Roux et al. (2007) note that "in order to be adaptable, organisations need employees with ability to adapt and handle change". This is consistent with Britton (2002) who notes that "learning must be happening on two levels: the individual level and the collective level." The collective level learning is addressed through the synergism principle. However, an important aspect of individual learning not addressed by other learning principles is the adaptability of the individual. This is distinct from organisational adaptability which is a necessary ability of the organisation to deal with change, complexity and threats to sustainability.

As noted above, the principles are intended "to enhance the nature and extent of learning". Referring to social-ecological systems (i.e. not individuals), the definitions of Walker et al. (2004) are as follows:

Adaptability is the capacity of actors in the system to influence resilience. Resilience they define as the capacity of a system absorb disturbance and reorganise while undergoing change so as to retain essentially the same core function, structure, identity and feedbacks.

Although our current context is that of the learning individual, it is prudent to remain consistent with this definition. Accordingly, Roux et al.'s definition was modified to that appearing in Section 2.6: Principles and Outcomes.

2.4 NEW PRINCIPLES

2.4.1 Introduction

Careful analysis of the original set of principles has resulted in the identification of a set of additional important principles. These, and their motivation, are presented in the following sub-sections.

2.4.2 Synergism

2.4.2.1 Individual versus organisation

What is so special about a "learning organisation"? In particular, what makes its different from a "learning individual"?

It is instructive to examine briefly which principles would apply to a hypothetical individual operating alone in an ecosystem governance context (requiring that the person be a "learning individual"). Although operating alone (e.g. making decisions alone), it is assumed that the individual does have contact with other people from whom he / she can learn. However, he / she is not part of a larger organisation. **Table 1** summarises the degree to which each principle is relevant to an individual.

Table 1 : Learning principles applying to "learning individuals".

Principle	Relevance to an individual
Common future focus	"Common" is not applicable although having a future focus may be essential for focused learning especially given the degree of "information overload" individuals are subjected to.
Prior knowledge engagement	Probably important
Transdisciplinarity	Important
Learning by doing	Important
Social knowledge sharing	Important
Patience	Important
Positive persistence	Important
Empathy	Important
Adaptability	Important
Synergism	This refers specifically to teams, not individuals
Experimentation	Important

The prior knowledge engagement principle is not likely to be particularly insightful and useful because an individual is likely to naturally base his / her learning on what they already know. However, the more ambitious (and perhaps reckless) may attempt to branch out into unfamiliar areas well outside their comfort zones. Since, by definition, they have little or no prior knowledge, learning is likely to be slower (than it would have been had they had prior knowledge). In this case, the learning rate will be determined by their inherent *ability* (not knowledge) to process new information logically. On balance therefore, it is probably safer to include this as an important principle.

Table 1 suggests that all the principles apply to individuals as well as organisations, except that having a "common" future focus is not relevant to an individual. One is therefore tempted to hypothesise that a learning organisation may simply be the sum of its parts (i.e. the combined capabilities of the individuals comprising it). This is equivalent to saying, fill an organisation with "learning individuals", give them a common future focus, and you will automatically have a "learning organisation".

Given the level of complexity typical of ecosystem governance and managing social-ecological systems, it is reasonable to assume that an organisation with this mandate should be able to function at a level above that defined by the "sum of its parts". To achieve this, some degree of "team work" is required.

This provides at least one answer to the question posed above, namely, what makes a "learning organisation" different from a "learning individual"? It is team work. This is a property that can raise the abilities of an organisation well beyond the sum of the abilities of its individuals.

The following sub-section explores what this might mean.

2.4.2.2 Levels of team work

It is useful to explore the concept of "team work" in some depth to better understand what this means. To begin with, we define "sum of its parts" to mean the combined achievements of a number of individuals.

Additive team work ("the whole equals the sum of its parts")

If the task is simple, say, peeling potatoes one-by-one by hand, then two individuals would peel about twice as many potatoes than a single individual in a given period of time. In this case, the "whole" equals "the sum of its parts". To some extent this might be regarded as "team work". However, it might better be called "additive team work" since the "whole" is simply the one individual's achievement added to that of the other. This is not a particularly inspiring level of team work though it is useful in some contexts.

Another analogy (although with a task that is more difficult) is a lioness pride scattering a herd of buffalo and each lioness pursuing a separate buffalo. The shared goal may well be "kill a buffalo for food" but, because the task is difficult, an uncoordinated strategy (simple additive team work) is unlikely to be successful.

Basic synergistic team work ("the whole is greater than the sum of its parts")

The next level of team work is "basic synergistic team work". This involves a series of individuals achieving something together that the same individuals acting separately cannot achieve. Synergism is often used in the context of medicinal drugs. A synergistic effect occurs when two drugs administered together have an effect that is greater than the sum of the two effects expected when administered separately.

Referring to the above potato analogy, this means two individuals working together (in some innovative way) to peel, say, three times more potatoes than a single individual. Similarly, the lionesses work together by a few consciously chasing the buffalo in the direction of other lionesses that have deliberately concealed themselves ahead. Achieving the "shared goal" is now much more likely. In both cases, synergism is present.

The strategy is obvious, well-practiced, and indeed, even routine. Everyone knows his / her role and executes it diligently. The result is (fairly) predictable. There is nothing particularly special about it (except perhaps the synergism itself).

Super synergistic team work ("the whole is very much greater than the sum of its parts")

There is yet another level to team work or synergism. Consider putting eleven randomly chosen skilled soccer players into a side. Because they are skilled, they are likely to have a basic repertoire of commonly-used strategies that enable the team to exhibit basic synergistic team work. However, the more they play and practice together, the more they develop implicit and tacit knowledge of the subtleties of each other's abilities. This creates the potential for purely inspirational play as the team is able to raise the capabilities of, say, one team member way beyond anything that could reasonably be expected under other circumstances. Each such play is, by definition, not routine and certainly not predictable.

2.4.2.3 Definition

As noted above, it is reasonable to assume that organisations with the mandate for ecosystem governance require a certain level of "team work". More specifically it is proposed that the minimum required is "basic synergistic team work". Although super synergistic team work may be a "nice to have", it is not regarded here as being essential for such organisations.

Furthermore, because the phrase "team work" can mean different things to different people (as indicated above), it is proposed that the word "synergism" rather than the phrase "team work" be adopted as a new formal principle of a learning organisation.

Although a principle like social knowledge sharing may enable synergism, it is not sufficient to ensure that synergism actually occurs. Therefore, synergism should be regarded as a separate principle in its own right.

The definition appearing in Section 2.6: Principles and outcomes is therefore proposed (based on the concept of "basic synergistic team work").

2.4.3 Experimentation

Experimentation has been proposed as an important attribute of learning organisations (Garvin (1993); Goh and Richards (1997)). Experimentation, in this context, is taken to mean a tentative or provisional approach or investigation that is not guaranteed to succeed or produce immediate good results (i.e. there is a possibility of failure). At least two of the current set of principles, namely learning by doing and adaptability, can be related to the concept of experimentation.

- **Learning by doing**. This is about doing things oneself for the primary purpose of gaining greater depth of understanding. Garvin (1993) noted that "all forms of experimentation seek the same end: moving from superficial knowledge to deep understanding." To this end, an experimental mind-set can be a useful attribute, but it is not necessarily essential. For example, it may be useful because it allows one to learn by doing in a more relaxed way because one feels less threatened by failure. On the other hand, Garvin (1993) has noted that experimentation is achieved by learning by doing. In other words, learning by doing is an integral part of experimentation.
- **Adaptability**. An experimental mind-set is useful in two contexts relating to adaptability:
  In the same sense as for learning by doing, acknowledging up-front that there is a possibility of failure creates a less threatening environment. This in turn is more likely to facilitate planning for failure (having a plan B) and learning from the failure.
  Experimentation, in the specific sense of being exploratory (i.e. trying completely new ideas), is a longer-term learning strategy for coping with unexpected circumstances.

Experimenting in these senses therefore facilitates learning by doing and adaptability.

The exploratory aspect of experimentation is also important as a balancing principle to prior knowledge engagement. The latter focuses on learning based primarily on what learners already know. In one sense, this can be interpreted as imposing a degree of restriction on what should be learned and how it should be learned. Such "self-referential" learning can limit the degree to which an organisation can become a learning organisation by creating paradigms that filter data, information and knowledge in ways that may not be optimal.

However, as noted above, an important survival attribute is to allow exploratory learning in order to cope with unexpected circumstances. In practice, a learning strategy must allow for an appropriate balance between learning based on prior knowledge and learning completely new things. No principle in the current set allows for this.

Accordingly, "experimentation" is proposed a new principle in its own right. It should be considered to (a) enable learning by doing and adaptability and (b) balance the possibly restrictive (though important) focus of prior knowledge engagement.

The principle defined in Section 2.6: Principles and outcomes is proposed.

2.5 CONSIDERED PRINCIPLES

2.5.1 Leadership

A variety of authors stress the importance of leadership in learning organisations and those with a mandate for social-ecological governance. The original set of principles proposed by Roux et al., (2007) did not address this. The question arises whether "leadership" should be a learning principle in its own right.

The following paragraphs quote what various authors have said.

2.5.1.1 The literature

Folke et al. *(2005)*

They emphasise the importance of leadership in their review of "adaptive governance of social-ecological systems":

"*Leadership is essential in shaping change and reorganization by providing innovation in order to achieve the flexibility needed to deal with ecosystem dynamics. Leaders can provide key functions for adaptive governance, such as building trust, making sense, managing conflict, linking actors, initiating partnerships among actor groups, compiling and generating knowledge, and mobilizing broad support for change. Key individuals also develop and communicate visions of ecosystem management that frame self-organizing processes. These individuals often have the ability to manage existing knowledge within social networks for ecosystem management and further develop those networks. Lack of leaders can lead to inertia in social-ecological systems. Visionary leaders fabricate new and vital meanings, overcome contradictions, create new synthesis, and forge new alliances between knowledge and action*."

Goh and Richards (1997)

They regard the combination of "leadership, commitment and empowerment" as one of five important learning dimensions of a learning organisation:

"*Leaders need to be committed to the accomplishment of organizational goals and to the goal of learning. Moreover, leaders need to create a climate of egalitarianism and trust where people are approachable and failures are a part of the learning process. Specifically, leaders need to help*

identify performance gaps and then help set goals that encourage the search for knowledge to narrow and solve these performance gaps. Leadership is mentioned by virtually all writers as an important element in fostering a learning climate through their behaviours, such as seeking feedback, being open to criticisms, admitting mistakes and empowering their employees to make decisions and take some risks."

Gunderson et al. *(2006)*

They emphasise that trust and leadership appear to be key elements for adaptability and transformability:

"*One of the key functions of leadership is to foster and maintain trust in the social network. It is the oil that keeps the network lubricated. Another key function of leadership is to integrate social and ecological understanding.*"

Olsson et al. *(2006)*

They identify leadership as a critical factor for social-ecological system transformability:

"*Key functions include trust-building, sense-making, managing conflict, linking key individuals and initiating partnerships among actor groups, compiling and generating knowledge, developing and communicating vision, mobilizing broad support for change, and gaining and maintaining the momentum needed to navigate the transitions and institutionalise new approaches.*"

"*Leadership functions include the ability to span scales of governance, orchestrate networks, integrate and communicate understanding, and reconcile different problem domains.*"

Kotter (1995) (cited in Olsson et al. (2006)) defines transformational leadership as " *... a process to establish direction, align people, motivate and inspire—with the ultimate goal of producing movement or change.*"

"*Transformational leadership therefore includes recognizing opportunities and identifying and transforming constraints and barriers such as conflicts of interest, values, and opinions. This is critical for reducing the resilience of undesired trajectories and building up the momentum needed to move into new trajectories.*"

Senge (2006)

Senge's understanding of the leadership necessary for a learning organisation covers a number of fundamental aspects.

One of his five disciplines, namely "building shared vision", is closely related to one important aspect of leadership. It is the capacity to hold a shared picture of the future we seek to create. However, to do so, leaders must be designers, teachers and stewards.

He quotes Lao Tzu from some 2 500 years ago:

The wicked leader is he whom the people revile.
The good leader is he whom the people revere.
The great leader is he of whom the people say, "We did it ourselves".

"*A great leader is also someone around whom others learn. They create space for learning and invite people into that space. They must help people see reality as a medium for creating their visions rather than as a limitation. To be a true teacher, you must be a learner first. The teacher's own passion for learning inspires their students as much as their expertise does. Leaders should serve those they lead. Leaders are stewards, in the sense of having commitment and bringing about change. Such commitment always co-exists with some element of questioning and*

uncertainty. This is different from being fanatical, where the leader acts with the certainty that they have the answer. Stewardship is about doing what is right for the whole."
Senge et al. *(1999)*

"*If leadership is simply a position in the hierarchy, then, in effect, there is no independent definition of leadership. [Rather] we will view leadership as the capacity of a human community to shape its future, and specifically to sustain the significant processes of change required to do so. We believe specifically, that leadership grows from the capacity to hold creative tension, the energy generated when people articulate a vision and tell the truth about current reality.*"

They recognise three different types of leaders and place much value on this diversity in leadership:

- **Local line leaders**. People with accountability for results and sufficient authority to undertake changes in the way that work is organised and conducted at their local level. Local line leaders are vital because only they and their colleagues, not executives, can undertake meaningful organisational experiments to test the practical impact of new ideas and approaches.

- **Network leaders or community builders**: These people promote the organic diffusion of innovative practices in and across organisations. Their strength is their ability to move about the larger organisation, to participate in and nurture broad networks of alliances with other like-minded individuals. The role of network leaders is tangible, but difficult to specify; because it belongs much more to the informal social networks of the company than it does to the hierarchy. In some ways, paradoxically, their lack of hierarchical authority makes them effective.

- **Executive leaders**: Effective executive leadership is probably more challenging today than ever before, especially because of the combination of the demands of profound change and extraordinary external pressures. They are vital to profound change through their efforts to create an organisational environment for continual innovation and knowledge generation. They focus on design more than making key decisions.

Argyris C. and D.A. Schön (1996)

Argyris and Schön lean on material by Edgar Schein (Organizational Culture and Leadership, 1985, later edition 1992; Jossey-Bass Publishers. San Francisco.) on the issue of leadership.

Schein defines leadership as "*the attitude and motivation to examine and manage culture*." Organisational culture is considered to be a pattern of basic assumptions shared by the group. In organisational learning, basic assumptions shift in the heads of the group members. In a world of turbulent change, organisations have to learn ever faster, which calls for a learning culture that functions as "*a perpetual learning system*". The primary task of a leader in contemporary organisations is to create and sustain such a culture, which then, especially in mature organisations, feeds back to shape the leader's own assumptions.

Cleveland (2004)

"*In the last century, we learned again and again that complex social systems work badly if they are too centralised. The complexities of modern life, and the interconnectedness of everything to everything else, mean that in our communities, our nations, and our world, nobody can possibly know enough to be in general charge of anything important or interesting. It may be one reason why, more and more, the 'followers' – especially university students and educated adults – seem so often to come forth with policy judgements while their established 'leaders' are still making up their minds.*" (p. 22). When nobody can be in general charge, and some self-selected subset of everybody is partly in charge, the notion of educating for leadership morphs into educating for

citizenship. Leadership in this sense means continuous dialogue – not acts but interactions between those who lead and those who follow.

The sheer complexity of what has to get done means that huge numbers of people exercise independent judgement and consult with each other and outsiders; they do not just do what they are told.

Executive leaders of the future will be more reflective practitioners (both by training and by temperament) than the executives of the past. They will be low-key people, who will show a talent for consensus and a tolerance for ambiguity. They will have a penchant for unwarranted optimism. And they will find private joy in complexity and change.

"*The work of executives often consists of meeting a series of unforeseeable obstacles on the road to an objective that can be clearly specified only when it has nearly been met. They try to imagine the unforeseen by posing contingencies and asking themselves how their organisation systems would adjust if these chances arose. Of course, the planned for contingency never happens; something else happens instead. The planning therefore does not use a usable plan but something more precious: people better trained to [conceptualise] analyse [and anticipate] the unpredicted and to filter out for the decision-makers the choices that would be too costly to fudge or postpone.*" (p. 26).

2.5.1.2 Definitions

Few of the above references actually define leadership although all list and describe many attributes of a good leader. If we want a definition for our context then we need to ensure that the learning-related attributes are dominant.

Accordingly, the following definition is proposed:

"Leadership" inspires and creates space for learning, and provides committed stewardship of the organisation based on such learning to bring about organisational change when necessary.

If we were to define an associated principle for a learning organisation, it may be worded as follows:

"Leadership" strives to ensure that many individuals are in place whose diverse styles create space for and inspire learning, and whose committed stewardship of the organisation uses such learning to bring about organisational change when necessary.

The following indicators would then indicate the degree to which an organisation is practising this principle:

Indicators:

- There are many individuals in the organisation whose styles create opportunities for learning from the broadest possible network.
- There are many individuals in the organisation whose styles inspire learning.
- There are many individuals in the organisation who use what they have learned to bring about organisation change when necessary.

It must now be asked whether introduction of "leadership" as a new principle is totally justified. Insight into a possible answer to this question lies in the answers to the following question: What is achieved when this principle is properly applied?

The leadership definition above is deliberately broad (e.g. "creates space for"). In the current context this in effect is defined as (a) ensuring that opportunities are provided for social knowledge

sharing, prior knowledge engagement, experimentation, (b) developing transdisciplinarity and (c) practising patience, empathy and positive persistence. The "committed stewardship" concept also implies a rallying of individuals to a common future focus. In essence therefore, a good leader is simply one who enables all of the current principles. Is a new stand-alone principle justified?

It is proposed that a "Leadership" principle is not justified. It is not being suggested that leadership is not important. It definitely is, not only for the reasons stated by the above-mentioned authors but because it can enable so many learning principles. It is a desirable attribute of any learning organisation. In this sense, "cultivation" and "nurturing" of committed leaders is better regarded as a *strategy* for facilitating implementation of the principles. Another way of saying this is that one way of ensuring the learning principles are practiced is to ensure an appropriate "enabling leader" is in place.

2.6 PRINCIPLES AND OUTCOMES

2.6.1 Introduction

In order to ensure that appropriate indicators are developed, it is important to understand clearly what is actually achieved when an individual principle is applied. This can be referred to as the anticipated outcome of the principle. This understanding is also augmented by understanding what is likely to happen when the principle is not applied. This section describes these two scenarios for each principle.

A formal systems thinking format is used to (a) illustrate the connections (the arrows) between issues (the boxes) and (b) describe succinctly why the one issue affects the other.

The figures link each principle to those issues directly affected. These can be:

- **Other principles**;
- **Intermediate issues** (like "learning efficiency", "knowledge depth", "self-confidence" and so on); or
- **Essential abilities**. These are identified in Section 1.3.4: Essential abilities as characterising the learning organisation with a mandate for ecosystem governance.

2.6.2 Intermediate issues

Before addressing the principles and their outcomes, it is necessary to examine the outcomes of various intermediate issues. A number of these are described here. They are regarded as "intermediate" issues because they are affected directly by the principles but they can also affect other principles or organisational abilities.

- ***Learning efficiency*** **improves the ability to deal with** ***information overload***. *Mechanism*: Learning more efficiently means that more information can be processed more quickly, mitigating against information overload.

- ***Learning effectiveness*** **improves** ***knowledge depth***. *Mechanism*: Learning effectiveness relates directly to applying the most appropriate learning practices. By definition therefore, knowledge depth is improved.

- ***Knowledge depth*** **improves ability to deal with** ***significant decision making***. *Mechanism*: A deep factual and contextual understanding enhances sound decision making because subtle nuances can be taken into account.

- ***Knowledge depth*** **improves ability to deal with** ***complexity***. *Mechanism*: A deep factual and contextual understanding enhances the ability to deal with complexity because (a) the symptoms characterising the system as a complex system can be recognised and (b) specific scenarios can be more easily identified as having such characteristics (e.g. unpredictability, small disturbances causing large effects, etc.) making those scenarios the focus of management attention.

- ***Knowledge breadth*** **improves the ability to deal with** ***complexity***. *Mechanism*: Systems can be complex partly because of their complicated nature (i.e. because there are many interconnecting elements). Knowledge breadth improves the chances that the cause and effect relationships that exist between such elements can be (a) recognised and (b) better understood.

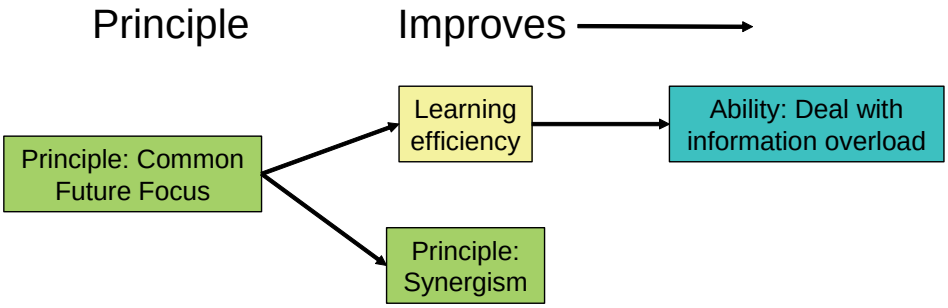
- ***Knowledge continuity*** **improves the ability to deal with** ***change***. *Mechanism*: Knowledge continuity within the organisation ensures that critical knowledge is maintained over time. It is therefore more easily learnt by new individuals (i.e. it does not have to be re-learnt from scratch). This is particularly relevant when change is inevitably imposed on the organisation when a key individual is suddenly no longer available.

- ***Self-confidence*** **facilitates the application of the principle** ***positive persistence***. *Mechanism*: A person who believes they have the ability to tackle a problem, even when the challenge may be unprecedented and the solution, or even approach, is unclear, is inherently positive and likely to be persistent because their belief in themselves encourages them to continue no matter what.

- ***Interpersonal relationships*** **facilitate the application of the principle** ***synergism***. *Mechanism*: Being able to get on well personally with other team members inherently facilitates the application of strategies that aim to improve the way the work and solve problems together. Working together is not impeded and distracted by what may be petty differences.

2.6.3 Common future focus

Principle: "Common future focus" strives to ensure that all stakeholders have agreed to a well-defined vision of the future and that this actively determines what is learned.



What is achieved when this principle is properly applied?

- **Individual learning efficiency is improved**. *Mechanism*: Because there is a common future focus (a "shared vision"), what the individual learns is more likely to be relevant to the common mission. This is because the objective of the learning is well-defined so information that is obviously irrelevant can be ignored.

- **Synergism is improved**. *Mechanism*: The degree of shared understanding is improved so individual efforts are more likely to be (a) aligned with each other (have the same focus) and (b) complementary (more complete). Combined efforts are therefore likely to be more effective, creating a more complete "whole" by not duplicating. Although a common future focus cannot guarantee synergism, it is an essential pre-requisite.

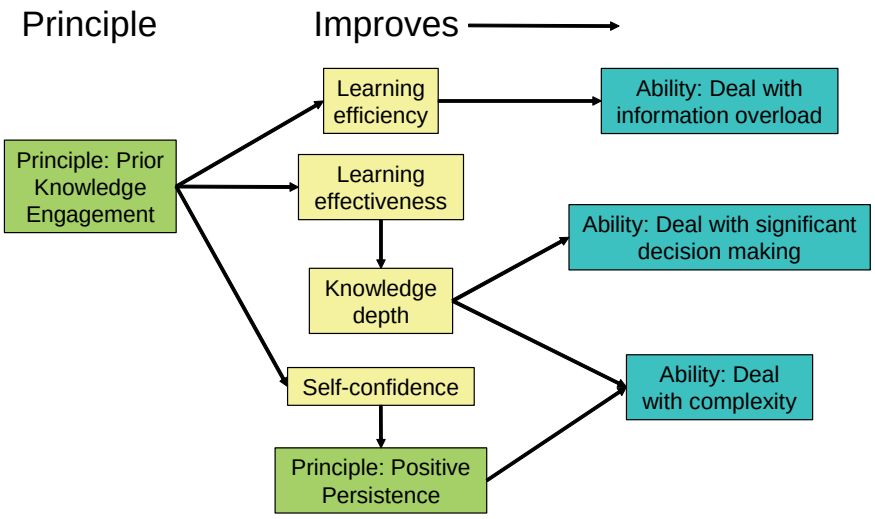
What happens when it is not applied?

- Individual learning efficiency may be compromised because much of what is learned by the individual may not be relevant to the common mission. This is because there may be a tendency to learn what they want to learn rather than what they should learn. Much valuable learning effort may be wasted, although some degree of exploratory learning could be useful in future. The efficiency of individuals is therefore likely to be compromised.

- Group efforts may be fragmentary, and synergism (team work) compromised, because what individuals are learning may be neither particularly well-aligned nor complementary. Even if group dynamics are good, the knowledge of individuals is unable to "come together" into a whole that is greater than any particular part. The group is therefore not necessarily effective in achieving its mandate.

2.6.4 Prior knowledge engagement

Principle: "Prior knowledge engagement" strives to ensure that knowledge creation acknowledges, monitors, adapts to, and builds on what learners already know.



What is achieved when this principle is properly applied?

- **Individual learning efficiency is improved**. *Mechanism*: Learning is taking place in a way that closely relates to what learners already know. Therefore they are able to grasp new concepts more quickly because they already have some depth.

- **Individual learning effectiveness is improved**. *Mechanisms*:

  Because they already have a relevant reference (knowledge) system, learners can process new concepts in depth. That is, they are better able to place those concepts in context (albeit their own), intimately relating them to concepts they already familiar with. One mechanism by which this occurs is negotiation of meaning with the teacher.

Besides building on "correct" existing knowledge, "incorrect" (incomplete, false, naïve) existing knowledge is also exposed and can be corrected.

- **Self-confidence is improved**. *Mechanism*: Learners naturally develop a "can do" attitude because what they are learning is so closely related to what they already know.

What happens when it is not applied?

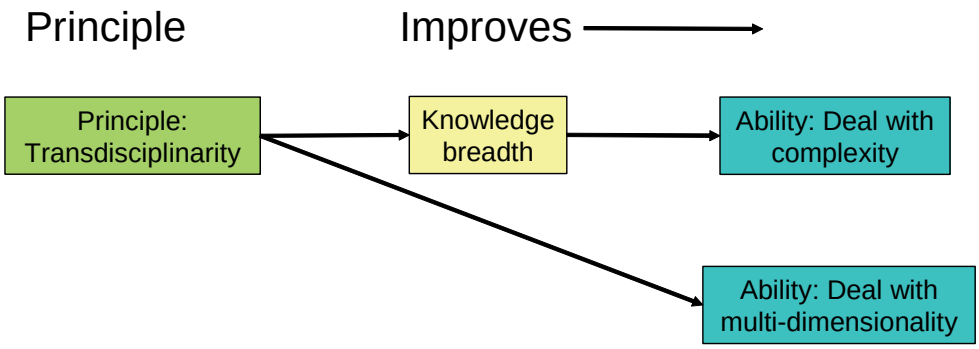
- Learning may be occurring outside "comfort zones". Without any prior "mental model", learners necessarily learn more slowly. Learning efficiency is therefore compromised.

- What is learned may also be fragmentary because the learner may be unable to relate some concepts. The resulting knowledge is therefore less robust.

- A worse scenario is incorrect prior knowledge resulting in learners wrongly interpreting new concepts. Without this prior knowledge being engaged, the learner (and teacher) may be oblivious of the fact that their interpretation is flawed.

2.6.5 Transdisciplinarity

Principle: "Transdisciplinarity" strives to ensure that the knowledge that is created (in individuals and in organisations) is appropriate and adequate at each level in a hierarchy of disciplines (e.g. ***from technical through political to ethical) and, where necessary, adequately detailed (***i.e. ***based on deep understanding).***



What is achieved when this principle is properly applied?

- **Knowledge breadth is improved**. *Mechanism*: The existence of knowledge in a wide variety of disciplines is, by its very nature, knowledge breadth. Strictly, this is not a mechanism. Transdisciplinarity is breadth.

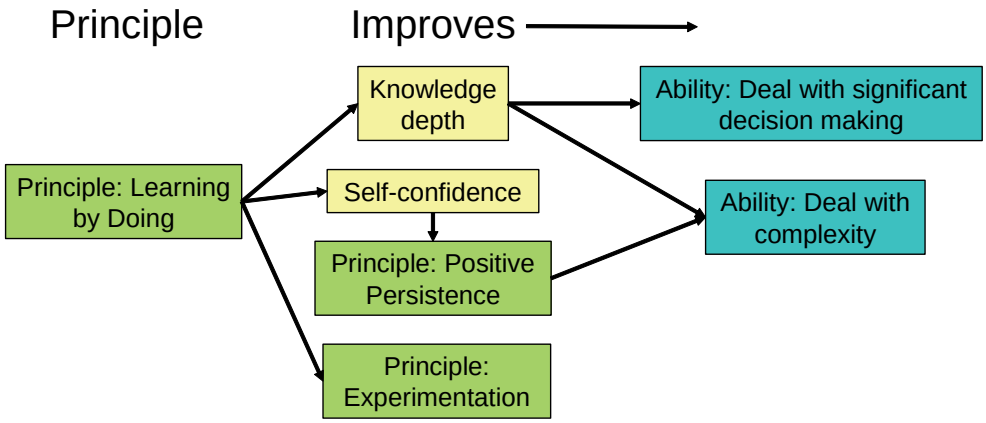
- **Ability for complex problem solving is improved**. *Mechanism*: Knowledge breadth, and in particular integration of disciplines, in an organisation is more likely to facilitate solving holistically the complex problems that characterise social-ecological systems. The solutions are also more likely to be communicable and accessible to the wide variety of stakeholders (people and organisations) comprising the social-ecological system.

What happens when it is not applied?

- Solutions to the complex problems of social-ecological systems are likely to be dominated by a few core disciplines and therefore not be sufficiently holistic. Important issues may not be evident to, or compatible with, the few core disciplines. Being limited in scope, the solutions may also be inaccessible to some of the important stakeholders in the social-ecological system.

2.6.6 Learning by doing

Principle: "Learning by doing" strives to ensure that knowledge is also created through hands-on practical experience.



What is achieved when this principle is properly applied?

- **Knowledge depth is improved**. *Mechanisms*:
  In the office environment, when learners are provided with the (un-pressured) opportunity to do things themselves (like write a report, the executive summary or give a presentation), albeit imperfectly, they achieve a greater depth of understanding of the subject matter if for no other reason than they have processed the subject matter for a significant length of time.
  In-the-field experience provides individuals with first-hand, and therefore deeper, knowledge of the complex functioning of ecosystems.
  Face-to-face social encounters with stakeholders provide individuals with first hand and therefore deeper knowledge of the complex functioning of social-ecological systems.
  If allowed to happen with patience and a mind-set of experimentation, this greater depth of understanding is more likely to result in tacit knowledge and a richer, context-sensitive basis for identifying and framing problems and associated solutions (Fazey et al., 2006).

- **Self-confidence is improved**. *Mechanism*: Learners produce results “with their own bare hands”, giving them a sense of achievement.

- **Experimentation is improved**. *Mechanism*: Many experimental approaches, by their very nature, require doing things oneself. Therefore any encouragement of learning by doing necessarily also encourages experimentation.

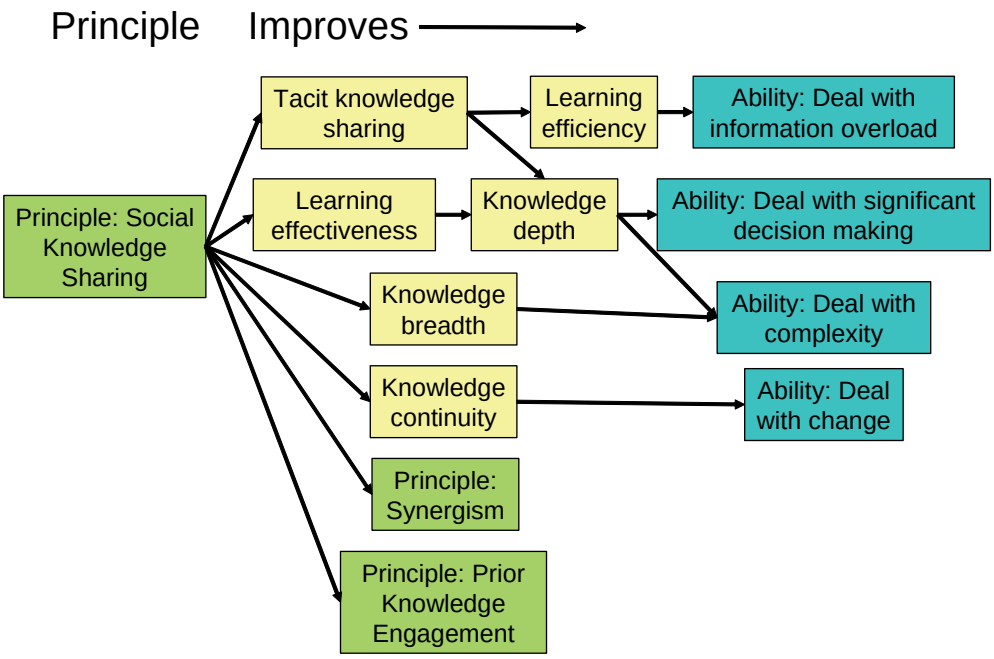
What happens when it is not applied?

- Knowledge depth may be compromised because knowledge is likely to remain theoretical, potentially somewhat removed from reality and second-hand (since learners have to rely only on what they learn directly from others).

- Learning effectiveness may be compromised because those learners whose natural approach is one of learning by doing are discriminated against.

2.6.7 Social knowledge sharing

Principle: "Social knowledge sharing" strives to facilitate freely interactive sharing, inquiry, debate and negotiation of new information between learners and those with the knowledge that should be shared.



What is achieved when this principle is properly applied?

- **Tacit knowledge can be shared**. *Mechanism*: Personal communication often conveys nuanced and sometimes subtle information (e.g. in tones of voice, facial expressions and body language), and hence insights, that cannot easily, if at all, be conveyed by other mechanisms.

- **Learning efficiency is improved**. *Mechanism*: The transfer of subtle tacit knowledge can quickly place other explicit forms of knowledge (e.g. that appearing in reports) in context making it immediately more understandable.

- **Knowledge depth is improved**. *Mechanism*: The transfer of tacit knowledge places other explicit forms of knowledge in context. Contextualisation is critical for knowledge depth. Debating of points of view also encourages individuals to defend their knowledge and think about it critically, and adapt it if necessary (leading to greater robustness). This also encourages a deep examination of context. Uncertainties and misunderstandings can also be addressed immediately.

- **Knowledge breadth is improved**. *Mechanism*: Completely new concepts are more easily conveyed (by the experienced) and absorbed (by the learner) in an informal face-to-face context because lack of alignment between the two sides can quickly be identified and addressed. This relates closely to engaging the prior knowledge of the learners.

- **Learning effectiveness is improved** (i.e. learners improve their cognitive development). *Mechanism*: First, by being exposed to different people, ideas and means of communication, learners may be exposed to different ways of learning, or be required to adopt new ways to absorb the new ideas. The learner may experiment with these in an attempt to find ways in which they can learn better. Secondly, by learning in the ways they are familiar with, those ways are refined and improved simply through practice.

- **Synergism improves**. *Mechanism*: Social knowledge sharing with empathy and prior knowledge engagement improves interpersonal relationships. This and improved understanding of each individual's capabilities improve the chances of good synergism between individuals, and hence improves the likelihood of true team work.

- **Social knowledge sharing provides one mechanism for prior knowledge engagement**. *Mechanism*: Learners can convey their prior knowledge (factual, culture, background, etc.) directly to more knowledgeable individuals. The latter are then able to understand, and hence accommodate, those backgrounds in subsequent communication.

- **Social knowledge sharing provides one mechanism for knowledge continuity**. *Mechanism*: Knowledge is communicated directly from knowledgeable individuals to learners, who can then use that knowledge when the more knowledgeable individuals are not available.

What happens when it is not applied?

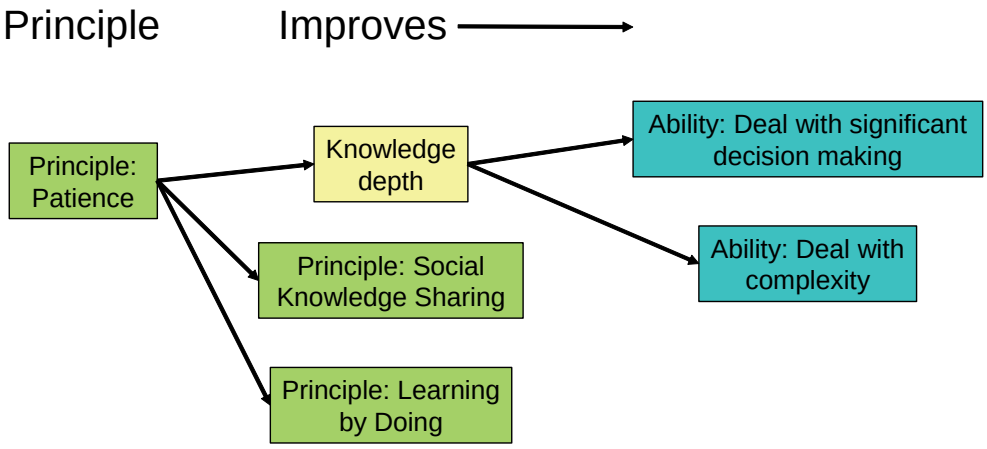
- Knowledge may lack robustness and remain shallow and individualistic because tacit knowledge is not being transferred.

- Individual knowledge is only gained by an individual at a rate determined by the abilities of that individual.

- The ability to operate in effective teams may be compromised.

2.6.8 Patience

Principle: "Patience" strives to ensure that adequate time is allowed for absorbing appropriate knowledge and that the expectations during the learning process, of all concerned, are realistic.



What is achieved when this principle is properly applied?

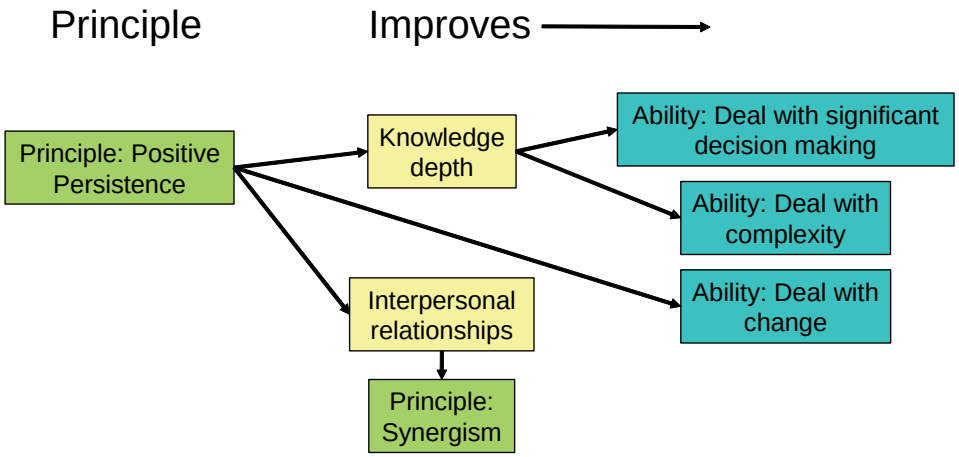
- **Knowledge depth is improved**. *Mechanism*: Processing new information and contextualisation of new concepts to achieve a deeper understanding necessarily takes time. This may involve social knowledge sharing, learning by doing, reflection, and other relatively time-consuming processes. Having patience allows for this time.

What happens when it is not applied?

- Knowledge depth will be compromised because many of the processes important to its achievement will be compromised, namely, social knowledge sharing, learning by doing, and reflection.

2.6.9 Positive persistence

Principle: "Positive persistence" strives to ensure that learners have determined yet positive and enthusiastic attitudes to acquiring new knowledge.



What is achieved when this principle is properly applied?

- **Knowledge depth is improved**. *Mechanism*: Closely related to the reason why patience improves knowledge depth. Grappling with new information and concepts with determination to understand them usually leads to a deeper understanding than that possible with only a cursory examination.
- **Complex subject matter is mastered**. *Mechanism*: Similar to the mechanism for improving knowledge depth.
- **Complex challenges faced with confidence**. *Mechanism*: Optimistic, self-confident and determined learners are not daunted by challenges. Their perseverance simply makes it more likely that they will find appropriate solutions.
- **Interpersonal relationships are improved**. *Mechanism*: The positive nature and energy of individuals will be more conducive to good interpersonal relationships simply because they are inherently constructive and likely to be less threatening.

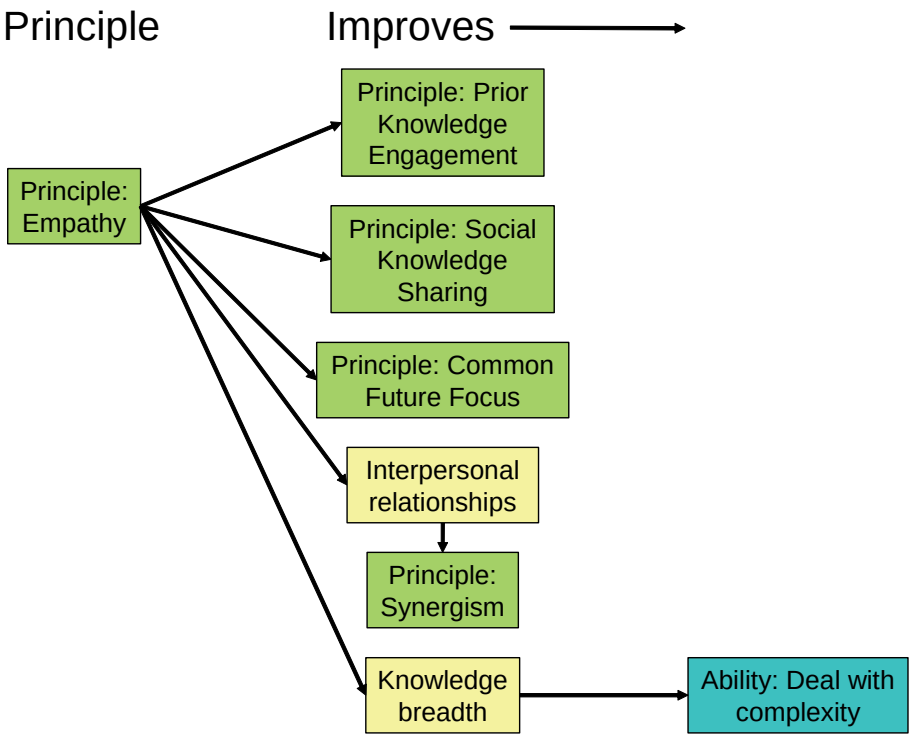
What happens when it is not applied?

- Knowledge depth and breadth may be compromised because learners may restrict their learning to easy subject matter.

- Because knowledge depth and breadth is compromised, the ability to solve complex problems will be compromised.

2.6.10 Empathy

Principle: "Empathy" strives to stimulate co-creation of new knowledge by nurturing a culture in learners to interact and share with other knowledge systems (cultural, political, scientific, etc.) and knowledge levels (novice, expert) with understanding and an ethic of mutual respect for knowledge (in all its forms), wisdom, culture, language, abilities, concerns and inputs of all stakeholders.



What is achieved when this principle is properly applied?

- **Prior knowledge engagement is enhanced**. *Mechanism*: By showing respect for another's whole knowledge system, the nature and extent of their knowledge is better understood and contextualised. Subsequent interactions are therefore more easily tailored to the knowledge of those individuals.

- **Social knowledge sharing is improved**. *Mechanism*: By showing respect for another's whole knowledge system, everyone is better able to interact more freely in a social environment in which knowledge is being shared.

- **Interpersonal relationships are improved**. *Mechanism*: First, initial respect is likely to lead to mutual respect. Secondly, deeper insight is gained into each individual's behaviour and motivation through the sharing of perspectives and letting people discover their interdependencies (Fazey et al., 2006).

- **Degree of common future focus is enhanced**. *Mechanism*: A more insightful understanding of each individual's knowledge system, values and preferences, can lead to a deeper alignment of efforts towards the shared goal.

- **Knowledge breadth is improved**. *Mechanism*: By showing respect for another's whole knowledge system, particularly when individuals have diverse backgrounds and experiences, new knowledge is likely to be gained simply by exposure to it.

What happens when it is not applied?

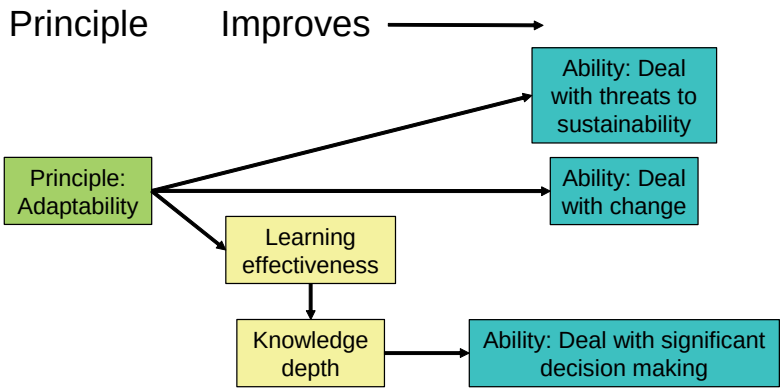
- Interpersonal relationships will not necessarily achieve their full potential because there is a lack of basic respect for individual knowledge systems.

- Knowledge breadth is compromised, tending to be individualistic, because exposure to other knowledge systems is compromised.

- Group learning and synergism (team work) may not reach full potential because a detailed knowledge of each other's knowledge systems means that interactions remain somewhat generic and not acutely tuned to each individual.

2.6.11 Adaptability

Principle: "Adaptability" strives to ensure that individuals learn to manage their own resilience, that is, their capacity to react constructively to disturbance and to change when necessary.



What is achieved when this principle is properly applied?

- **Ability of the organisation to deal with unexpected threats to sustainability improves**. *Mechanism*: Because the individual is better equipped to deal with disturbance, the organisation as a whole is more likely to be able to deal with those threats. Individuals are less threatened and can therefore concentrate their efforts on addressing the real nature of the threat constructively.

- **Ability to deal with change is improved**. *Mechanism*: The individual is at least aware of that change is inevitable. Even in less threatening instances where change is gradual and predictable, the adaptable individual can take such change in his / her stride, "going with the flow" and is not demoralised.

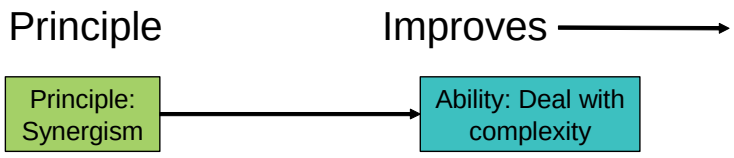
- **Learning effectiveness is improved**. *Mechanism*: Reacting constructively to change may mean (a) modifying learning practices and (b) what is learned in ways aligned with the disturbance. This, by its very nature, improves learning effectiveness.

What happens when it is not applied?

- The sustainability of organisation is at greater risk because the organisation may be "caught off guard" by new and unexpected challenges. The ability to achieve its mandate is compromised because the organisation has either (a) been forced into a situation in which this is difficult or (b) has to focus excessive efforts on addressing the challenges thus distracting it from its core focus.

2.6.12 Synergism

Principle: "Synergism" strives to ensure that teams are able to apply routine strategies that result in achievements greater than that attainable by the individuals operating separately ("the whole is greater than the sum of its parts").



What is achieved when this principle is properly applied?

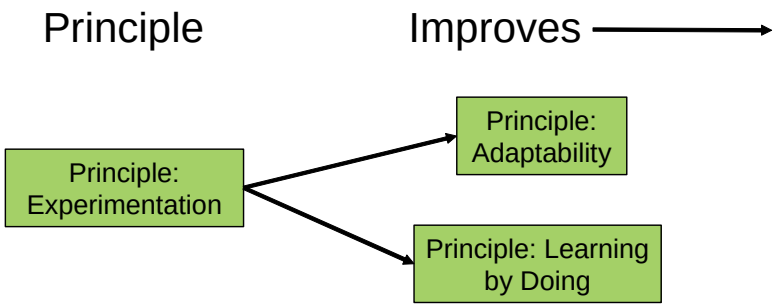
- **Ability for complex problem solving is improved**. *Mechanism*: The whole (team) is able to apply its knowledge in a way that is more effective than the sum of its parts (i.e. the individuals acting separately).

What happens when it is not applied?

- Ability for complex problem solving is limited to the combined capabilities of the individuals typically acting separately.

2.6.13 Experimentation

Principle: "Experimentation" strives to completely embrace (allow, plan for, and learn from) provisional or exploratory initiatives that are not necessarily guaranteed to succeed or produce short-term desirable results.



What is achieved when this principle is properly applied?

- Adaptability is improved. *Mechanisms*:
  Acknowledging up-front that there is a possibility of failure creates a less threatening (i.e. more relaxed) environment. This facilitates planning for possible failure and, if it occurs, learning from it.
  Experimentation, in the specific sense of being exploratory (i.e. trying completely new ideas), is a longer-term learning strategy for coping with unexpected, and possibly rare, circumstances.

- Learning by doing is improved. *Mechanism*: Acknowledging experimentation allows individuals to learn by doing in a more relaxed way because they feel less threatened by failure.

What happens when it is not applied?

- Adaptability is compromised because (a) failures are regarded in an entirely negative light, limiting the degree to which lessons can be learned, and (b) there is less likelihood that rare unforeseen and threatening circumstances can be addressed.

2.7 REPUTABLE LITERATURE TEST

As noted above, the current set of principles can be assessed to some extent against the suggestions of reputable authors. The following sub-sections quote directly from a series of authors who have proposed key success factors for learning organisations.

2.7.1 What the experts say

2.7.1.1 Building blocks of Garvin (1993)

- **Systematic problem solving**: This comprises (a) relying on the scientific method, rather than guesswork, for diagnosing problems, (b) insisting on data rather than assumptions as background for decision making, and (c) using simple statistical tools to organise data and draw inferences.

- **Experimentation**: This involves the systematic searching for and testing new knowledge. Unlike problem solving, experimentation is usually motivated by opportunity and expanding horizons, not by current difficulties. They include ongoing programmes (aimed at continuous and incremental improvement) and larger and more complex "demonstration" projects (holistic system-wide changes at one site often with the goal of creating new organisational abilities).

- **Learning from past experience**: This entails reviewing successes and failures, assessing them systematically, and recording the lessons in a form that employees find open and accessible. It recognises the value of a productive failure as opposed to an unproductive success. It involves reflection and self-analysis.

- **Learning from others**: This involves "benchmarking" which is a disciplined ongoing investigation and learning experience that ensures that the best industry practices are uncovered, analysed, adopted, and implemented.

- **Transferring knowledge**: Knowledge must be spread quickly and efficiently throughout the organisation.

2.7.1.2 Learning organisation measures of Garvin (1993)

- **Cognitive**: Members of the organisation are exposed to new ideas, expand their knowledge, and begin to think differently. They focus on attitudes and depth of understanding and try to truly understand the meaning of self-direction and teamwork. There must be time for reflection and analysis, to think strategically, assess current systems and invent new products. The exchange of ideas must be stimulated.

- **Behavioural***:* Employees begin to internalise new insights and change their behaviour. The organisation's deeds match its words.

- **Performance**: Changes in behaviour lead to improvements in performance.

2.7.1.3 Learning dimensions of Goh and Richards (1997)

- **Clarity of purpose and mission**: The degree to which employees have a clear vision/mission of the organisation and understand how they can contribute to its success and achievement.

- **Leadership commitment and empowerment**: The role of leaders in the organisation with respect to (a) helping employees learn and (b) eliciting behaviours consistent with an experimenting and changing culture.

- **Experimentation and rewards**: The degree of freedom employees enjoy in the pursuit of new ways of getting the job done and freedom to take risks. Compensation systems should be designed to reward innovation and risk-taking.

- **Transfer of knowledge**: The systems that enable employees to learn from others, from past failures and from other organisations. The type of information acquired and distributed should relate to organisational problems and opportunities.

- **Teamwork and group problem solving**: The degree of teamwork possible in the organisation to solve problems and generate new and innovative ideas.

2.7.1.4 Empowerment model of Cook (1997)

Cook (1997) proposed a relatively simple model highlighting three important and interdependent dimensions of empowerment. Although not purporting to be related to learning organisations *per se*, it does touch on a few characteristics relevant in the current context.

- **Objective empowerment**: This refers to the individual's movement from oppression to influence and opportunity in organisational terms. This can occur through promotion, exposure to information, job enrichment, exposure to opportunities, and use of reward systems that support personal development.

- **Competence**: This refers to possessing the necessary skills to carry out functions successfully. These refer to technical skills, interpersonal relationships, and self-management.

- **Subjective empowerment**: This manifests in a sense of confidence, motivation, enjoyment of the challenge of other's high expectations, and reliance on one's own initiative.

2.7.1.5 Five disciplines of Senge (2006)

In a recent book, “The Fifth Discipline: The Art & Practice of The Learning Organisation”, (Senge, 2006), five so-called “disciplines” are strongly motivated as being cornerstones of learning organisation. The extent to which the current sets of principles and indicators are aligned with these is examined in the following sub-sections.

- **Systems thinking**: Systems thinking is a conceptual framework and a body of knowledge and tools that help make patterns clearer and help us see how to change them effectively. Multiple levels of cause and effect are involved. Event-based understanding (“who did what to whom”) leads to reactive management. Understanding based on “patterns of behaviour” focuses on seeing longer-term trends and assessing implications. “Structural”

understanding asks "what causes the patterns of behaviour"? Structural changes are usually generative.

- **Personal mastery***:* The discipline of continually clarifying and deepening our personal vision, of focusing our energies, of developing patience, and of seeing reality objectively.

- **Mental models***:* The discipline of working with mental models starts with turning the mirror inward; learning to unearth our internal pictures of the world, to bring them to the surface and hold them rigorously to scrutiny. Mental models are deeply engrained assumptions, generalisations, or even pictures or images that influence how we understand the world and how we take action. Allowing mental models (paradigms) to surface, be tested and be improved will ensure conflicting mental models will not impede the implementation of a new idea or strategy.

- **Building shared vision***:* The discipline of shared vision involves the skills of unearthing shared "pictures of the future" that foster genuine commitment and enrolment rather than compliance. Individual visions must be translated into shared visions, not through a "cookbook" but a set of principles and guiding practices.

- **Team learning**: True learning teams not only produce extraordinary results but individual members grow more rapidly than could have occurred otherwise. Individuals discover insights not attainable individually.

2.7.2 Assessment of principles

This section assesses the degree to which important factors identified by other authors are addressed by the currently proposed learning principles.

2.7.2.1 Building blocks of Garvin (1993)

- **Systematic problem solving**: No principle addresses this issue.

- **Experimentation**: Addressed directly by the Experimentation principle.

- **Learning from past experience**: Enabled by Patience, Prior knowledge engagement, Learning by doing, and to some extent Experimentation. The specific issue of recording what is learnt in a form accessible to employees is not addressed directly.

- **Learning from others**: Enabled by Social knowledge sharing, Patience, Positive persistence, and Empathy.

- **Transferring knowledge**: Since the emphasis is on spreading knowledge efficiently, this is enabled by Prior knowledge engagement, Social knowledge sharing, and Empathy. However, this factor may be better addressed by the existence of specific organisational mechanisms for such knowledge transfer.

Factors not addressed by a principle: Systematic problem solving.

Principles not explicitly addressed by Garvin (1993): Common future focus, Transdisciplinarity, Adaptability, and Synergism.

Conclusion: Three of the five factors are enabled (as opposed to addressed directly) by the current principles. One (experimentation) is addressed directly. Another (systematic problem solving) is not addressed. This perspective suggests that the proposed principles serve the role of

providing an underlying enabling environment in which effective and efficient learning can take place. Many of the specific issues identified by Garvin are more mechanistic in nature and would be closer to the outcomes of applying the principles. Measurement of the extent to which these mechanisms are in place (or the outcomes achieved) would provide an enhanced picture of the extent to which an organisation is learning (beyond that possible from examining only the extent to which they are applying the learning principles).

2.7.2.2 Learning organisation measures of Garvin (1993)

- **Cognitive**: Enabled by Prior knowledge engagement, Learning by doing, Social knowledge sharing, Patience, Positive persistence, Empathy, Synergism and Experimentation.

- **Behavioural***:* Enabled by any principle that improves knowledge depth: Prior knowledge engagement, Learning by doing, Social knowledge sharing, Patience, Positive persistence, Empathy and Experimentation.

- **Performance**: No principle addresses this issue.

Measures not addressed by a principle: Performance.

Principles not explicitly addressed by Garvin (1993): Common future focus, Transdisciplinarity, and Adaptability.

Conclusion: By their very nature, the learning principles relate to an enabling environment and therefore will not address measuring performance of the organisation. The degree to which performance improves and behavioural changes manifest relate more to the desired outcomes of application of the learning principles. Measuring the degree to which an organisation is actually learning would need to take these issues into account.

2.7.2.3 Learning dimensions of Goh and Richards (1997)

- **Clarity of purpose and mission**: Addressed directly by Common future focus.

- **Leadership commitment and empowerment**: No principle addresses this issue.

- **Experimentation and rewards**: Addressed directly by Experimentation. No principle addresses rewards directly.

- **Transfer of knowledge**: Enabled by Prior knowledge engagement, Learning by doing, Social knowledge sharing, Patience, Positive persistence, and Empathy.

- **Teamwork and group problem solving**: Addressed directly by Synergism.

Dimensions not addressed by a principle: Leadership commitment and empowerment; Rewards.

Principles not explicitly addressed by Goh and Richards (1997): Transdisciplinarity, and Adaptability.

Conclusion: The principles identify the nature of the empowerment necessary but not that leadership is required to apply them. Good leadership can be regarded as an organisational requirement for ensuring that the principles can be, and are applied. The issue of rewards is best regarded as a mechanism for encouraging application of the principles, not a fundamental learning principle itself. It relates more to organisational strategy than learning *per se*.

2.7.2.4 Empowerment model of Cook (1997)

- **Objective empowerment**: Enabled by Prior knowledge engagement, Learning by doing, Social knowledge sharing, Patience, Positive persistence, Empathy, and Experimentation.
- **Competence**: Enabled by Prior knowledge engagement, Learning by doing, Social knowledge sharing, Patience, Positive persistence, Empathy, and Experimentation.
- **Subjective empowerment**: Enabled by Positive persistence and Empathy.

Factors not addressed by a principle: None.

Principles not explicitly addressed by Cook (1997): Common future focus, Transdisciplinarity, Synergism, and Adaptability.

Conclusion: It is encouraging that each empowerment factor is enabled by multiple learning principles. That some principles are not addressed by Cook is understandable because empowerment, by its very nature, is largely one way (in favour of the individual). He does not consider how such individuals might benefit (provide feedback into) the organisation.

2.7.2.5 Five disciplines of Senge (2006)

- **Systems thinking**: No principle addresses this issue directly.
- **Personal mastery***:* Enabled by Prior knowledge engagement, Learning by doing, Social knowledge sharing, Patience, Positive persistence, Empathy, and Experimentation.
- **Mental models***:* Enabled by Prior knowledge engagement and Empathy. Prior knowledge engagement can lead to "unearthing" of internal pictures of the world. Empathy enables the more deeply engrained mental models of others to be uncovered and understood.
- **Building shared vision***:* Addressed directly by Common future focus.
- **Team learning**: Addressed directly by Synergism.

Factors not addressed by a principle: Systems thinking. The *use* of mental models is also not addressed directly.

Principles not explicitly addressed by Senge (2006): Transdisciplinarity and Adaptability.

Conclusion: Personal mastery and avoiding the negative nature of mental models (paradigms) are outcomes that are enabled by the learning principles. They are not appropriately regarded as learning principles themselves. It is encouraging that both building shared vision and team learning are directly addressed by learning principles. As for Garvin (1993) above, systems thinking is not addressed directly by a principle. It can perhaps be better regarded as a particular learning tool (mechanism or strategy).

2.7.3 Conclusions

An assessment of four publications referring explicitly to learning organisations suggests that the current set of indicators is well aligned with much that the respective authors suggest is required for learning organisations. **Table 2** summarises the alignment between learning principles and what the various authors regard as important.

Table 2 : Assessment of proposed principles against key factors of other workers. (S = Same as key factor; E = Enables key factor)

	Ref. 1								Ref. 2					Ref. 3			Ref. 4				
Principle	Systematic problem solving	Experimentation with new approaches	Learning from past experience	Learning from others	Transferring knowledge	Cognitive (exposure, expand knowledge)	Behavioural (internalise, alter behaviour)	Performance (improvement in results)	Clarity of purpose & mission	Leadership commitment & empowerment	Experimentation	Transfer of knowledge	Teamwork & group problem solving	Objective empowerment	Competence	Subjective empowerment	Systems thinking	Personal mastery	Mental models	Shared vision	Team learning
Common future focus	.	.	.	.	.	.	.	.	S	.	.	.	.	.	.	.	.	.	.	S	.
Prior knowledge engagement	.	.	E		E	E	E	.	.	.	.	E	.	E	E	.	.	E	E	.	.
Transdisciplinarity	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Learning by doing	.	.	E	.	.	E	E	.	.	.	.	E	.	E	E	.	.	E	.	.	.
Social knowledge sharing	.	.	.	E	E	E	E	.	.	.	.	E	.	E	E	.	.	E	.	.	.
Patience	.	.	E	E		E	E	.	.	.	.	E	.	E	E	.	.	E	.	.	.
Positive persistence	.	.	.	E		E	E	.	.	.	.	E	.	E	E	E	.	E	.	.	.
Empathy	.	.	.	E	E	E	E	.	.	.	.	E	.	E	E	E	.	E	E	.	.
Adaptability	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Synergism	.	.	.	.	.	E	.	.	.	.	.	.	S	.	.	.	.	.	.	.	S
Experimentation	.	S	E	.	.	E	E	.	.	.	S	.	.	E	E	.	.	E		.	.

* Ref. 1; Garvin (1993), Ref. 2: Goh and Richards (1997); Ref. 3: Cook (1997); Ref. 4: Senge (2006)

The above authors are not proposing ideal characteristics of a learning organisation at the same low enabling level of the proposed learning principles. For the most part they are more concerned with what might be termed “outcomes” of effective learning. This makes a comparison with their suggestions somewhat less appropriate than may be desired. Nevertheless, in a number of instances it is possible to make fairly direct connections between the learning principles and their outcomes.

An interesting and relevant perspective is that the current set of principles goes beyond what the above authors suggest is important. Specifically, the two principles of transdisciplinarity and adaptability are both regarded as essential for learning organisations with a mandate for governance of social-ecological systems. It is hypothesised that the above authors may be more focused on “traditional” business environments, not the more demanding environments of governance of social-ecological systems.

2.8 LEARNING ORGANISATIONS AND ENTREPRENEURSHIP

It is instructive to make a brief comparison between a learning organisation and entrepreneurship. The following definitions are used here:

Learning organisation: An organisation skilled at creating, acquiring and transferring knowledge, and at modifying its behaviour to reflect new knowledge and insights (Garvin, 1993).

Entrepreneurship: The process of creating value by bringing together a unique package of resources to exploit an opportunity (Morris and Kuratko, 2002).

Morris and Kuratko (2002) are focused on the traditional business organisation (as opposed to one with a social-ecological governance mandate). However, they do state that "when a company is confronted with dynamic, threatening, and complex change in the external environment, it is forced to adapt". As noted in Chapter 1: Background, this is regarded as the norm for an organisation involved in governance of a social-ecological system.

Morris and Kuratko (2002) note that being forced to adapt typically involves various forms of innovation, and this and adaptation are both dependent on an ability to learn. In essence, entrepreneurship is facilitated by the company's ability to learn. They also stress the importance of continual experimentation, especially putting failure "front and centre". This is complete alignment with the experimentation learning principle proposed above (Section 2.4.3).

The traditional business organisation is competing within a market environment and is typically there to make financial profits (through value creation) by cleverly exploiting opportunities. This is not typical of an organisation with a social-ecological governance mandate, which is not functioning in a competitive environment. It is not expected to make its owners rich. However, salaries, capital and operating expenses do need to be covered. Any "profits" would be expected to be ploughed back into improving the way they achieve their mandate. Perhaps, in a sense, if a parallel is to be sought, the "profits" strived for by our social-ecological governance organisation will be "richness" of the social-ecological system. The "profits" are then ploughed back into the whole system, i.e. the benefits accrue to the social system and the ecological system.

A further parallel exists. The complex challenges faced by an organisation with a social-ecological governance mandate will inevitably require "*unique packaging of resources*", possibly even "*to exploit an opportunity*". In other words, our organisation will also need to be clever, perhaps very clever.

2.9 CONCLUSIONS

Section 2.2: Principle validation tests above noted three potential tests of the appropriateness of the set of principles. One, the "organisational audit test" was deduced to be unlikely to produce useful results. However, the "Principles and outcomes test" and the "Reputable authors test" were explored.

The "Principles and outcomes test" demonstrated that the principles, if applied appropriately, can reasonably be associated with the required abilities of an organisation with a mandate for social-ecological system governance. This suggests that the principles are reasonable.

The "Reputable authors test" also showed that the proposed principle are in good alignment with what recognised authors propose for learning organisations. Therefore this test is also encouraging in respect of the correctness of the principles.

Overall therefore the assessment of the principles suggests that they are appropriate considerations for learning organisations.

CHAPTER 3: INDICATORS AND LEARNING AUDITS

This chapter describes the development and application of a questionnaire for a "learning audit".

3.1 INTRODUCTION

A series of indicators and a "learning audit" questionnaire were developed to explore in more depth the degree to which an organisation is a "learning organisation" and the degree to which it applies the learning principles.

3.1.1 Learning audit indicators

3.1.1.1 Process-based versus outcome-based indicators

There are two well-defined though fundamentally different kinds of indicators relating to organisational performance: Process-based and outcome-based. The following table summarises the differences (adapted from DNRE, 1997).

Table 3 : The generic frameworks of process-based and outcome-based indicators.

	Process-based	Outcome-based
Goal:	Broadly defined, often not measurable, generally organisationally-based; (e.g. "To be the best …")	Specific, measurable, issue-based (e.g. "To maintain ecological integrity …")
Standards:	Process-based, not clearly related to organisation goals (e.g. guidelines, manuals, code of practice)	Outcomes, clear relationship to organisation goal (e.g. no loss of species diversity, no loss of threatened species)
Performance indicators:	Compliance with standards and/or level of activity (e.g. degree of compliance with guidelines)	Measurement of outcomes (e.g. number of species, number of threatened species)
Reporting:	Level of activities undertaken (i.e. inputs not outputs); generally doesn't report on levels of compliance with standards	Comparison between standards and measured performance indicators; Review and discussion of trends
Feedback mechanism:	No specific mechanisms	Use performance indicators to (a) improve organisational performance by learning from successes and failures and (b) feedback to managers

It is quite evident from **Table 3** that a series of indicators that tests for correctness (see Section 2.2.1) must necessarily be process-based. For example, their purpose will be to determine the degree to which the organisation is applying the associated principle. In the terminology of the above table, the principles are "standards". The "performance indicators" will measure the degree of "compliance" with (or application of) each principle.

On the other hand, if we wish to establish the degree to which an organisation is a "learning organisation", then it will be preferable to use a series of outcome-based indicators. These should ideally be totally independent of any of the indicators relating to the principles. They should be directly related to the achievements (desirable outcomes) of the organisation.

The relative advantages of the above two frameworks are summarised in the following table (adapted from DNRE, 1997).

Table 4 : Relative advantages of process-based and outcome-based indicator frameworks.

	Process-based	**Outcome-based**
Costs:	Relatively cheap	More expensive
Relation to mandate:	May not be directly related	Directly related to the issues important to the organisation's mandate (and what society expects)
Accountability:	Appropriate when the organisation needs to be held accountable for "due process"	Accountability for mandate-related issues is facilitated
Guidance:	Only guides processes (which is good if they are effective), not necessarily on what the organisation should be achieving	Clear guidance to all levels of the organisation on what they should be trying to achieve
Facilitation of learning:	Encourages organisation learning by quantifying the extent to which learning processes are being practiced correctly (but not the degree to which the mandate is actually being achieved)	Encourages organisational learning by quantifying achievements directly related to the mandate

Irrespective of the general framework of a series of indicators, one particularly desirable property is mutual exclusivity. It simplifies communication and subsequent analysis of the responses.

Irrespective of whether a formal mathematical (or statistical) analysis is performed on the results, it is fundamentally preferable that each individual issue is addressed in the questionnaire in one statement only. Subsequent analysis of responses is then considerably simplified (even when the responses are analysed subjectively).

Furthermore, a perceptive interviewee may detect that a particular issue is addressed in more than one indicator statement and potentially be confused by this. This may influence their responses. Addressing a single issue in a single statement avoids this.

Multiple issues in a single statement force the interviewee to think about multiple issues, make judgements about relative importance, and make an overall judgement of the final score (even

though this may occur entirely subconsciously). This can be highly subjective and vary considerably from person to person. Interpretation of the reply can also be made more difficult.

Limiting each indicator statement to a single issue not only makes the statement clearer but limits the interviewee's focus (and hence response) to just that issue. Subsequent interpretation of the response is therefore simplified.

Achieving these ideal characteristics need to be balanced in practice with pragmatism. In order to avoid excessively large numbers of indicator statements, it may be acceptable in some cases to relax the above ideals, particularly if confusion (either in the interviewee's mind or in subsequent analysis is thought to be unlikely).

3.1.2 Indicator development process

The list of indicators (in the format of the questionnaire) is given in Appendix A.

The project team came together on a number of occasions and collectively proposed and assessed individual indicators for each of the learning principles. Account was taken of the issue of mutual exclusivity to the extent that this was thought necessary.

Every attempt was made to ensure that each statement was understandable on its own. However, in some cases, it was accepted that certain concepts could not be adequately explained within the statement itself. In these instances it was ensured that simple definitions were available in the Chapter 6: Description of Terms.

The total number of indicators was a significant issue. It was not the intention to simply ask individuals to answer the questionnaire in their own time. The team performed the interview face-to-face since it was also the intention to learn as much as possible from the interviewees. An hour was thought adequate plus half an hour for general discussion.

The interviewee was asked to respond to the statement with the degree to which they thought the statement was true:

NA = not applicable
Don't know
0 = definitely not true
1 = partially true
2 = largely true
3 = definitely true

The current list of indicators in Appendix A represents the modified principles based on the first series of interviews (see Section 3.2: SANParks learning audit).

3.1.3 Indicators for learning principles

A total of 27 indicator statements exist for the eleven learning principles (with a maximum of three indicators per principle).

3.1.4 Indicators for essential abilities

Based on the six essential abilities of a learning organisation (identified in Section 1.3.4: Essential abilities), a similar series of indicator statements was developed to enable assessment of the degree to which ability exists in the organisation. The ability to deal with multi-dimensionality was not dealt with in this section as this was regarded as addressed by the principle of transdisciplinarity.

Seven indicators were chosen to assess the remaining five abilities.

3.1.5 Indicators for enabling objectives

The ultimate intention of the learning principles is the creation of an environment in which a learning organisation is created and sustained. The principles are largely focused on the nature of individual and group learning. However, there are also various other necessary conditions. These are depicted in **Figure 4**.

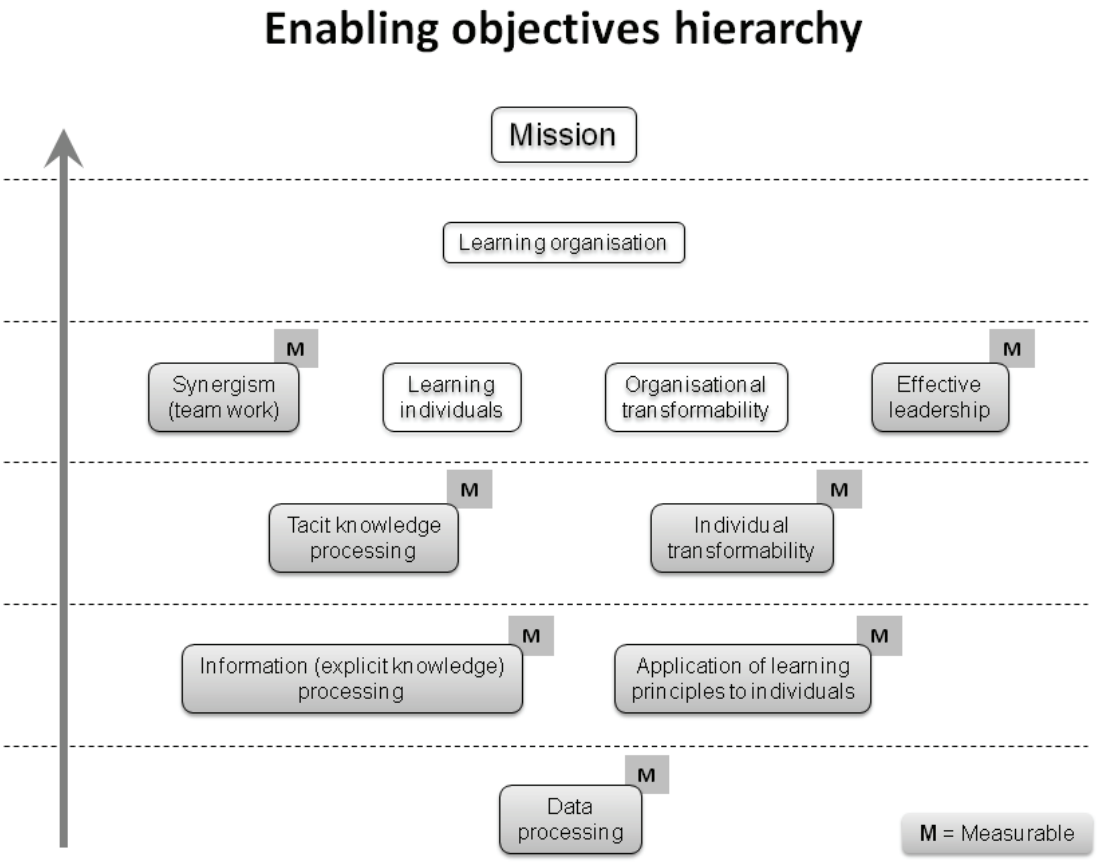


Figure 4 : A hierarchy of enabling objectives for a learning organisation.

The Ms indicate those enabling objectives that are measurable at least to some extent. The indicators mentioned above for the principles themselves and the essential organisation abilities also provide measurements for some of the above enabling objectives.

An additional nine indicators were formulated to address some of the above enabling objectives.

3.1.5.1 Learning organisation

At present no indicator explicitly measures the degree to which an organisation is a learning organisation.

3.1.5.2 Synergism

This objective is regarded as identical to the synergism learning principle. Therefore, each indicator of the latter is an indicator of the former.

3.1.5.3 Learning individuals

At present no indicator explicitly measures the degree to which an individual is a learning individual. All the indicators are process-based (see Section 3.1.1.1: Process-based versus outcome-based indicators). This strictly means that only the degree to which an enabling environment exists is being measured, not the degree to which that environment is actually being successful (i.e. resulting in the required learning outcomes).

3.1.5.4 Organisational transformability

At present no indicator explicitly measures the degree to which an organisation is capable of transforming.

3.1.5.5 Leadership

As noted in Chapter 3: Learning Principles, effective leadership is an important component of learning organisations. One indicator was chosen for this.

3.1.5.6 Tacit knowledge processing

Many of the learning principles specifically enable this objective. However, whether it is actually occurring is difficult to measure. One extra indicator, relating to whether individuals engage relevant theory, is the only indicator specific to this objective. It too is only an enabling factor, not guaranteeing that tacit knowledge processing is actually occurring.

3.1.5.7 Individual transformability

It is assumed that any indicator of individual adaptability (relating to the corresponding learning principle) is an indicator of individual transformability.

3.1.5.8 Information processing

Information is regarded as synonymous with explicit knowledge. Information processing is regarded as an essential prerequisite for knowledge processing in the sense that if information is not being processed effectively, then it is unlikely that knowledge, and tacit knowledge in particular, is being processed effectively.

A set of indicators was developed to assess the degree to which information is acquired, created and transferred (shared).

3.1.5.9 Application of principles to individuals

All of the learning principles that apply to individuals apply here. Therefore all their respective indicators are measuring this objective, although again only in an enabling sense.

3.1.5.10 Data processing

Just as information processing enables tacit knowledge processing, so does data processing enable information processing. As above, it is assumed here that if data is not being processed effectively, then it is unlikely that either information or tacit knowledge is likely to be processed effectively.

A set of indicators was therefore formulated for this enabling objective, including data acquisition, data creation and data transfer.

3.1.6 Comparison with literature

3.1.6.1 Introduction

The following sub-sections assess the indicators against various reputable literature sources. Specifically, the degree to which the chosen indicators would measure what the authors suggest is important (see Section 2.7.1: What the experts say), is assessed. This analysis is similar to that performed on the principles (Section 2.7.2: Assessment of principles). If that analysis identified a relevant principle then naturally associated indicators exist. These are not repeated here. The following sub-sections describe only those indicators associated with essential abilities (ability to deal with threats to sustainability, ability to deal with change, etc.) and enabling objectives (information processing, data processing, etc.).

3.1.6.2 Building blocks of Garvin (1993)

- **Systematic problem solving**: No indicator exists that establishes the degree to which the scientific method is used. However, data processing (acquiring, creating and transferring) is regarded as an important enabling factor for which a number of indicators are proposed. No indicator addresses the use of simple statistical tools.

- **Experimentation**: Addressed by a principle.

- **Learning from past experience**: Addressed by principles.

- **Learning from others**: Addressed by principles.

- **Transferring knowledge**: Addressed by principles. Also, an indicator establishes whether acquired data can be found efficiently and extracted for processing.

3.1.6.3 Learning organisation measures of Garvin (1993)

- **Cognitive**: Addressed by principles.

- **Behavioural***:* Addressed by principles. Furthermore, a number of indicators explicitly address the degree to which the unit is influenced by the knowledge gained through applying the various principles.

- **Performance**: Not addressed by a principle or indicator.

Conclusion: Only performance is not addressed by the questionnaire.

3.1.6.4 Learning dimensions of Goh and Richards (1997)

- **Clarity of purpose and mission**: Addressed by a principle.
- **Leadership commitment and empowerment**: Addressed by one indicator.
- **Experimentation and rewards**: Experimentations addressed by a principle. Rewards not addressed.
- **Transfer of knowledge**: Addressed by principles. Furthermore, indicators exist that address information transfer and data transfer.
- **Teamwork and group problem solving**: Addressed by a principle.

Conclusion: Most issues proposed by Goh and Richards are addressed by the existing set of indicators.

3.1.6.5 Empowerment model of Cook (1997)

- **Objective empowerment**: Addressed by principles.
- **Competence**: Addressed by principles.
- **Subjective empowerment**: Addressed by principles.

Conclusion: Each type of empowerment is addressed by a number of indicators. However, there is no specific emphasis on:

- Common future focus;
- Adaptability;
- Synergism;
- The unit being able to respond well to loss of key individuals;
- What needs to be known (e.g. change and complexity in social-ecological systems);
- Leadership.

Therefore, although Cook's model may be useful in respect of creating an enabling environment for individuals, it must be realised it does not attempt to address many other important aspects of learning organisations.

3.1.6.6 Five disciplines of Senge (2006)

- **Systems thinking**: One indicator related to the principle of adaptability is relevant. This is the extent to which double- or triple-loop learning occurs. This is explicitly based on understanding patterns of behaviour and what causes them.
- **Personal mastery***:* Addressed by principles.
- **Mental models***:* Addressed by principles.
- **Building shared vision***:* Addressed by a principle.
- **Team learning**: Addressed by a principle.

Conclusion: All disciplines are addressed by one or more indicators. However, systems thinking is not addressed particularly directly.

3.1.6.7 Conclusions

The above assessment suggests that the current set of indicators is well aligned with what the respective authors suggest is required for learning organisations. As noted for the equivalent analysis for principles, the set of indicators goes further than that suggested by those authors. Specifically such issues as adaptability and transdisciplinarity and the essential abilities of an organisation with the mandate for governance of social-ecological systems also have associated indicators.

On the whole, therefore, except for the issue of the role of systems thinking, the current set of indicators is thought to be quite comprehensive and appropriate.

3.2 SANPARKS LEARNING AUDIT

3.2.1 Introduction

A single audit of the unit within SANParks responsible for the greater Kruger National Park was undertaken in September 2006. Eight people were interviewed in seven separate interviews (in one two people were interviewed together).

The interviewees were chosen on the basis of the following criteria:

- **Knowledge**. The interviewee must have a good knowledge of all aspects of the target organisational unit. This will inevitably mean that the interviewee will:
  Have had at least some years of experience in the unit,
  Know at least most of the people and
  Be functioning in a decision support or decision making capacity in respect of ecosystem governance.
- **Representative**. The interviewee must be able to provide responses to the questionnaire that are representative of all others in the target unit.
- **Willingness**. The interviewee should be willing to spend the necessary time to complete the questionnaire.

For present purposes (i.e. development and refinement of indicators), this learning audit was extremely useful. On the basis of these interviews, and particularly the degree to which indicator statements were misunderstood, the original set of statements was updated. It is this list that is given in the questionnaire in Appendix A.

3.2.2 Extra attributes

A few extra attributes were defined with indicators from the original list. The new attributes were the following:

- Learning attribute: Time for acquiring deep understanding
- Learning attribute: Benefiting from external knowledge
- Learning attribute: Potential for cognitive development
- Organisational attribute: Supportive work environment
- Organisational attribute: Institutional memory

The indicators chosen to represent these can be found in Appendix B. These were included in the analyses in the following sub-sections.

3.2.3 Indicator and attribute statistics

Simple statistics such as averages and ranges (for both indicators and attributes) are given in Appendix B.

The following observations can be made and conclusions drawn:

- No indicators were regarded as "not applicable".
- No interviewee responded with "don't know".
- All but three indicator averages were either "Partially true" or "Largely true". The three averaging at "Definitely true" were the following:
  - The unit and the network have substantial knowledge depth in critical core disciplines.
  - Individuals get extensive hands-on practical experience in the field.
  - There is considerable debate about the extent to which experiments on ecosystems should take place.
- The ranges of responses (as reflected in "Indicator Ranges") are generally relatively high (31 of the 42 indicators had a range of 3 or 4, the maximum possible being 4). This suggests that there may be some degree of disagreement between interviewees.
- Application of nine of the eleven learning principles was considered, on average, to be "largely true". Application of the remaining two (Patience and Adaptability) were only "partially true". This apparently relatively good application of learning principles might have been expected for a progressive organisation like the research component of SANParks.

3.2.4 Interviewee agreement

3.2.4.1 Introduction

Given the above suggestion that there may be some degree of disagreement between the interviewees, this issue was examined in more detail from a number of perspectives. These are described in the following sub-sections.

3.2.4.2 Overall similarity

The Jaccard similarity index was used to determine the overall degree of similarity between responses of the eight interviewees to the indicator statements (two of whom were interviewed together). Because this coefficient requires responses to be binary (1 or 0), their responses (for each indicator statement) were grouped in two categories:

- 1 if response = "Largely true" or "Definitely true";
- 0 if response = "Definitely not true" or "Partially true".

The following table shows the resulting similarity matrix.

Table 5 : Learning audit: Jaccard similarity matrix of interviewee responses.

1	2	3	4	5	6	7	
.	0.43	0.62	0.45	0.50	0.49	0.60	**1**
.	.	0.61	0.55	0.41	0.50	0.48	**2**
.	.	.	0.52	0.59	0.67	0.46	**3**
.	.	.	.	0.44	0.61	0.50	**4**
.	.	.	.	.	0.53	0.52	**5**
.	.	.	.	.	.	0.46	**6**
.	.	.	.	.	.	.	**7**

There are no very low (close to zero) or very high (close to one) coefficients. These respectively suggest that while there are no interviewees that show extreme disagreement, there are also no interviewees that show great agreement between their respective responses.

3.2.4.3 Attribute agreement

Given that conclusions drawn from the analysis using the overall Jaccard similarity coefficient were somewhat inconclusive, a more detailed analysis was carried out. This focused on the degree of agreement of responses to specific attributes (i.e. learning principles, organisation abilities, enabling objectives, and others).

An "agreement coefficient" was calculated for each indicator and each attribute (being a combination of indicators). This indicator agreement coefficient was defined as follows:

Indicator agreement coefficient = R^{max} + (2 – Range/2)

Where

R^{max} = maximum value of the combined responses (of all interviewees) for each indicator for any possible response (from "definitely not true" to "definitely true" - given in the "indicator responses" sheet). This is the main contributor to the coefficient. If all interviewee's responses are the same (say all "largely true"), then R^{max} is the highest possible value, namely N if there are N interviewees.

Range = the spread of responses (given in the "indicator ranges" sheet). For example, Range = 1 if all interviewee's responses are exactly the same, or Range = 4 if the responses are spread from "definitely not true" to "definitely true".

Agreement coefficients for the attributes were calculated as averages:

Attribute agreement coefficient = average of associated indicator agreement coefficients

Table 6 shows the values obtained as well as the actual attribute averages. They are plotted in **Figure 5**.

Table 6 : Learning audit: **Actual attribute averages and attribute agreement coefficients.**

Actual average	Agree. coef.	Attribute
2.29	6.0	Organisation ability: Deal with Change
2.67	5.8	Learning principle: Transdisciplinarity
2.79	5.3	Organisation ability: Deal with Significant decision making
3.48	4.8	Learning principle: Learning by doing
2.52	4.8	Organisation ability: Deal with Threats to sustainability
3.32	4.8	Learning attribute: Potential for cognitive development
1.57	4.5	Learning principle: Experimentation
2.46	4.5	Organisation ability: Deal with Complexity
2.62	4.5	Organisation ability: Deal with Information overload
2.86	4.5	Enabling objective: Information processing
3.19	4.3	Organisational attribute: Supportive work environment
3.21	4.3	Learning principle: Positive persistence
2.71	4.2	Learning principle: Common future focus
2.19	4.0	Learning principle: Adaptability
2.00	4.0	Learning attribute: Time for acquiring deep understanding
2.86	3.8	Enabling objective: Data processing
2.14	3.8	Learning principle: Synergism
3.00	3.8	Organisational attribute: Institutional memory
2.86	3.8	Learning attribute: Benefiting from external knowledge
2.95	3.7	Learning principle: Social knowledge sharing
3.00	3.5	Learning principle: Prior knowledge engagement
3.00	3.5	Learning principle: Empathy
2.24	3.3	Learning principle: Patience

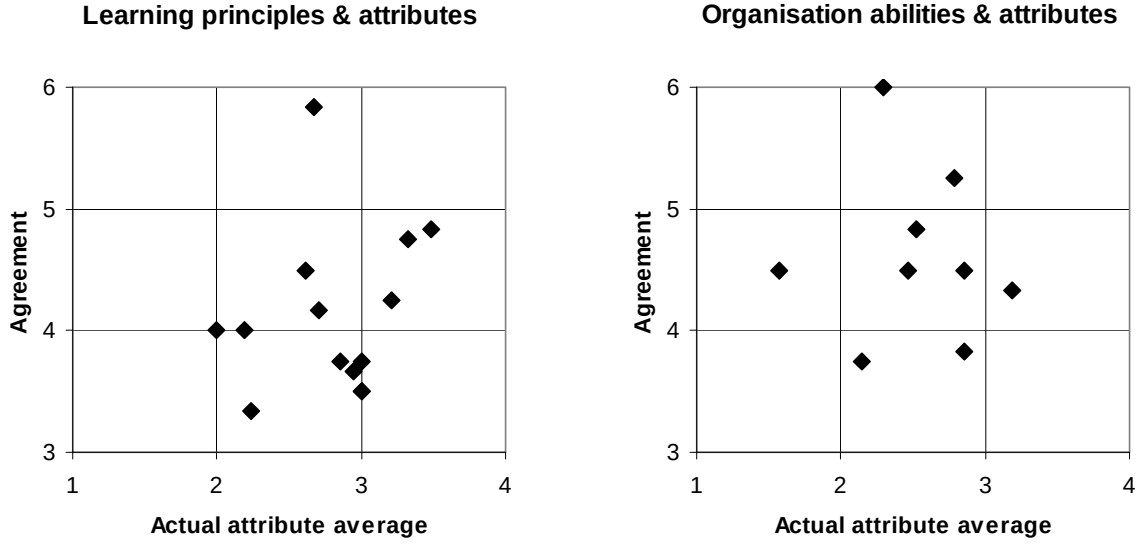


Figure 5 : Learning audit: Plotted agreement coefficients versus actual attribute average.

The left figure shows the learning principles and learning attributes. The right figure shows organisation abilities, organisation attributes and the two enabling objectives (namely information processing and data processing).

On the “agreement” axis 3-4 can be regarded as low agreement, 4-5 as average agreement and 5-6 as good agreement. On the “actual attribute average” axis 1 corresponds to “definitely not true” and 4 to “definitely true”.

The following observations can be made:

- On the whole the greater agreement between interviewee's perceptions of organisation abilities (**Figure 5** right) and attributes than of the application of learning principles and attributes (**Figure 5** left).
- There is good agreement between interviewee's perceptions of two of the "organisation abilities" (namely dealing with change and significant decision making). However, the ability to deal with threats to sustainability and information overload also rate at 4.5 or higher. The actual average for these four attributes varies from about 2.3 to 2.8 (roughly "Partially true" to "Largely true").
- There is only good agreement between interviewee's perceptions of learning principles in respect of transdisciplinarity (actual average 2.7). However, learning by doing (actual average 3.5) and experimentation (actual average 1.6) also rate at 4.5 or higher.
- There is low agreement among interviewees regarding the degree to which six learning principles are being applied. These include adaptability, synergism, social knowledge sharing, prior knowledge engagement, empathy and patience.

3.2.5 Conclusions

Results from the first (SANParks) learning assessment suggest that while individuals and groups are applying learning principles and doing quite well in this regard, scores on organisational capabilities and information and data processing are dramatically lower in comparison. When results are organised per attribute cluster (i.e. learning principles, organisational capabilities and enabling objectives), this disparity is conspicuous and probably worthy of further interrogation. It is interesting, for example that organisational capabilities, which tend to ask questions about the application of learning to outcomes (e.g. decision-making, dealing with complexity and change), should be perceived to be low while the organisation is generally adept at applying learning principles. These results seem to emphasise the importance of the context in which organisational learning finds application and perhaps the need to seek and use conceptual models that incorporate such aspects into our understanding of learning performance.

An institutional model such as proposed by Anderies, Janssen and Ostrom (2004) may be helpful in our interpretation. According to this model, resource users, the resource, public infrastructure providers and public infrastructure (comprising physical capital or infrastructure as well as social rules and norms) are all linked to form a social-ecological system through their interrelationships (**Figure 6**). The system responds to both biophysical and socio-economic changes.

Public infrastructure providers (in this case SANParks) also have their own infrastructure, including their learning system, the physical capital that supports learning (e.g. computers and data) and the rules, norms and cultures that influence how learning happens.

Results from the first survey suggest that physical capital in the form of information and data processing needs some attention – within the context of how data and information processing supports the learning environment. The Anderies model also suggests that deficiencies in organisational capabilities may lie within the larger-scale learning system (Snyder and Wenger, 2004). For example, some significant decision-making (e.g. relating to elephant culling policy) happens within SANParks' parent organisation, namely The Department of Environmental Affairs and Tourism. In effect, SANParks staff can individually and collectively be proficient learners, but still, the quality of decision-making depends in part on the joint learning capabilities of the larger system. Broadly speaking, the use of this model to interpret observed levels of capabilities suggests that in-house learning capabilities need in part to be extended to influence the larger learning system via influencing the relationships between the organisation and other organisations and between the organisation and resource users and their norms and values. In this way, espousing and applying the learning principles (at which SANParks appears to be quite good) can

exert an impact on organisational capabilities such as coping with complexity and significant decision-making.

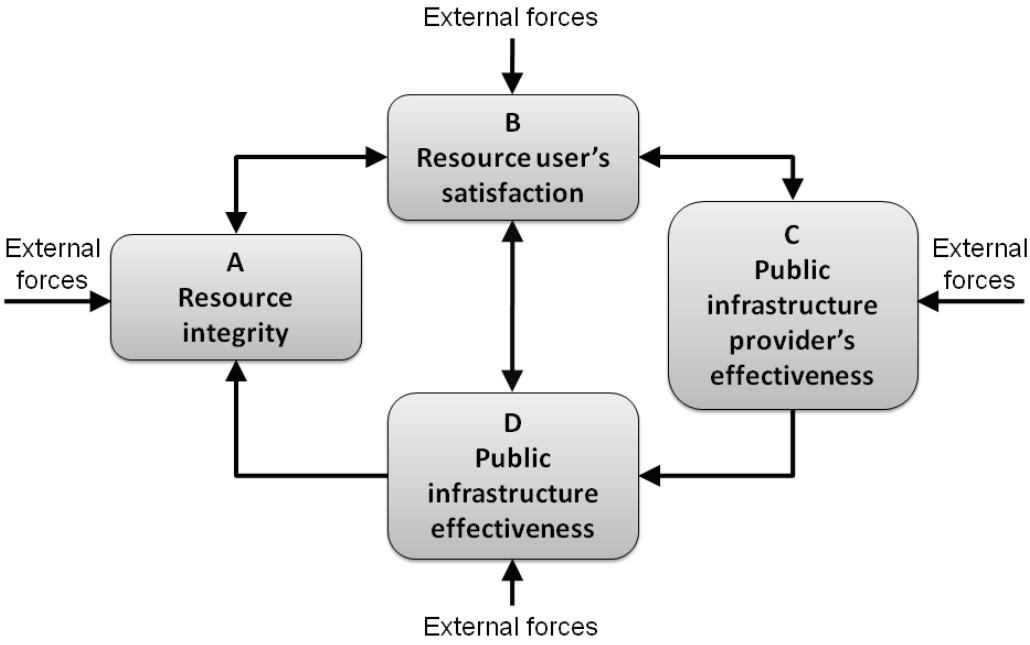


Figure 6 : The social-ecological system (Anderies et al., 2004).

However, this has many implications. It means at least that good knowledge workers must step outside of their usual domain to engage issues within the larger learning system and to deal with complexity and response scenarios across a range of organisations and scales. This may not be possible or even desirable (e.g. pulling good people out of current responsibilities and positions where they are performing well), depending on the context.

3.3 CONCLUSIONS

The execution of the learning audit with SanParks was a useful exercise in the following respects:

- It facilitated an in-depth examination of individual learning principles within a specific organisation (which is generally perceived as a learning organisation).
- It added a degree of practical reality to the principles.
- It strengthened links with the organisation.

Notwithstanding the usefulness of the exercise, the degree of quantitativeness associated with such an audit was thought to be inappropriate and excessive. It was felt that there was too much emphasis on individual principles and specific outcomes, and the measurement thereof. Instead of assuming that each principle should be applied within an organisation (albeit to different extents), each should be rather be regarded more loosely as "touchstones" to be suggested, tried and tested, and even discarded if appropriate. The general rigidity of the questionnaire, its indicators, and the associated principles and outcomes was also considered inappropriate. By its nature, the "learning audit" approach does not necessarily fully account for the inevitable complexity (i.e. emergence and unpredictability) in such an organisation.

Accordingly, this quantitative "learning audit" approach was not continued.

CHAPTER 4: COMPLEXITY

This chapter describes complex systems, provides many examples, and explores how the concept is relevant to organisations with a mandate for ecosystem governance.

4.1 INTRODUCTION

The philosophy upon which a strategy for learning organisations should be based is firmly grounded in a number of general frameworks. One important framework is complexity. The following sections describe complexity theory.

Complex systems are systems with specific characteristics or properties, many of which are described and discussed below. They are relevant to the current context because it is claimed that organisations are complex systems (Seel, 1999) or, equivalently, one property of organisations is complexity (Fioretti and Visser, 2004). Similarly, ecological systems, social systems, and overall "social-ecological systems" can also be regarded as complex systems (Folke et al., 2004).

A basic generic understanding of complex systems is presented here and then the question is asked "So what?" If we assume the existence of organisational complexity, ecological complexity, and social complexity (and hence social-ecological complexity), how can we use this generic understanding of complex systems to develop learning organisations?

A series of practical examples are presented (within a classification system) to illustrate the nature of complex systems. More generic descriptions of the critical components of complex systems then follow.

4.2 A CLASSIFICATION SYSTEM

4.2.1 Introduction

For current purposes (i.e. **relating to learning organisations) a classification system is not necessarily particularly important. Of more immediate relevance are the examples listed. They (a) demonstrate the wide variety of complex systems and (b) help better understand their nature.**

Fromm (2005) has proposed the following classification of complex systems based on the nature of the emergent properties.

Table 7 : **Classification of complex systems (Fromm, 2005).**

Type	Emergence	Roles	Predictability	System
I	Simple	Fixed	Predictable	Closed, with passive entities
II	Weak	Flexible	Predictable in principle but not in every detail	Open, with active entities
III	Multiple	Fluctuating	Not predictable (or chaotic)	Open, with multiple levels
IV	Strong	New world of roles	Not predictable in principle	New or many systems

Some may regard Fromm's simple complex system as a "complicated" system, i.e. one consisting of many interacting components with a behaviour that is entirely predictable and understandable. Nevertheless, as the examples below suggest, they do have a kind of "emergent property" that is not possessed by their respective agents. What also distinguishes the simple complex system from the others is that no top-down feedback (i.e. from the emergent property to the agents) exists. This is illustrated in **Figure 7**.

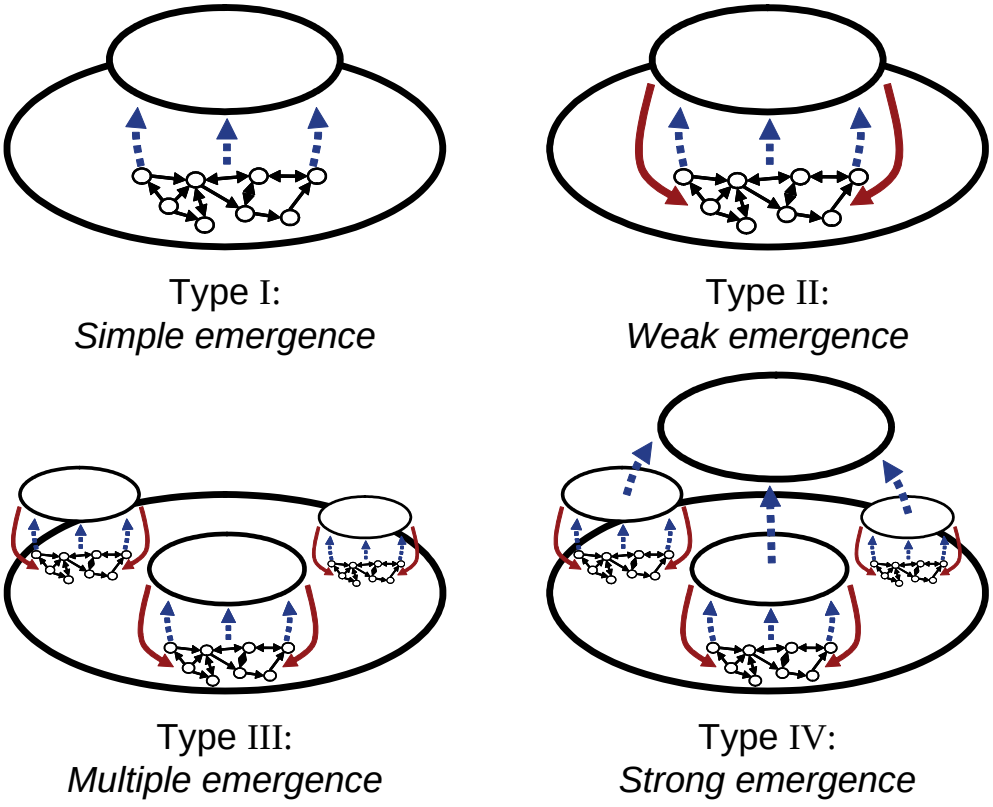


Figure 7 : Types of complex systems (Fromm, 2005).

The following examples are taken largely, and slightly adapted, from Fromm (2005) unless otherwise indicated.

4.2.2 Examples

4.2.2.1 Type I: Simple emergence

Top-down feedback: None

Complex system example:	Machine (e.g. clock)
Agents:	Clock parts (e.g. gears)
Rules of agent interaction:	Mechanics
Emergent property:	Machine function (e.g. displays time)

Complex system example:	Software
Agents:	Lines of code, variables, etc.
Rules of agent interaction:	Rules of software language compiler
Emergent property:	Software function e.g. calculates average

Complex system example:	Spoken sentence
Agents:	Words, sounds
Rules of agent interaction:	Grammar; pronunciation rules
Emergent property:	Meaning of sentence

Complex system example:	Snow slopes
Agents:	Snow particles
Rules of agent interaction:	Mechanics
Emergent property:	Avalanche

Complex system example:	Sand pile
Agents:	Sand particles
Rules of agent interaction:	Mechanics
Emergent property:	Slope of sand pile

4.2.2.2 Type IIa: Weak stable emergence

Top-down feedback: Simple negative (constraining)

Complex system example:	Ant colony
Agents:	Ants
Rules of agent interaction:	Collective goal (e.g. find food), follow pheromone trail
Emergent property:	Foraging behaviour

Complex system example:	Flock of birds
Agents:	Birds
Rules of agent interaction:	*Separation*: Steer to avoid crowding local flockmates *Alignment*: Steer towards the average heading of local flockmates *Cohesion*: Steer to move towards the average position of local flockmates (Reynolds, 2001)
Emergent property:	Bird flocking

Complex system example:	Free-market economy (capitalism)
Agents:	Demand, supply
Rules of agent interaction:	Law of supply and demand
Emergent property:	Optimum prices of goods

4.2.2.3 Type IIb: Weak unstable emergence

Top-down feedback: Simple positive (reinforcing)

Complex system example:	Stock market
Agents:	Buyers & sellers, resources
Rules of agent interaction:	Blind imitation without estimating value
Emergent property:	Stock market crash

Complex system example:	Fashion
Agents:	The fashion conscious
Rules of agent interaction:	Imitation
Emergent property:	Fashion fad or cycle

Complex system example:	Social / political system
Agents:	Oppressors & oppressed
Rules of agent interaction:	Oppression, frustration
Emergent property:	Social unrest

4.2.2.4 Type IIIa: Multiple emergence

Top-down feedback: Multiple, short-range positive and medium-range negative

Complex system example:	Stripes & spots in animal patterns
Agents:	Melanocytes (the cells that produce coloured pigments)
Rules of agent interaction:	e.g. add up the number of immediate neighbours who are white (=short-range) minus 1/10 of the number of white neighbours in 20x20 blocks to the left and right of its immediate neighbours (=medium-range). If the sum is greater than one the cells becomes white, otherwise it becomes black
Emergent property:	Zebra stripes

Complex system example:	Stock market
Agents:	Buyers & sellers
Rules of agent interaction:	Blind imitation (=short-range); Careful consideration (=medium-range)
Emergent property:	Oscillating and chaotic behaviour

4.2.2.5 Type IIIb: Multiple adaptive emergence

Top-down feedback: Multiple, positive and negative

Complex system example:	Ecosystem
Agents:	Ecosystem components and processes
Rules of agent interaction:	Complex
Emergent property:	Increased adaptability after disturbance

Complex system example:	Scientific revolutions
Agents:	Scientists
Rules of agent interaction:	Complex
Emergent property:	Publication avalanche after new paradigm breakthrough

4.2.2.6 Type IV: Strong emergence

Top-down feedback: Multiple, multiple level, positive and negative

Complex system example:	Social systems
Agents:	Genes, amino acids, etc. etc.
Rules of agent interaction:	Complex, multiple levels
Emergent property:	Life

Complex system example:	Social systems
Agents:	People, language, etc
Rules of agent interaction:	Complex, multiple levels
Emergent property:	Culture

4.3 CHARACTERISTICS

4.3.1 Self-organisation and emergent properties

System-wide patterns, behaviours or properties, that are not properties of individual agents, emerge over time as the system organises itself.

This is the defining characteristic of a complex system. System-wide patterns develop out of (or emerge from) the aggregate behaviour of, and local interactions between, agents (also called components, individuals or elements). In essence, the emergent property is a manifestation of "self-organisation" of the system. These patterns confer a degree of high-level order or structure on the system. An emergent property is not a property of any single agent. It is a property of the whole.

4.3.2 Near-neighbour interactions

The rules governing the interactions between agents are usually such that only near-neighbour (short- and medium-range) interactions are relevant.

The primary interactions between agents tend to only involve the exchange of information with near neighbours (either short-range or medium-range). Distant agents do interact but through these cumulative near-neighbour interactions. Another way of putting this is that single agents do not have access to all the information in the system. They only react to local information.

It is these interactions that ultimately result in the emergence of the above-mentioned global characteristics. High-level (system-wide) order is therefore conferred on the system in a bottom-up manner. These characteristics typically feed back into the system changing the nature and/or behaviour of the agents.

These interactions are also typically "non-linear". This means that cause and effect relationships are not necessarily simple (although in some complex systems sometimes they can be).

4.3.3 Handful of rules

Only a small number of rules governing agent interactions are necessary for global properties to emerge.

Properties can emerge with as few as 2-5 rules of interaction between agents. However, the richness of connections between agents, especially in social systems (where the agents are humans) can mean that information will pass through the system and be modified along the way (Lewin, 1999). This is not necessarily so in purely mathematical models of complex systems in which such relationships are well-defined (there are strict unambiguous rules). Some examples (the law of supply and demand and 'zebra' stripes) are described later in this section. However, in social complex systems, these relationships are governed by heuristics which, because of their ambiguous nature, allow for modification of the message along the way. (See Section 4.5 for more on the difference between mathematical and social complexity).

4.3.4 Feedback

A variety of feedbacks from the emergent properties may exist which can affect an agent's future behaviour.

There can be an abundance of top-down feedback mechanisms. These mechanisms feed back the effects of an agent's actions (namely the emergent property or behaviour) to that agent, affecting the way that agent acts in future. These interactions between agents, and in particular the rules governing the interactions, can therefore be constantly adapting as a result of such feedbacks.

Some feedbacks are such that they constrain the agents. These "negative" feedbacks confer a degree of stability on the system. Others can be positively reinforcing and hence confer a degree of instability, and hence greater unpredictability, on the system. It is usually such feedbacks that can cause rapid even sudden change (surprise).

Like the interactions between agents, these feedback mechanisms can be "non-linear", meaning the effects they cause (in the agents and their interactions) are not necessarily simple.

4.3.5 Edging on chaos

Complex systems exist on the "edge of chaos".

Self-organisation occurs (or equivalently, global properties emerge) when the system exists in a state between stability and chaos (see **Figure 8**). Too much stability (manifesting as "inertia") inherently impedes the development of new system-wide characteristics. Also by its very nature, total chaos (randomness) is inherently not conducive to the development (emergence) of coherent system-wide patterns. It is on the borderline (the "edge") between stability and chaos that the system has the maximum ability to transform and evolve new system-wide (global) patterns and behaviours.

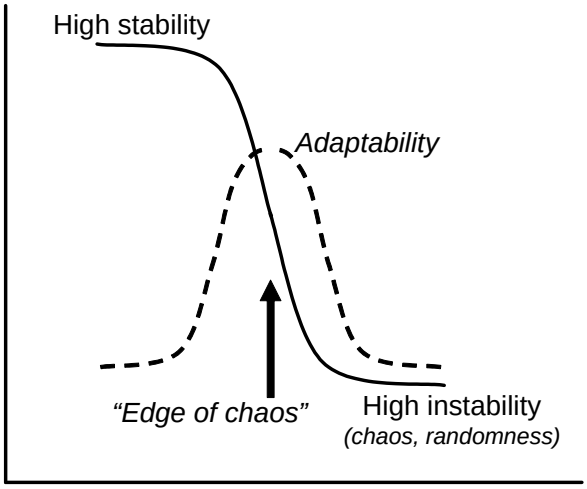


Figure 8 : Complexity: Schematic illustration of the "edge of chaos".

4.3.6 Openness

Social and ecological complex systems are open systems with flows of various kinds occurring across their boundaries. In other words, they interact with their environment.

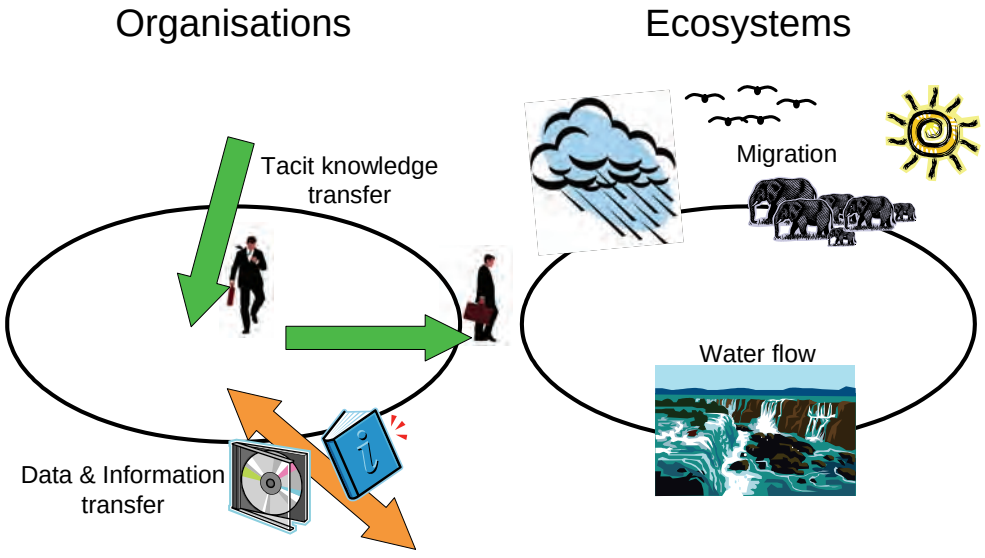


Figure 9 : Complexity: Organisations and ecosystems with cross-boundary flows.

Ecological systems, like aquatic ecosystems, are subject to the cross-boundary flow of many kinds of energy, substances, objects and animals: Rain, sunlight, migrations of animals, water, air, soil, etc. (**Figure 9**).

Social systems, for example within the boundary of a town or region, are also subject to cross-boundary flows: water, people (with their tacit knowledge), information, data, etc. An organisation is a social system. Its nature can be particularly sensitive to flows of people, information, and data. However, this does not necessarily mean that there is no stability. An emergent property may confer a degree of stability.

4.3.7 Unpredictability

The behaviour of complex systems can be unpredictable.

The very nature of complex systems is such that their emergent properties, particularly their detailed nature, are largely unpredictable. This is probably the basis for them being called "complex" systems in the first place. Besides this, it is also fairly self-evident that aspects such as openness and edging on chaos can contribute directly to unpredictability.

A particular manifestation of unpredictability is that very small differences in the initial conditions of two identical systems may result in their respective emergent properties being fundamentally different. However, it is also possible that their emergent properties will be identical.

The nature of the emergent properties is usually impossible to predict. However, the cause-and-effect relationships may sometimes be evident, at least in some general sense, in retrospect (Snowden and Stanbridge, 2004).

4.3.8 Nesting

The agents in complex systems can themselves be complex systems.

Organisations consist of people, who have brains and cells, all of which are complex systems in themselves. Therefore, the agents depicted in **Figure 10** below can also be complex systems (i.e. with their own agents, emergent properties, feedback loops, history, etc.) (**Figure 10** left). Similarly, the organisation exists within a social system which in turn exists in the broader social-ecological system (**Figure 10** right).

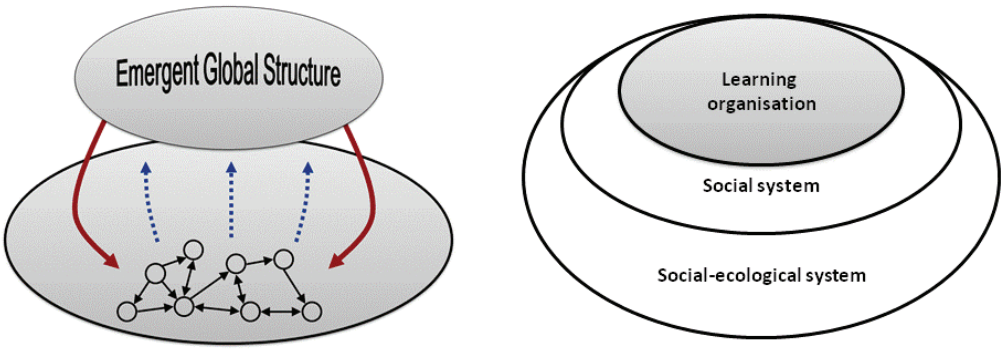


Figure 10 : Nested complex systems.

4.4 RELEVANCE TO A LEARNING STRATEGY ("SO WHAT?")

4.4.1 Learning organisations as complex systems

Are learning organisations, ecosystems, and social-ecological systems "complex systems"? As noted above, a number of authors claim this is so in respect of ecosystems and social-ecological systems. However, the following sub-sections suggest that this is also an appropriate assumption specifically in respect of learning organisations:

4.4.1.1 The emergent properties

A number of learning-related properties can be regarded as emergent:

- **The individual**: The learning abilities and knowledge of an individual can be regarded as emergent properties. Although in general the following examples are desirable and, in a best case scenario, even predictable, their precise detailed nature is not:
  - Greater learning efficiency and effectiveness;
  - Greater knowledge depth;
  - Greater knowledge breadth;
  - Greater adaptability.
- **A team**: Synergism in team work, proposed in this work as an important learning principle (see Section 2.4.2), can be regarded as an emergent property of learning teams. Synergism is, by its very nature, a property of the whole team, not of individuals.
- **The organisation**: The learning abilities of an organisation can be regarded as emergent properties if they are properties of the organisation and not of individual agents. They should be truly "embedded" in organisation procedures and culture in a way largely independent of its staff members (although the latter may be required to implement them). They may be "tried and tested" but, as above, their final detailed implementation and their precise effects are unpredictable.

4.4.1.2 The agents

The agents include people (with their tacit knowledge) and explicit knowledge forms (like databases, scientific reports, and recorded reflections on successes and failures).

4.4.1.3 The short-range interactions

Social interactions in an organisation, particularly as proposed by the learning principles "social knowledge sharing", "learning by doing", "empathy" and "synergism", are short-range by their very nature. Other short-range interactions could include interactions between people and explicit knowledge forms.

4.4.1.4 The feedback

The nature and functions of both the people and the explicit knowledge forms can change as a result of top-down feedback from any emergent property (such as what has been learned an individual or the organisation).

- In the case of people, what and how they learn inevitably changes how they do things in future.
- Similarly, the nature of the explicit knowledge forms will change (more specifically, will be changed by people) to reflect new knowledge and requirements as the people learn. This might include greater data and information content and new means of accessing them.

4.4.1.5 Nesting

People are complex systems. Social groups and learning (and other) teams are potentially complex systems. These are nested within the overall complex system that is the organisation.

4.4.1.6 Conclusion

The fact that so many parallels can be made with the formal components of complex systems strongly suggests that a learning organisation can quite reasonably be regarded as a complex system.

4.4.2 Strategy pointers

The following are some specific pointers that should influence any strategy to create a learning organisation.

4.4.2.1 Unpredictability

Perhaps the most obvious relevance of complex systems in this context is that the nature of the emergent properties is largely unpredictable. This suggests a number of issues:

- **Lack of control**: Managers cannot control organisations to the degree that a mechanistic perspective ("an organisation is a machine") suggests (Lewin, 1999). Emergent properties cannot be "designed" from first principles (or "designed away" in an attempt to avoid unwanted properties).
- **Adaptable mindset**: A mindset that "expects the unexpected" is necessary.
- **Continual monitoring**: Continual monitoring of strategy implementation and associated outcomes and performance is necessary to:
  Nip potential problematic emergent properties in the bud, and
  Nurture desirable properties.

4.4.2.2 Handful of rules

This aspect of complex systems suggests that properties emerge from agent interactions based on only a few rules. It has even been suggested that changes in social-ecological systems can be understood by examining typically no more than five variables (Walker et al., 2006). Two rules that encapsulate all the learning principles are "*Empathise and Internalise*" (see **Figure 11**):

- **Empathise**: This relates primarily to receptiveness. Such openness is important to both empathy and experimentation.
- **Internalise**: Complementing the receptiveness of empathy, internalising builds the capacity to respond to signals received. The all-encompassing nature (the "breadth") of what should be internalised is epitomised by Transdisciplinarity (see Section 2.6.5: Transdisciplinarity). How this should be internalised is through social knowledge sharing, common future focus, learning by doing, prior knowledge engagement, synergism, positive persistence, patience, and adaptability. All of these principles improve learning efficiency and effectiveness, and knowledge depth (see Section 2.6: Principles and outcomes).

4.4.2.3 Feedback

Feedback and evolving rules of agent interaction are directly related to learning:

- **Learning means change**: Feedback that changes future behaviour is the essence of "learning". Learning to remain the same is contradictory. If we want people to learn (so

that the organisation can learn), then we are explicitly acknowledging its dynamic nature. This demands a sufficiently dynamic (adaptable) strategy.

- **Importance of organisational memory**: Current agent interaction rules depend on the system's history. If memory of the system is deficient, then different, and possibly bad, rules may evolve. To ensure that the two most fundamental agent interaction rules (namely, "don't make the same mistake twice" and "make the most of that good situation if it arises again") operate with greatest effectiveness, effective organisational memory is essential.

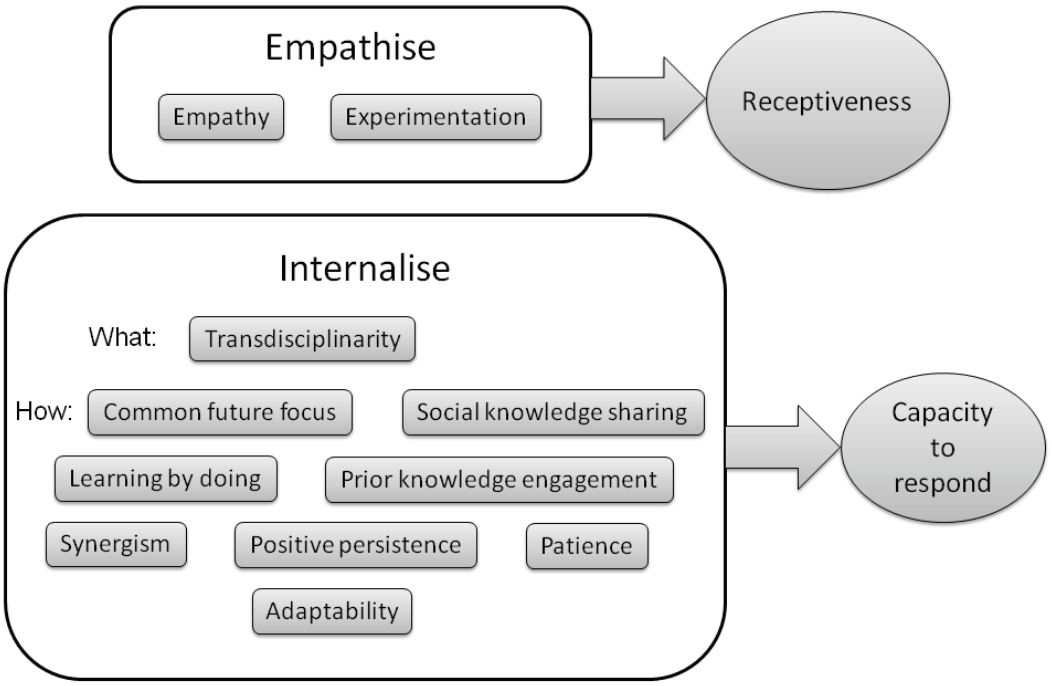


Figure 11 : Categorisation of the learning principles into two core learning rules.

4.4.2.4 History

Memory, whether organisational, institutional, social, or ecological, is explicitly or implicitly manifest in the rules governing interactions between agents. As global properties emerge, top-down feedback can change the rules of agent interaction. These evolve and further influence the global emergent property. The rules of agent interaction at any time are therefore a function of the system's history.

Watts (2003) (quoted in Hammond and Glenn, 2004) describes interaction rules in social systems as the rules by which relationships are formed and how they function. He suggests that interaction rules are how history is relevant to your future. Interaction rules are the locus of the conflict between structure and agency. While the structure is provided by the social rule, agency is provided by the individual.

What an individual learns in an organisation is very much dependent on what is already known to (or believed by) other members of the organisation and what kinds of information are present in the organisation environment (Simon, 1991), namely, organisational memory. This is consistent with the notion that current rules depend on the history (and memory) of the organisation.

In the context of organisational change, Smith (2005) noted the importance of a strong set of collective beliefs and expectations, which bind an organisation to its history and traditional operational practices. Without changing the values that fasten an organisation to these old behaviours, no amount of other changes will endure.

The evolution of emergent properties and the agent interactions responsible for them has particular relevance in a country like South Africa. Any social-ecological system in South Africa is very likely to involve people who were disadvantaged by the previous political regime and those who benefited from it. South African society is currently somewhat divided into two camps. One insists on remembering the past. The other insists on looking forward. If history is important for understanding (and possibly influencing) complex systems, then we must all take cognisance of where we have come from when planning where to go.

4.4.2.5 Edging on chaos

In order for an organisation to change (or adapt) it must exist on the edge of chaos i.e. it must not be too stable or too "chaotic". Stable organisations can move towards the edge of chaos if (Seel, 1999):

- Their agents become better connected; or
- If there is more diversity (but not to the extent of random misalignment), for example as implied by the "experimentation" learning principle; or
- If information transfer is increased (but not to overload levels); or
- The level of contained anxiety is increased (but not to "headless chicken" levels); or
- If the power differentials between different parts of the organisation are reduced (but not to the point of anarchy).

4.4.2.6 Openness

The concept of being "open" highlights the potential sensitivity (and hence vulnerability) to the nature and extent of knowledge, information and data flow into and out of the organisation. The fact that these flows can be highly dynamic creates a sense of uncomfortable dependence (i.e. a lack of control) and a sense of unpredictability of their effects. These issues further emphasise the importance of (a) a mindset that expects the unexpected and (b) continual monitoring.

4.4.2.7 Nesting

Although a strategic focus might be on trying to influence the emergence of global learning properties, the inevitable emergence of many other kinds of properties, at multiple levels and in many contexts, will also occur. These may influence the desirable learning properties, be influenced by them, or be totally independent of them.

4.4.3 Strategy principles

If an organisation is a complex system, then the above issues suggest the following series of strategy principles for moulding a learning organisation:

Table 8 : Complexity-based strategy principles for moulding a learning organisation.

Strategy principle	Reason
Influence, don't control	*Self-organising systems, by definition, can't be controlled*
Focus on a few critical rules	*Only a few rules are necessary for emergent properties*, e.g. *empathise and internalise*
Monitor, monitor, monitor	*Complex systems with emergent properties that have positive reinforcing feedbacks can cause very rapid change*
Expect the unexpected	*Complex systems are unpredictable*
Acknowledge the past	*In a self-organising system the present depends intimately on the past*
Don't get too comfortable	*A system is most adaptable on the edge of chaos*

4.5 MATHEMATICAL VERSUS SOCIAL COMPLEXITY

Snowden and Stanbridge (2004) suggest a four-quadrant classification of management styles based on order/un-order and rules/heuristics (see **Figure 12**).

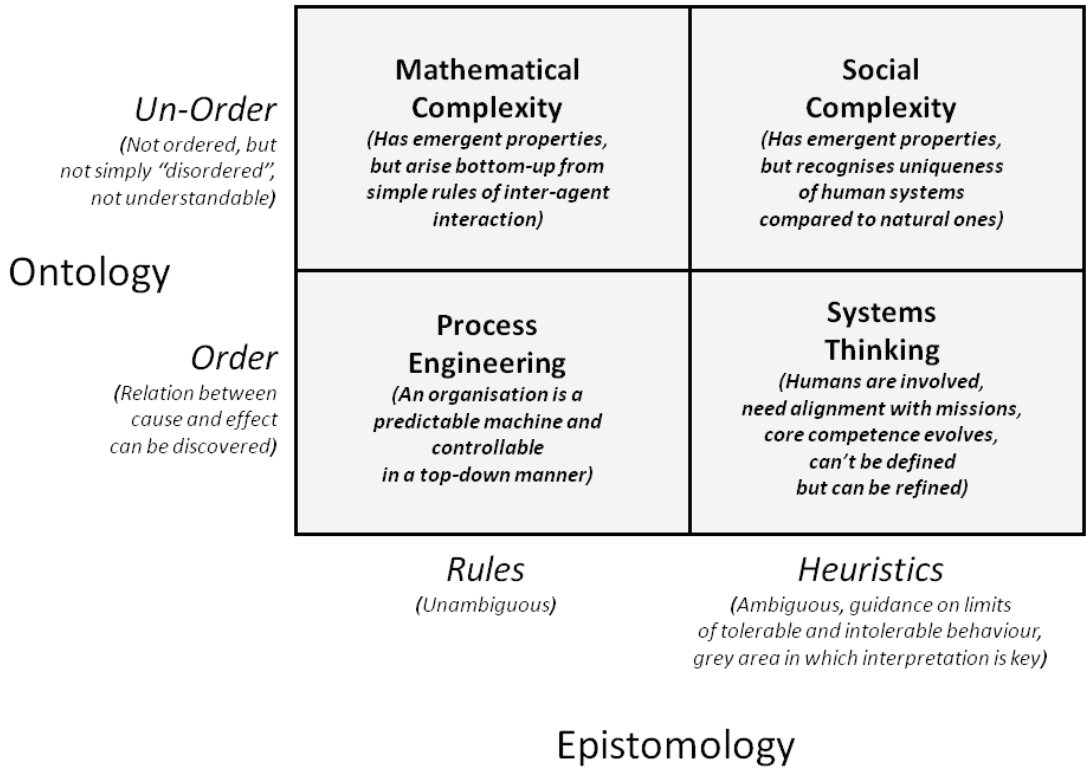


Figure 12 : Snowden's and Stanbridge's (2004) management landscape.

Systems thinking (as for example proposed by Senge (2006)), acknowledges the ambiguity of heuristics but does not accommodate the "un-order" of complex systems. "Un-order" is being used in the same form as Bram Stoker in Dracula talks of the "undead" as something neither dead nor alive but somehow "other" that we cannot fully understand or comprehend.

Mathematical complexity encompasses un-order and emergence but is based on rules, however not applied as a top-down control mechanism but at the level of agent behaviour to simulate system level (global) properties.

Social complexity acknowledges the uniqueness of humans. Snowden and Stanbridge (2004) propose the following unique aspects of humans:

- **Humans make decisions based on patterns**. Therefore, in other than a constrained set of circumstances there are *no rules to model*.
- **Humans create and maintain multiple identities** (home-based, work-based, father-brother-son-husband, fisherman, runner, soccer player, etc.). Therefore, in other than a constrained set of circumstances there are *no clear agents to be modelled*.
- **Humans ascribe intentionality and cause where none necessarily exist**. If a particular accidental or serendipitous set of actions on our part lead to beneficial results we have a natural tendency to ascribe them to intentional behavior and come to believe that because there were good results, those results arose from meritorious action on our part. Instead we should acknowledge that some things just 'are' by virtue of multiple interactions over time.
- **Humans have learnt how to structure their social interactions to create order**. These might include rules of the road, social etiquette, etc.

The "richness of connections" in an organisation is reflected in the relative abilities of people to understand a message and then communicate it accurately. This is undoubtedly dependent on innate skills and prior knowledge. The heuristic nature of human interpretation, and hence the potential for modification of information during transfer, highlights at least the need to acknowledge its possible existence. It also places a particular onus on those individuals primarily responsible for data and information management, interpretation and subsequent transfer.

4.6 UNPREDICTABILITY OR PREDICTABILITY (OR BOTH)?

The fact that humans can create structure prompts a fundamental question:

*To what extent can an organisation learn how to structure its learning-related interactions so that the organisation as a whole "learns" in an entirely predictable (*i.e. *non-complex) way?*

An equivalent question is: To what extent is the emergence of an organisation-wide learning property solely an emergent property typical of a complex system?

If we accept that humans can create structure by working within certain rules, then why can humans in an organisation not create a learning organisation simply by (a) ensuring certain pre-requisites are in place, and (b) applying a series of well-defined rules?

It is not "to be or not to be" (i.e. it is not either or). It is something involving both. It seems not unreasonable to assume that reality may be a combination of both predictable outcomes and unpredictable (complex system related) outcomes. An alternative expression is that the behaviour of real organisations includes both that predicted using the "an organisation is only a machine" model and "an organisation is a 'pure' complex system". Accordingly, the following is proposed as a working hypothesis:

Hypothesis:

The general transformation of an organisation into a learning organisation, involves predictable (i.e. non-complex) cause and effect relationships between (a) a series of well-defined infrastructural pre-requisites and learning-related activities and
(b) the organisation's ultimate ability to be a true "learning organisation".

However, the precise path taken to achieve this,
and hence the precise nature of that ultimate ability,
will be determined by unpredictable emergent properties
(either directly or indirectly related to learning)
typical of a complex system.

In essence, this hypothesises that organisations are generally predictable machines whose detailed evolutionary paths and states at given points in time are (a) fine-tuned or (b) occasionally totally disrupted by unpredictable complex emergent properties.

If this working hypothesis is accepted, then this means that a strategy to transform an organisation to a learning organisation involves the following three general issues:

- Defining and implementing the necessary infrastructural pre-requisites (such as sound data and information processing practices), and

- Defining and implementing the optimum learning activities (defined largely at present by the learning principles).
- Applying the above-mentioned strategy principles.

4.7 EXAMPLES OF MATHEMATICAL COMPLEX SYSTEMS

4.7.1 Introduction

The following sub-sections describe in a very superficial manner a few simple mathematical complex systems. The primary purpose of this exercise was to explore very briefly the behaviour of certain relatively simple systems that exhibit complexity. In particular, this behaviour includes emergent properties and feedback from these properties to the agents. The latter property in effect makes these systems "complex adaptive systems" because the agent's behaviour changes (i.e. adapts) over time as a direct result of the emergent property. It might also be noted that the complex systems examined here are not open systems in the sense defined above.

This exercise is deliberately not in-depth. It reflects a small degree of "learning by doing", that is, exploring the mechanics of an actual (albeit mathematical) complex system.

4.7.2 Free-market economy: The law of supply and demand

The "free-market economy" is defined as one in which the allocation of resources (synonymous with supply) is determined solely by supply and demand, both of which are not subject to regulation (Bannock et al., 1987). The same source also provides the following definitions:

Supply: The quantity of a good or service available for sale at any specified price.
Demand: The desire for the good or service supported by possession of the means of exchange to effect ownership.
Price: What is given in exchange for the good.

Three sources, namely Fromm (2005), Bannock et al. (1987) and Pallister and Isaacs (1996) were consulted for a more in-depth definition of the "law of supply and demand". However, it is evident that they are not all in total agreement. Accordingly, a combination of concepts from each was compiled that is hoped is a holistic representation of this law. In essence, this law comprises three statements:

The "law of supply of demand" means:

1. A rise in demand will cause both supply and price to increase.
2. A rise in supply will cause both a fall in price and a drop in demand.
3. A rise in price will cause the supply to increase and demand to decrease.

Demand and supply are regarded as the "agents". The price is regarded as the emergent property. The third rule above is the feedback rule (from emergent property to the agents). The three rules (and a brief attempt to explain them) are captured in **Figure 13**. Solid lines mean an increase in the value of the variable at the tail of the arrow results in an increase in the variable at the head of the arrow. A dashed line means an increase in the variable at the tail of the arrow results in a decrease in the variable at the head of the arrow.

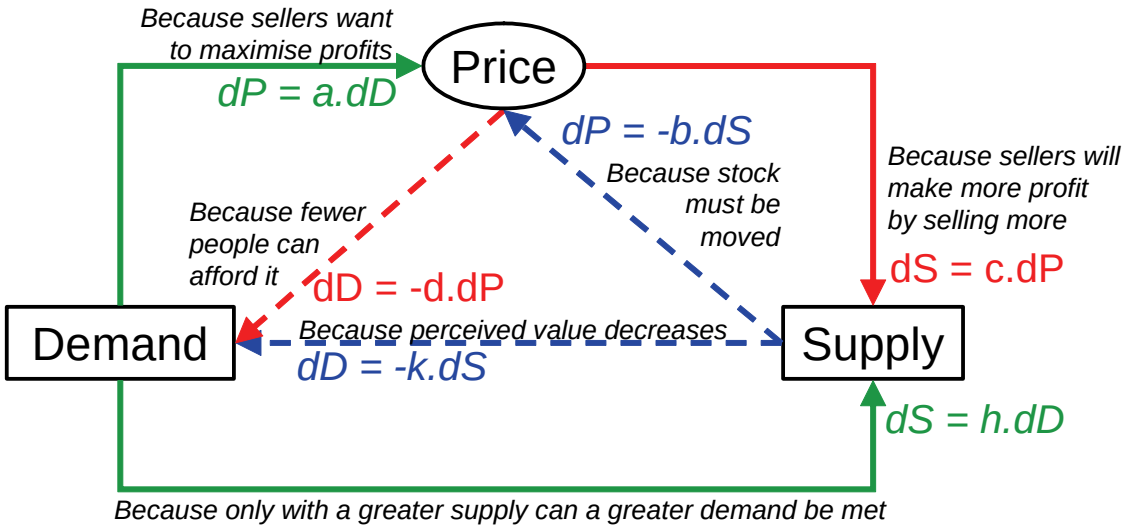


Figure 13 : Law of supply and demand: A systems model.

The six simple formulae (two for each of the above three rules) are shown in "differential" format (e.g. dP). The differential is closely related to the difference in the function at two nearby values (ΔP). As an example, the rule "a rise in demand D causes an increase in supply S" can be written as follows:

$$dS = h.dD$$

This formula states that an infinitesimal increase in demand, namely dD causes an infinitesimal increase in supply, namely dS. The latter change can be calculated by multiplying dD by some (as yet unknown) positive constant, namely h.

A fundamental (and possibly unjustifiable) assumption is made here, for simplicity, that the function is linear.

The six formulae can be combined into three mathematical "rules" that describe how P, D and S change as a function of the others:

$$\mathbf{dP = a.dD - b.dS} \qquad \textbf{Eqn. 1}$$

$$\mathbf{dD = -d.dP - k.dS} \qquad \textbf{Eqn. 2}$$

$$\mathbf{dS = c.dP + h.dD} \qquad \textbf{Eqn. 3}$$

A simple iterative algorithm can be set up that proceeds as follows (assuming the constants a, b, d, k, c, and h are known):

1. Given dD and dS, calculate dP (Eqn. 1).
2. With dS and the calculated dP, calculate dD (Eqn. 2).
3. With the calculated dD and the calculated dP, calculate dS (Eqn. 3).
4. Repeat from Step 1.

An in-depth examination of the precise quantitative nature of each interaction and an estimation of values for the constants that reflect "reality" would be ideal. That is, it may make the model more "realistic" and hence representative of an actual free-market economy. However, under the current circumstances of merely wanting to gain generic insights into the nature of complex systems (and not predict "real" free-market behaviour, or any kind of "real" behaviour for that matter), this is unjustifiable. Accordingly, values for the constants were simply guessed and absolutely no attempt

was made whatsoever to reflect "reality". The system was therefore simply regarded as a mathematical system whose sole purpose is investigation of its behaviour.

This was done by choosing different values for the constants and observing how dP (the change in price) changed. Actual values for price, demand and supply were not considered. The way equations 1 to 3 are expressed only requires changes in these variables to be considered. The whole idea behind the law of supply and demand is that, simplistically, the "forces" between the three variables are such that a kind of "equilibrium" price emerges that "balances" these forces. As such, Fromm (2005) notes that this is an example of a Type IIa system (weak stable emergence) with "simple negative (constraining)", or equivalently, stabilising, top-down feedback that, for example, prevents the price from "sky-rocketing".

Note that the system can be regarded as "stable" if dP tends to zero (that is, no further change in the price is evident – it has stabilised on a particular value). It would be "unstable" if it did not, that is, if dP increased in value away from zero.

On the whole the system showed widely varying behaviour (see **Figure 14**). In some circumstances it was stable. However, under other circumstances it was impressively unstable, sometimes showing severe oscillatory behaviour. As examples, the following table shows six sets of values for the constants and the initial values of dS and dD.

Table 9 : Law of supply and demand: Constants and initial values for the model.

	a	dS	b	dD	d	k	c	h
1	0.1	0.1	5	0.1	0.1	1	0.1	0.1
2	0.1	0.1	0.2	0.1	5	1	0.1	0.1
3	5	0.1	0.2	0.1	0.1	1	0.1	0.1
4	0.1	0.1	0.2	0.1	0.1	10	0.1	0.1
5	0.1	0.1	0.2	0.1	6	1	0.1	0.1
6	0.1	0.1	0.2	0.1	0.1	1	8	0.1

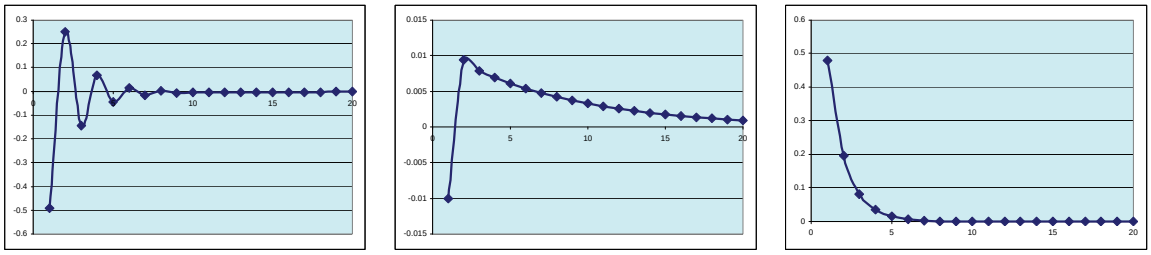
The X-axis is simply reflecting each step in the iterative solution of the above equations. This may be regarded for current purposes as being more-or-less equivalent to time.

The following observations are made:

- Behaviours 1, 2 and 3 show how the price stabilises.
- Behaviours 4, 5 and 6 show how the price destabilises.
- Behaviours 1 and 4 show convergent and divergent oscillatory behaviour respectively.
- Behaviours 2 and 5 show how a small difference in a single constant (namely d) can flip the system from stabilising to destabilising behaviour.

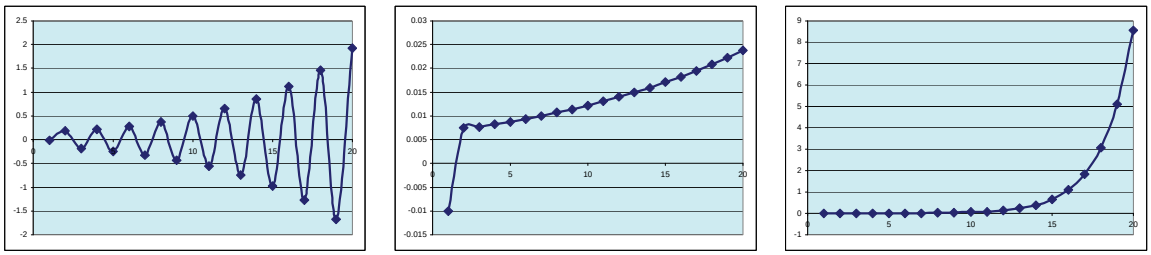
Although not shown above, it was also easy to demonstrate that changing certain constants over very wide ranges produced the same general behaviour over the whole range (i.e. either stabilising over the large range or destabilising over the large range). Only when certain "thresholds" were exceeded did the behaviour change radically (like from stabilising to destabilising).

Negative, constraining, stabilising



1 2 3

Positive, reinforcing, destabilising



4 5 6

Figure 14 : Law of supply and demand: Graphs of behaviour of model.

Although this exercise was deliberately superficial, a few general conclusions can be drawn.

- A wide variety of behaviours is possible.
- That large ranges of constant values resulted in the same kind of behaviour suggests an overall collection of states that are either (a) relatively stable and even somewhat predictable or (b) unstable and divergent.
- Flipping between these states can occur quite suddenly with only small changes in the rules (reflected in the values of the constants) governing agent interactions. This is a typical property of complex systems. This kind of behaviour also contributes to the unpredictability of this complex system. The values of the constants at these flip-over points are clearly “thresholds”.
- Contrary to the implications made by Fromm (2005), the mathematical system chosen here shows behaviour of both Type IIa (weak stable emergence) and Type IIb (weak unstable emergence) complex systems.

As an aside, it might be noted there that there are few examples of true free-market economies (i.e. strictly obeying the law of supply and demand) since there are limitations on market freedoms in all countries (Bannock et al. (1987)). This may be one reason why destabilising behaviour may be uncommon in practice (although examples such as run-away inflation in Zimbabwe may well be such behaviour).

4.7.3 "Zebra" stripes

As noted above, animal stripes, such as those of a zebra, are emergent properties of a complex system. Melanocytes, the cells that produce coloured pigments, are the interacting agents. In the following zebra stripe model they are either white or black.

Feedback occurs through two routes (see **Figure 15**). The short-range positive (reinforcing) feedback of immediate neighbours has the potential to be destabilising (possibly reflected in excessive numbers of white cells or excessive black cells). However, this is countered (i.e. stabilised) by negative feedback of sets of neighbours to the left and right of the block of immediate neighbours (i.e. those agents occurring at what might be termed medium-range). It is inevitably this left and right characteristic that imparts the directionality to the emerging stripes.

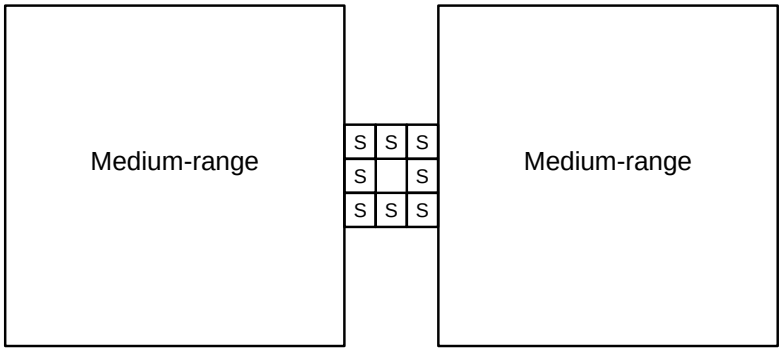


Figure 15 : "Zebra" stripes model: Location of short-range and medium-range cells.

To be more specific, Fromm (2005) quotes the following rules of interaction:

1. Sum the number of immediate neighbours that are white (the short-range feedback).
2. Calculate 1/10 (one tenth) of the number of white neighbours in 20x20 blocks to the left and right of its immediate neighbours (the medium-range feedback).
3. Subtract the answer obtained from 2 from the answer obtained from 1.
4. If the result is greater than 1, then the cell becomes white. Otherwise it becomes black.

Details of model: The model was programmed in Visual Basic within Excel. It might be noted that Fromm (2005) did not provide any detail on initial conditions and the sequence in which cells should subsequently be processed. These were established by trial and error. The following provides the necessary detail:

A matrix of 150x150 cells was defined. It is evident from the above rules that an initial condition must exist that contains some white cells (otherwise there are no white cells enabling others to become white). All cells were initially defined as "undefined" and 30 white "blotches" imposed in random positions in the matrix. These blotches were defined as being 5x5 cells in size. The cells were then processed according to the above rules one (horizontal) row at a time. For each row in turn, each column was then processed from 1 to 150. Once assigned as either white or black, a cell was assumed to remain so. A series of seven initial blotches were also placed in row one at equal intervals over the 150 columns.

After some trial and error, it was found that rule 2 above provided "better" results (i.e. apparently more realistic) when 7x7 blocks were used (not 20x20). Three examples of the results obtained are shown in **Figure 16**.

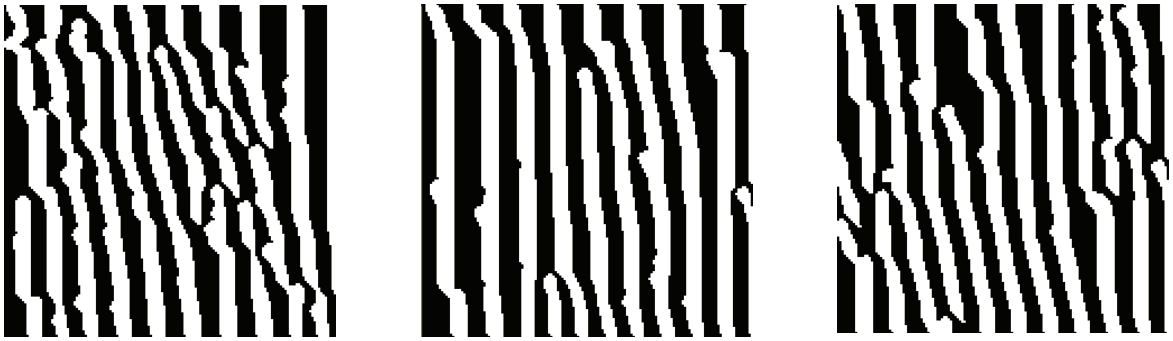


Figure 16 : "Zebra" stripes model: Examples of the model output.

The following are some observations:

- Without hindsight and experience with the model, it is not immediately obvious from the above relatively simple rules that alternately black and white stripes will emerge. This is typical of a complex system.
- In retrospect (and with experience) one can roughly understand from the nature of the short-range and medium-range interaction rules that (a) the spread of white cells is encouraged when there are no or few white cells in the medium range and (b) some kind of constraint and possibly directionality may result when the medium-range blocks become increasingly filled with white cells. However, the detailed outcome is certainly not obvious.
- This fascinating example of an emergent property clearly illustrates, for example as reflected in the average width of the stripes, how simple agent interaction rules result in a global pattern. Compare this situation with what might perhaps be a more intuitively obvious model that *explicitly* imposes some average width (and directionality). In the latter the effect (the width) is explicitly related to the cause (the mathematical term that imposes the width). In the above example the effect is not so obviously related to the cause.

It should be noted that the existence of the above rules and model that (very roughly) simulate "zebra" stripes should not be regarded as any evidence whatsoever that these may be related in any way to the actual process determining real zebra stripes. In other words, this is an entirely empirical explanation (and possibly one of a number). It is not intended to be mechanistic in any way. At most this model suggests that if one were to search for the actual mechanism of zebra stripe formation, one might consider looking for simple rules between a few "agents", one kind of agent presumably being the melanocytes.

This latter caution on the interpretation of the above model highlights the most important conclusion of this exercise. This is that a striking pattern (in this case in nature) may be explained by a small set of simple rules of interaction between a set of agents (which the pattern itself influences). This is the very essence of a complex system.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

This chapter describes the overall outcome of the work, drawing conclusions and providing recommendations.

5.1 INTRODUCTION

The preceding chapters have described much of the underlying and preparatory thinking of the ultimate intended learning philosophy and strategy for enabling effective learning in catchment management agencies (which appear in WRC Report No. TT 421/09).

5.2 CONCLUSIONS

The following summarise the conclusions drawn from the work:

- This work, as captured in this and WRC Report No. TT 421/09, has addressed the three original objectives of the project.
- The general environment in which catchment management agencies currently operate, and will operate in future, is very demanding from many points of view.
- This demanding working environment will place specific demands on those catchment management agencies which explicitly choose to place emphasis on appropriate learning. It cannot be simply be business as usual.
- The nature of learning and its underlying principles is such that it is difficult to be categorical about anything. It is particularly difficult to be quantitative.
- Equivalently, it is difficult to rigorously test whether the proposed learning principles are correct (i.e. the essential ones) or sufficient (i.e. they are all captured). Nevertheless, those subjective tests that can be performed (like comparing them with the recommendations of reputable workers in the field) have given reason for confidence in their appropriateness.
- The proposed learning principles are at a very low-level enabling level in the sense of the kind of guidance a policy might provide. Their guidance is very general and therefore strategies that may make them operational might vary considerably from one situation (and catchment management agency) to the next.
- The new business ethic will demand a special human-centred sensitivity to change and a tricky balancing of the inevitable short-term demands of the social-ecological system with the optimum long-term strategies that will ensure an appropriate level of sustainability.
- Complexity theory has much to offer the water resource manager. Probably its most important role will be to provide a justification for the kind of management mindset that is required, especially in acknowledging the inevitability of surprise. However, it also

suggests how complex systems should be managed, namely that constructive emergent behaviour should be managed with gentle persuasion, not command and control.

5.3 RECOMMENDATIONS

The following recommendations are made:

- It is strongly recommended that the basic concepts of complexity theory be understood by water resource managers.

- Because a water resource governance and management mindset must acknowledge surprise, or equivalently, unpredictability, it is strongly recommended that strategic adaptive management be considered as an appropriate framework within which to develop sound learning practices. It has been developed specifically to cope with the uncertainty associated with decision making.

- The nature of learning is such that it is recommended that monitoring of learning-related progress (e.g. in a strategic adaptive management context) be more qualitative than quantitative.

- It is recommended that this and WRC Report No. TT 421/09 be distributed directly to at least (a) the DWAF Institutional Oversight directorate, (b) all current DWAF regional offices, and (c) all existing CMAs and proto-CMAs.

- Because of the fundamental nature of sound learning to the effectiveness of a CMA, it is recommended that it be explicitly captured in any CMAs catchment management strategy.

- The nature of the work undertaken in this project was of a fundamental nature leading to a general philosophy and strategy. It is therefore recommended that this work be continued by a phase which makes these practically operational for at least the Inkomati CMA.

CHAPTER 6: SURVEY OF TERMS

This chapter presents a survey of literature definitions and explanations of useful terms used in the context of learning and knowledge management.

Importantly, being a component of the background research to the ultimate philosophy and strategy captured in WRC Report No. TT 421/09, this chapter makes no concerted effort to provide a single internally-consistent series of definitions of the terms. Many are discussed in some detail and some present multiple definitions and related concepts appearing in the literature.

Absorptive capacity

Absorptive capacity is the ability of an individual, organisational or social grouping to recognise the value of new, external information/knowledge, assimilate it and exploit it for benefit. It refers to a limit to the rate or quantity of information that can be absorbed and is largely a function of the level of prior related knowledge. This prior knowledge may include basic skills, a shared language or knowledge of the most recent scientific or technical developments in a given field – all of which permits effective communication across boundaries (Cohen and Levinthal, 1990).

Adaptability

- Adaptability is the capacity of actors in a system to influence the resilience of that system – e.g. whether they can intentionally avoid crossing into an undesirable system regime (Walker *et al*., 2004).

- Adaptability is the ability to adjust our own identity to retain fitness in the face of changing goals and changing constraints, where fitness means the ability to maintain congruence among a) a set of goals, b) the set of processes required to achieve them, and c) constraints imposed by boundary conditions (Giampietro, 2004).

Benchmarking

The continuous, systematic process of measuring and assessing products, services and practices of recognised leaders in the field to determine the extent to which they might be adapted to achieve superior performance (TBCS, 1996, quoted in DNRE, 1997).

The process of benchmarking and the sharing of best practices are ways of learning from the experience of others, adapting the knowledge gained and significantly improving operational performance. Simply stated, if you are going to redefine or reshape the way you serve your internal and external customers, check to see if someone else has already gone in the direction you're headed (TBCS, 1996, quoted in DNRE, 1997).

Best practices sharing

The capture, dissemination and sharing of a work method, process or initiative to improve organisational effectiveness, service delivery and employee satisfaction (TBCS, 1996, quoted in DNRE, 1997).

Cognitive

Relating to the mental act or process by which knowledge is acquired, including perception, intuition and reasoning.

Community of practice

A group of people who (a) share a passion and (b) meet regularly and informally to learn and practice how to do things better (Wenger, 2004). Wenger lists three fundamental characteristics of communities of practice:

- **Domain**: A community of practice is about something. Its identity is defined not only by a task, as it would be for a team, but by an "area" of knowledge that needs to be explored and developed. The area of focus, or domain, provides a common purpose that gives the community its identity and defines the key issues that members need to address;
- **Community**: A community involves people who interact and who develop relationships that enable them to address problems and share knowledge. Community refers to the group of people for whom the domain is relevant, and the quality of the relationships among members. These relationships enable collective learning; and
- **Practice**: A community of practice is not merely a community of interest. It brings together practitioners who are involved in doing something. Over time, they accumulate practical knowledge in their domain. They also have a special connection with each other because they share actual experiences. They understand each other's stories and insights. This allows them to learn from each other and build on each other's expertise. Practice refers to the body of knowledge, methods, tools, stories, cases and documents which members share and develop together.

Complementary knowledge

Knowledge between entities can only be complementary if it is different, yet at the same time related (Zahra and George, 2002).

Complicated

Consisting of many interconnecting elements; intricate (Compact Oxford English Dictionary). A *complicated* system differs from a *complex* system (see Complexity) in that the behaviour of a complicated system can be deduced from the understandable interactions of its component parts. Complex systems are inherently unpredictable.

Deeply embedded life interests

Long-held, emotionally driven passions, intricately entwined with personality. They drive the kinds of activities that make people happy. It keeps people engaged, and it keeps them from quitting (Butler and Waldrop, 1999).

Double-loop learning

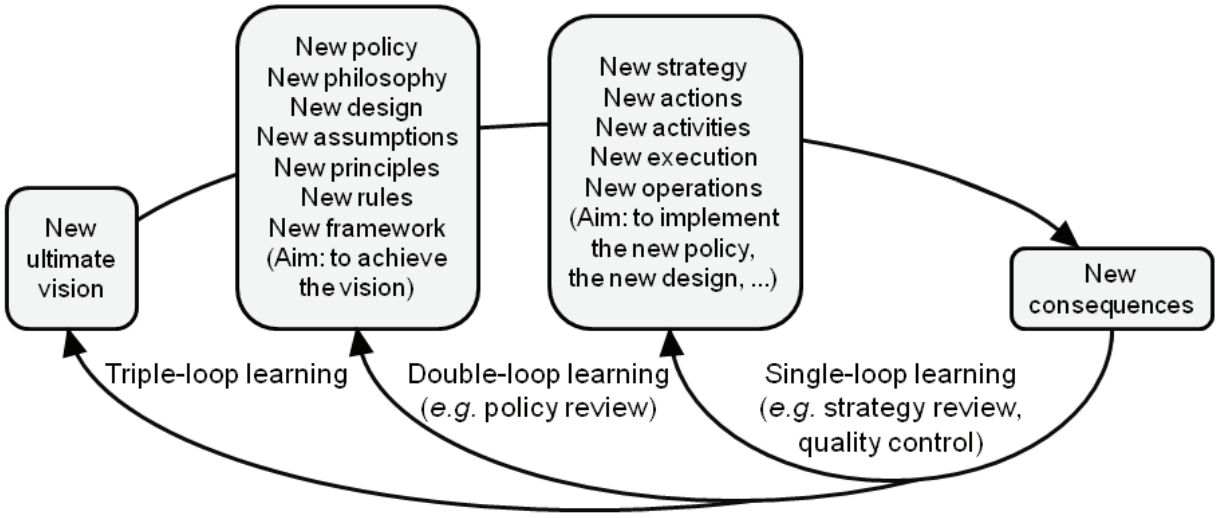


Figure 17 : Single-, double- and triple loop learning.

The general framework within which single-, double-, and triple-loop learning can be understood is as follows: An ultimate vision leads to a policy (design, assumptions, principles etc.) to achieve it, which in turn requires a strategy (actions, activities, etc.) to implement, which leads to consequences from which learning takes place.

In essence, single-loop learning changes what or how something is done. Double- and triple-loop learning changes why things are done.

Single-loop learning involves detection and correction of errors relating to everyday operations, much like in quality control. It typically results in incremental change (Smith, 2005).

Single-loop learning is concerned with improving efficiency and effectiveness within existing goals and objectives, keeping organisational performance within the range specified by existing values and norms. Thus the values and norms remain unchanged (Argyris and Schön, 1996). Changes in behaviour are at the level of "*more of the same, but better*." (Groot and Maarleveld, 2000).

Double loop learning involves questioning (reviewing), and revising if necessary, the policy, design, assumptions, principles, etc. for which an original strategy was developed. This can result in extensive revision of operational strategies (Smith, 2005).

This is learning that results in a change in the values of theory-of-use, as well as in its strategies and assumptions. The double loop refers to the two feedback loops that connect the observed effects of action with both strategies and the values and norms that define effective performance. Double loop learning exposes underlying norms, assumptions and objectives to questioning in an effort to reformulate them into innovative and creative responses to organisational problems. (Argyris and Schön, 1996).

Triple-loop learning occurs when the original premise behind the policy, design, assumptions, etc. is questioned (reviewed) and revised if necessary (Raelin, 2001). Radical reorganisation can result.

This learning occurs when essential underlying principles are questioned to the extent that it includes (re)designing the norms and protocols that govern single and double loop learning. Thus it entails learning about single and double loop learning (Groot and Maarleveld, 2000).

Ecological memory

See Memory, ecological

Ecological surprise

A qualitative disagreement between ecosystem behaviour and *a priori* expectations – an "environmental cognitive dissonance" (Gunderson, 2003).

Entrepreneurship

The process of creating value by bringing together a unique package of resources to exploit an opportunity (Morris and Kuratko, 2002).

Epistemology

The part of philosophy that is about the study of how we know things (Compact Oxford English Dictionary).

Governance

Governance is a political process of participative government in which society shapes the general rules of the game, one outcome of which is policy.

Governance, adaptive

The concept of adaptive governance is used to expand the focus from adaptive management of ecosystems by addressing the broader social contexts that enable ecosystem-based management (see Dietz *et al*., 2003). Governance refers to creating the conditions for ordered rule and collective action; creating institutions for social coordination; structures and processes by which societies make decisions and share power.

Governance, cooperative

Cooperative governance refers to a means for achieving direction, control, and coordination of individuals and organisations that have varying levels of autonomy to advance the interests or objectives to which they jointly contribute. It also involves formal organisational structures, personal relationships, and judgement by those individuals working in the complex space of

administering public programmes. It is inherently political and involves bargaining, negotiation, and compromise (Imperial, 2004).

Cooperative governance is also referred to as network governance.

Governance, ecosystem

Good ecosystem governance can be defined as cooperative governance of functional social-ecological systems underpinned by the principles of (a) transparency (honesty and openness), (b) effective stakeholder engagement (including co-operation between all relevant government departments), (c) accountability of all role players, (d) consistency (of application of procedures), and (d) adaptability and transformability

Heuristic learning

Self-education through a combination of experimentation, trial and error, experience, and self-discovery (as opposed to being taught directly).

Heuristic rule

Ambiguous rules that permit a degree of ambiguity of interpretation. They provide general guidance in which extremes of tolerable and intolerable behaviour or interpretation may be clear, but for which there is a large grey area where personal interpretation is key (adapted from Snowden and Stanbridge, 2004).

Indicator

An estimable, or preferably directly measurable, attribute of a system used to represent the degree to which another related property of the system exists. It can be expressed either semi-quantitatively (e.g. low, medium, high) or quantitatively (e.g. on a scale of 0 to 10). The related property would typically be difficult to measure directly so surrogate measures (i.e. the indicators) are used instead. The following are some examples:

- A measurement of the single bacterium *E. coli* is used to indicate the presence of microorganisms of faecal origin (which may include a wide range of bacteria, viruses, and parasites).
- Percentage staff turnover in an organisation is one (inverse) indicator of the general degree of staff satisfaction.

Information

Interpreted data or data endowed with some relevance and purpose (e.g. Drucker, 2001). In the current context, information in explicit from is that which is stored in books, libraries and on computer systems.

Interdependence

The degree to which two or more activities interact to determine the outcome jointly. Interdependence can be classified into three categories. Pooled interdependence links independent entities. Sequential interdependence occurs in cases where serial dependence exists. Reciprocal interdependence refers to instances where one party affects the output of a second party and vice versa (Thompson, 1967).

Knowledge

That which is known, or knowable, by a person, that can contribute to their capacity to act effectively (partly based on Dawson, 2000). For a person, that which is knowable exists in, for example, books (containing explicit knowledge) and in other people (possessing tacit knowledge) that may be consulted by the person who needs to take effective action.

Knowledge is sometimes referred to as a capacity, either to act (Sveiby, 1997) or act effectively (Dawson, 2000). However, a capacity to act cannot be comprised of knowledge alone. It also requires an enabling environment (e.g. infrastructure, finance, etc.). Knowledge should not therefore be defined as the capacity itself.

Knowledge can fall into a number of different categories:

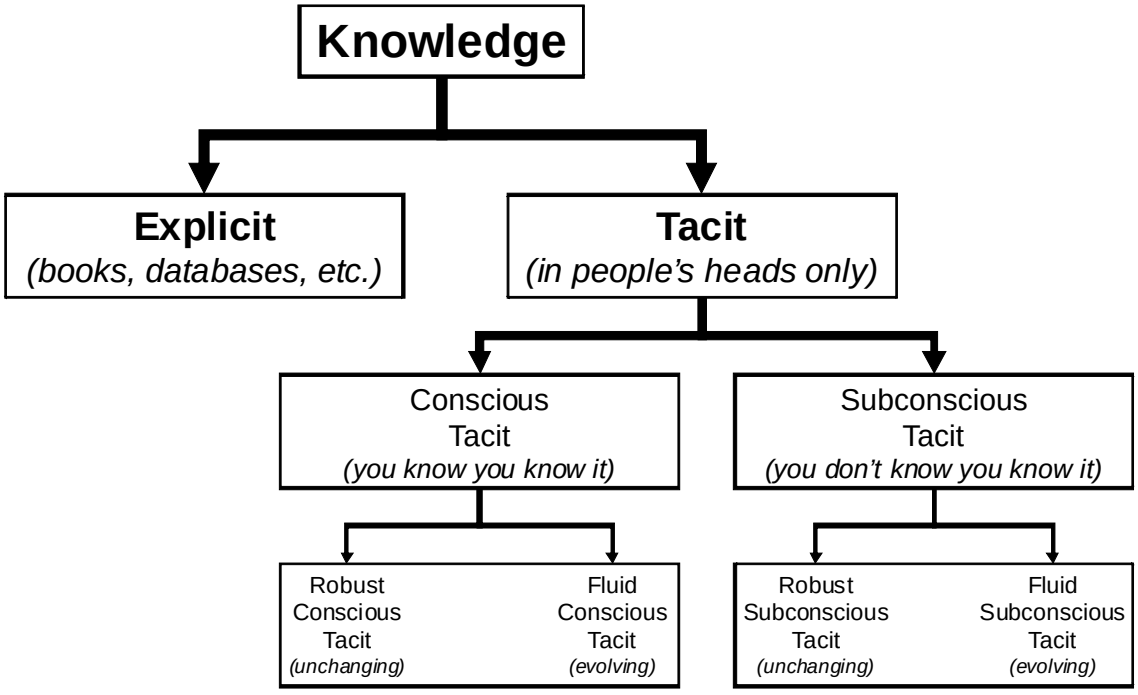


Figure 18 : A breakdown of knowledge.

Explicit knowledge

*Information in explicit form (*e.g. *stored in written form, equations, in databases, etc.).*

Tacit knowledge

Tacit knowledge is regarded as existing only in a person's head. A reason why it exists only in a person's head may simply be because it has not yet been communicated (for whatever reason). However, it may also be there because it is not easily communicated. It may simply be factual and

easily communicated. It may also be conceptual, perhaps subtle, or be little more than "gut feeling" and therefore possibly difficult to communicate at first.

Specifically, tacit knowledge can exist in the following forms:

- **Conscious tacit knowledge.** *Knowledge in a person's head that they know they know*. This can exist in a spectrum of forms varying from robust to fluid:

  Robust conscious tacit knowledge. *Knowledge in a person's head that they know they know, that is unchanging over time*. Examples include:
  - An observation that the person has made but that he / she has not explicitly recorded or communicated although it can be easy to do so.
  - A simple stable mental model, or sense-making framework, which may exist entirely within the person's own frame of reference, and that he / she has not recorded or communicated. It may be used to understand new concepts and learn.

  Fluid conscious tacit knowledge. *Knowledge in a person's head that they know they know, that evolves over time*. Examples include:
  - A somewhat vague mental model that may be difficult at first to explain and rationalise. The person's behaviour is consciously driven by it. However, when forced to examine and explain the reasons for their behaviour they reflect on it and attempt to understand it and hence communicate it. In so doing, their understanding of the mental model evolves into something that can be better explained each time this occurs.

- **Subconscious tacit knowledge**. *Knowledge in a person's head that they don't know they know*. This may "surface" on demand and become conscious tacit knowledge when, for example, the person is faced with an unprecedented challenge that forces them to examine their knowledge in ways they have not had to do before. This kind of knowledge can also exist in a spectrum of forms varying from robust to fluid:

  Robust subconscious tacit knowledge. *Knowledge in a person's head that they don't know they know, that is unchanging over time*. Examples include:
  - A subconsciously recorded observation. It was not consciously considered relevant at the time though the observation is recalled later and its relevance suddenly realised. Some examples are:
    - "I remember the land sloped to the north. So that must mean, …".
    - "Now that you mention it, I don't remember seeing that either. That probably meant that …".
    - "That is now the second time I have heard someone say that. This must mean …".

  Fluid subconscious tacit knowledge. *Knowledge in a person's head that they don't know they know, that evolves over time*. Examples include:
  - Intuition that is perhaps difficult at first to explain. However, it nevertheless drives (possibly subconscious) responses to unprecedented challenges although the person may be unable to immediately explain themselves. Such situations may force the person to examine, and perhaps explain, their own reasons for their behaviour or responses. In so doing, they attempt to make the knowledge conscious so that they can reflect on it and understand it. In so doing, their understanding (both conscious and possibly subconscious) evolves until eventually the knowledge becomes fully conscious and easily communicable.
  - An intense period of conscious data and information processing may be followed by a period of complete distraction from the original subject matter.

At the end of this period, a sudden insight may suddenly surface or, on consciously returning to examine the original subject matter there is a clearly discernable improvement in understanding. In each case, the brain has apparently been "processing" the original subject matter subconsciously and evolving understanding and this is evident in the insight or better understanding (although these mean that it has now become conscious knowledge).

Knowledge continuity

The uninterrupted availability of knowledge over time. This relates particularly to how this is achieved when key knowledgeable individuals are no longer available to an organisation.

Knowledge depth

An acute factual and contextual understanding of the subject to the extent that tacit knowledge becomes an integral part of communicating that understanding.

Knowledge-intensive organisations

In these organisations, knowledge has relatively more importance than tangible assets such as property, equipment and capital. The most important assets for knowledge-intensive organisations are knowledgeable people and applied brainpower (Sorrells-Jones and Weaver, 1999).

Knowledge, tacit

Knowledge that is implied or inferred without overt expression. Knowledge that is conveyed subconsciously.

Knowledge work

Knowledge work refers to non-repetitive and non-routine work that entails substantial levels of cognitive activity. It involves analyzing information and applying specialised expertise to solve problems, generate ideas, teach others, or create new products or services (Drucker, 1993). Knowledge work frequently results in the creation of new information and knowledge. Thinking, reflection and learning are integral to knowledge work.

Knowledge worker

The knowledge worker is someone who works both with his or her hands and with theoretical knowledge. Knowledge workers acquire and use theoretical and analytical knowledge in highly sophisticated ways, as well as develop significant physical/manual skills. The training of the knowledge worker involves formal education and cannot solely be obtained through on-the-job training or apprenticeship. Due to the rapidly changing nature of information and knowledge, knowledge workers must be committed to and skilled in the habit of continuous learning (Sorrells-Jones and Weaver, 1999).

Knowledge work team

The interdependent nature of knowledge work implies that knowledge workers can only be successful through working together. This gave rise to the concept of a knowledge work team, which comprises a small number of people with complementary knowledge and skills, who recognise their interdependency, are committed to a common purpose, and hold themselves mutually accountable (Sorrells-Jones and Weaver, 1999).

Learning

Learning for current purposes is regarded as synonymous with "knowledge creation". It is defined as gaining knowledge, comprehension, or mastery of a specific field through experience and study. Miller and Morris (1999) suggest that knowledge comes about through the integration of (a) information derived from data, (b) theory that puts the information in the proper context, and (c) experience of how things work in the real world. This process of integration is also referred to as learning.

Learning audit

A formal procedure of measurement and assessment of an organisation's ability to learn. The audit may use both quantitative measurements and narrative feedback.

Learning intervention

An activity with the explicit objective of facilitating learning (e.g. a training course, attending a relevant conference, reading a relevant publication, an opportunity to interact with an expert, an opportunity to reflect, etc.).

Learning organisation

An organisation skilled at creating, acquiring and transferring knowledge, and at modifying its behaviour to reflect new knowledge and insights (Garvin, 1993).

Management, adaptive

Management is about bringing together existing knowledge, from diverse sources, into new perspectives for practice (Westley, 1995).

Adaptive management is commonly proposed as a more realistic approach to deal with ecosystem complexity than management for optimal use and control of resources (Holling, 2001). Whilst there is general consensus that adaptive management can facilitate functional feedback loops between social and ecological systems (e.g. Olsson *et al*., 2004), and thereby enhance the resilience of these linked systems, the institution of such adaptive processes has proven problematic (Walters, 1997). A key reason for implementation failure seems to be the tendency to superimpose an adaptive approach on a non-adaptive (e.g. command-and-control or bureaucratic) decision-making environment (Rogers *et al*., 2000). Through inherent self-interest, agencies, groups or individuals responsible for ecosystem management may see adaptive management as a threat to existing research programmes and management regimes, rather than as an opportunity for improvement.

Institutional capacity to adapt to and shape change is an important prerequisite for effecting adaptive management of ecosystems (Berkes *et al*., 2003).

When adaptive management is practised, policies become hypotheses and management actions become the experiments to test those hypotheses (Folke *et al*., 2005). An adaptive approach to ecosystem management involves a triad of activities: adaptive governance as the process of resolving trade-offs and of providing a vision and direction for sustainability; adaptive management as the process of executing the vision; monitoring that provides feedback and enables informed adaptation of the governance and management processes (Boyle *et al*., 2001, cited in Folke *et al*., 2005).

Memory, ecological

The species, processes and learning that persist in an ecosystem after a disturbance event (adapted from Berkes et al., 2003b).

Memory, organisational

- "the means to retain and transmit information from past to future members" (Stein 1995);
- "how organisations encode, store, and retrieve the lessons of history despite the turnover of personnel and the passage of time" (Levitt and March 1988).

These definitions highlight the need for some degree of institutional stability (maintaining memory through people staying in the system long enough to develop a sense of shared responsibility and ownership of outcomes) as a balance for adaptability (relinquishing outdated knowledge and adjusting to more appropriate responses).

Memory, social

The long-term communal understanding of the dynamics of environmental change. It captures the experience of change and successful adaptations. It is actualised through community debate and decision-making processes into appropriate strategies for dealing with ongoing change (Berkes et al., 2003b).

Metacognition

The ability to monitor one's current level of understanding and decide when it is not adequate (NRC, 2000).

Network

The broader institution of which an organisational unit is part, including external stakeholders with which either regular or occasional contact is necessary.

Paradigm

A paradigm is a constellation of concepts, values, perceptions and practices shared by a community, which forms a particular vision of reality that is the basis of the way a community organises itself (Capra, 1997).

Reflection

The practice of periodically stepping back to ponder the meaning to self and to others in one's immediate environment about what has recently transpired (Raelin, 2001). By taking time to reflect on life instead of spending all our time just living, we can become aware of the consequences of our choices and learn from living (Covey *et al*., 1994).

Resilience

Resilience is the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same functions, structure, identity, and feedbacks (Walker *et al*., 2004).

Self-referential

A state that is internally focussed and lacking in external peer review. While the associated knowledge may be logical, it is based excessively on the individual's or group's own experience. It does not take into account, and therefore has not been tested by, the related learning and knowledge that exists outside the individual's or group's specific environment.

Single-loop learning

See double-loop learning.

Social adaptive capacity

Includes social capacity (including trust, leadership and social networks), social memory (including experience for dealing with change), adaptive expertise (ability of individuals to make sense and deal with new situations)

Processes that promote learning, create knowledge and foster negotiation of the meaning of such knowledge are part of the social capacity of responding to environmental change.

Social capital

Pretty and Ward (2001) have identified four central features of social capital: (1) relations of trust; (2) reciprocity and exchanges; (3) common rules, norms, and sanctions; and (4) connectedness in networks and groups.

Social-ecological system

An ecosystem consists of plants, animals and microorganisms that live in biological communities and which interact with each other and with the physical and chemical environment, with adjacent ecosystems and with the water cycle and the atmosphere (Odum, 1989). Ecosystems play a fundamental role in supporting life on Earth at all hierarchical scales; e.g., ecosystems produce renewable resources and ecological services.

Although the above definition of an ecosystem is essentially ecological, most aspects of the structure and functioning of Earth's ecosystems cannot be understood without accounting for the strong influence of humanity; at least in the present era. Social and ecological systems are co-evolving at both local and global levels – where human behaviour shapes nature and nature influences the development and behaviour of human society (Folke, 2003). Our capacity to effectively govern ecosystems requires an understanding of not only the ecological system but also the integrated social-ecological system.

Scholars have used terms such as coupled human-environment systems, ecosocial systems and socioecological systems to illustrate the interplay between social and ecological systems. However, treating the social or ecological dimension as a prefix may give it less weight during the analysis (Folke *et al*., 2005). Consequently, Berkes and Folke (1998) suggest that the term "social-ecological system" be used to emphasise the integrated concept of humans in nature and to stress that the delineation between social and ecological systems is artificial and arbitrary. The social and ecological dimensions as well as the linked social-ecological system reflect properties of complex adaptive systems. Social and ecological systems also display strong reciprocal feedbacks.

Linked social-ecological systems are complex systems, containing the inherent features of change and uncertainty (Gunderson and Holling, 2002). The properties of these systems (e.g. vegetation cover and capital wealth) emerge from the interaction among the various components of the entire system and which themselves feed back to influence the subsequent development of those interactions (Levin, 1998). Consequently, the behaviour of coupled social-ecological systems (a) is emergent rather than predetermined, (b) can rarely if ever be reversed to some exact prior state, and (c) has a changing path that is often unpredictable (Stafford Smith and Reynolds, 2002). As these systems change over time, any combination of external forces and intrinsic changes may result in slower or faster rates of change in each subsystem. When the rates of change in each subsystem get out of synchrony with each other, for example when ecological systems are changing faster than the ability of society to learn and respond or vice versa, the overall social-ecological system becomes dysfunctional (Robbins et al., 2002).

The implications for as well as the outcomes of analysing social-ecological systems generally differ from analysing social or ecological systems alone. A particular policy intervention may be socially desirable and economically successful but ecologically unsustainable. Similarly, a shift in the state of an ecological system may indicate that that system has lost its resilience; however, there may be capacity in the social system to effectively respond to the change which implies that the overall social-ecological system is still resilient (see Folke *et al*., 2005).

Social memory

See Memory, social

System change

We can distinguish between gradual or incremental change and abrupt change. "During periods of steady progress, things move forward in roughly continuous and predictable ways. At other times,

change is abrupt, disorganizing, or turbulent. During such periods, experience tends to be incomplete for understanding, consequences of actions are ambiguous, and the future of system dynamics is often unclear and uncertain (Gunderson and Holling, 2002). Evidence points to a situation where periods of abrupt change are expected to increase in frequency, duration, and magnitude. At the same time, the capacity of ecosystems to remain within desired states in the face of abrupt change seems to have been reduced as a consequence of human actions. Vulnerable terrestrial and aquatic ecosystems may easily shift into undesired states in the sense of providing ecosystem services to society. The existence of such alternate regimes poses new fundamental challenges to environment and resource management" (Folke *et al*., 2005).

During abrupt change, existing structures are most challenged and the risk of shifting into undesirable states is highest (Folke *et al*., 2005)

Transdisciplinary hierarchy

A combination of (1) natural social, economic, science and engineering disciplines, (2) sector disciplines (water, agriculture, industry, etc.), (3) country and international disciplines (political, legal, etc.), and (4) human value disciplines (ethics, etc.).

Specific disciplines were proposed at four levels by Max-Neef (2005) (**Figure 19**)

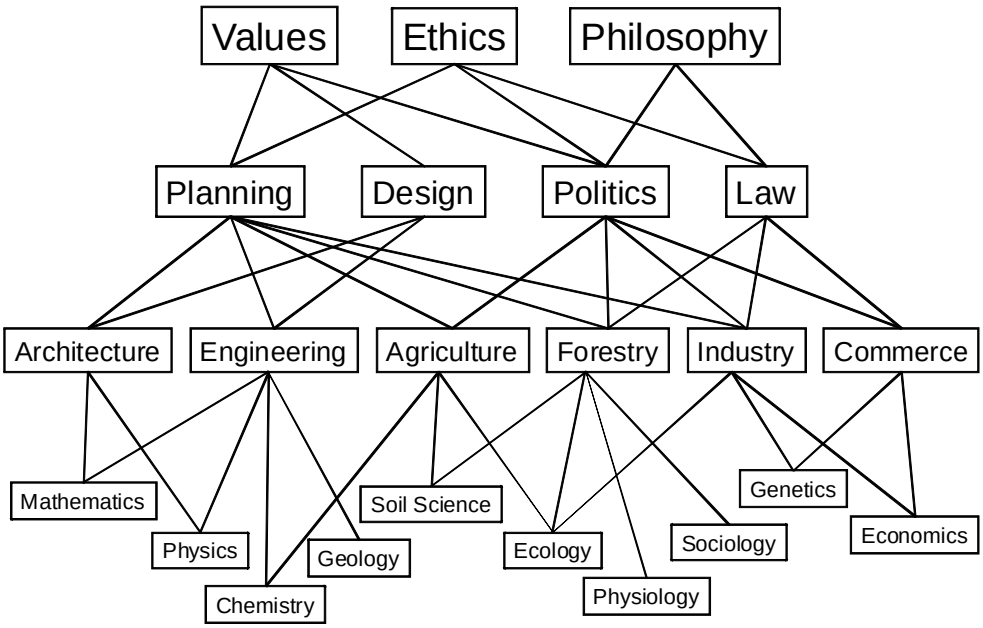


Figure 19 : Disciplines in the transdisciplinary hierarchy proposed by Max-Neef (2005).

Triple-loop learning

See double-loop learning.

Unlearning

Relinquishing the application of previous inappropriate knowledge in favour of newer knowledge considered to be more appropriate (Nystrom and Starbuck, 1984). Work by Klein (1989) and Bouton (2002) indicates that unlearning is not about the disappearance of existing knowledge, but rather the 'overwriting' of it.

CHAPTER 7: REFERENCES

Anderies JM, MA Janssen, and E Ostrom (2004). A Framework to Analyze the Robustness of Social-ecological Systems from an Institutional Perspective. *Ecology and Society* 9(1): 18. [online] URL: http://www.ecologyandsociety.org/vol9/iss1/art18.

Argyris C and DA Schön (1996). *Organisational Learning II. Theory, Method and Practice.* Addison-Wesley Publishing Company, Inc. Massachusetts.

Bannock G, RE Baxter, and E Davis (1987). *Dictionary of Economics*. Penguin Books. London.

Berkes F, J Colding and C Folke (Eds.) (2003a). *Navigating Social-ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press, Cambridge, UK.

Berkes F, J Colding, and C Folke (2003b). Building Capacity to Adapt to Change: The Context. In: *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. F Berkes, J Colding, and C Folke (Eds.) Cambridge University Press. Cambridge. 1-29.

Berkes F and C Folke (Eds.) (1998). *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge University Press. Cambridge, UK.

Bouton ME (2002). Context, ambiguity, and unlearning: sources of relapse after behavioural extinction. *Society of Biological Psychiatry* 52: 976-986.

Britton B (2002). *Learning for change: Principles and practices for learning organisations. Swedish mission council*. Sundbyberg.

Brückner G (2004). Learning Culture in a Global Context. In: *Creating a Learning Culture. Strategy, Technology and Practice*. ML Conner and JG Clawson (Eds.). Cambridge University Press. UK. 282-301.

Butler T and Waldroop J (1999). Job Sculpting; The Art of Retaining Your Best People. *Harvard Business Review* Sep-Oct: 144-152.

Capra F (1997). *The Web of Life: A New Synthesis of Mind and Matter*. Flamingo, London.

Cleveland H (2004). Leading and learning with nobody in charge. In: *Creating a Learning Culture. Strategy, Technology and Practice*. ML Conner and JG Clawson (Eds.). Cambridge University Press. UK. 19-34.

Cohen WM and DA Levinthal (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly* 35: 128-152.

Cook J (1997). Empowering people for sustainable development. In: *Managing Sustainable Development in South Africa*. P 279-296. P Fitzgerald, A Mclennan and B Munslow (Eds.). Oxford University Press, Cape Town.

Covey SR, Merrill AR and Merrill RR (1994). *First Things Thirst: Coping with the Ever-increasing Demands of the Workplace*. Simon & Schuster , London.

Davenport TH and L Prusak (1997). *Working Knowledge: How Organizations Manage What They Know*. Harvard Business School Press, Boston.

Dawson R (2000). *Developing Knowledge-Based Client Relationships – The Future of Professional Services*. Butterworth-Heinemann, Boston.

Dietz T, E Ostrom, PC Stern (2003). The struggle to govern the commons. *Science* 302: 1902-1912.

DNRE (1997). *Best Practice in Performance Reporting in Natural Resource Management. A Report to the ANZECC Working Group on National Park and Protected Area Management*. Department of Natural Resources and Environment, Victoria.

Drucker PF (1993). *Post Capitalist Society*. Harper Business Publishers, New York.

Drucker P (2001). *Management Challenges for the 21st Century*. Harper Business Press, New York.

Easterby-Smith M (1997). Disciplines of organizational learning: Contributions and Critiques. *Human Relations* 50(9): 1085-1113.

Fazey I, JA Fazey, JG Salisbury, DB Lindenmeyer and S Dovers (2006). The nature and roles of experiential knowledge for environmental conservation. *Environmental Conservation* 33: 1 – 10.

Fioretti G and Visser B (2004). A cognitive interpretation of organizational complexity. *Emergence, Complexity & Organization* 6(1-2): 11-23.

Folke C (2003). Freshwater for resilience: a shift in thinking. *Philosophical Transactions of the Royal Society of London* 358: 2027-2036.

Folke C, Carpenter S, Walker B, Scheffer M, Elmqvist T, Gunderson L and Holling CS (2004). Regime shifts, resilience, and biodiversity in ecosystem management. *Annual Review of Ecology, Evolution, and Systematics* 35: 557–81.

Folke C, T Hahn, P Olsson and J Norberg (2005). Adaptive governance of social-ecological systems. *Annual Review of Environmental Resources*. 30:441-473.

Fromm J, 2005. *Types and Forms of Emergence*. Online: http://arxiv.org/abs/nlin.AO/0506028.

Garvin DA (1993). Building a Learning Organisation*. Harvard Business Review*, July-August: 78-91.

Giampietro M (2004). *Multi-Scale Integrated Analysis of Agroecosystems*. CRC Press, London.

Goh S and G Richards (1997). Benchmarking the Learning Capabilities of Organizations. *European Management Journal* 15(5): 575-583.

Groot A and M Maarleveld (2000). *Demystifying facilitation in participatory development*. IIED Sustainable Agriculture and Rural Livelihoods Programme. Gatekeeper series no. 89.

Gunderson LH (2003). Adaptive Dancing: Interactions between Social Resilience and Ecological Crises. In: *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. F Berkes, J Colding, and C Folke (Eds.) Cambridge University Press. Cambridge. 33-52.

Gunderson LH and CS Holling (Eds.) (2002). *Panarchy: Understanding Transformations in Human and Natural Systems*. Island Press, Washington, D.C.

Gunderson LH, SR Carpenter, C Folke, P Olsson, and G Peterson (2006). Water RATs (Resilience, Adaptability, and Transformability) in Lake and Wetland Social-Ecological Systems. *Ecology and Society* 11(1):16.

Hammond SC and Glenn LM (2004). The ancient practice of Chinese social networking: Guanxi and social network theory. *Emergence, Complexity & Organization* 6(1-2): 24-31.

Holling CS (2001). Understanding the complexity of economic, ecological and social systems. *Ecosystems* 4: 390-405.

Imperial MT (2004). *Collaboration and Performance Management in Network Settings: Lessons from Three Watershed Governance Efforts*. IBM Center for The Business of Government, Washington, DC.

Klein JI (1989). Parenthetic learning in organisations: towards the unlearning of the unlearning model. *Journal of Management Studies* 26: 291-308.

Levin SA (1998). Ecosystems and the biosphere as complex adaptive systems. *Ecosystems* 1: 431-436.

Levitt B and March J (1988). Organizational Learning. *Annual Review of Sociology* 14: 319-40.

Max-Neef MA. 2005. Foundations of Transdisciplinarity. *Ecological Economics*. 53: 5-16.

Miller WL and L Morris (1999). *4th Generation R&D – Managing Knowledge, Technology, and Innovation*. John Wiley & Sons, Inc. New York.

Morris MH and DF Kuratko, 2002. *Corporate Entrepreneurship. Entrepreneurial Development within Organizations*. Thomson South-Western, Mason, USA.

NRC (2000). *How People Learn: Brain, Mind, Experience, and School*. National Academy Press, Washington, DC.

Nystrom PC and Starbuck WH (Eds.) (1984). 'To Avoid Organizational Crises, Unlearn'. *Organizational Dynamics* 12(4): 53.

Odum EP (1989). *Ecology and Our Endangered Life-Support Systems*. Sinauer Associates, Sunderland, Massachusetts.

Olsson P, C Folke and T Hahn (2004). Social-ecological transformation for ecosystem management: the development of adaptive co-management of a wetland landscape in southern Sweden. *Ecology and Society* 9: 2.
Online: http://www.ecologyandsociety.org/vol9/iss4/art2.

Olsson P, LH Gunderson, SR Carpenter, P Ryan, L Lebel, C Folke, and CS Holling (2006). Shooting the Rapids: Navigating Transitions to Adaptive Governance of Social-Ecological Systems. *Ecology and Society* 11(1):18.
Online: http://www.ecologyandsociety.org/vol11/iss1/art18/.

Pallister J and A Isaacs (Eds.) (1996). *Dictionary of Business*. Oxford University Press. Oxford.

Pretty J and Ward H (2001). Social Capital and the Environment. *World Development* 29(2): 209-227.

Raelin JA (2001). Public Reflection as the Basis of Learning. *Management Learning* 32(1): 11-30.

Robbins PF, N Abel, H Jiang, M Mortimore, M Mulligan, GS Okin, DM Stafford Smith and BL Turner II (2002). Desertification at the community scale: sustaining dynamic human-environment systems. P 326-355. In *Global Desertification: Do Humans Cause Deserts?* Reynolds JF and Smith MS (Eds.). Dahlem University Press, Berlin.

Republic of South Africa, 1998. *The National Water Act (Act no. 36 of 1998)*. Government Printers, Pretoria, South Africa.

Reynolds C 2001. *Boids: Background and Update*. http://www.red3d.com/cwr/boids/.

Rogers K, D Roux and H Biggs (2000). Challenges for catchment management agencies: Lessons from bureaucracies, business and resource management. *Water* SA. 26: 505-511.

Roux DJ, K Murray and E van Wyk (2007). Principles Enabling Learning Environments for Good Ecosystem Governance. In: Turton AR, Hattingh J, Maree GA, Roux DJ, Claassen M and Strydom WF (Editors). *Governance as a Trialogue: Government-Society-Science in Transition*. Water Resources Development and Management Series. Springer-Verlag, Berlin, p 253-280.

Roux DJ, K Murray, E van Wyk and L Hill (2009). *Enabling effective learning in catchment management agencies: Philosophy & Guidelines.* Water Research Commission Project K5/1689. Pretoria, South Africa.

Schein EH 2004. Innovative Cultures and Adaptive Organizations. In: *Creating a Learning Culture: Strategy, Technology, and Practice*. M. L. Conner and J. G. Clawson (Eds.). Cambridge University Press, Cambridge. 123-151.

Seel R (1999). *Complexity & Organisational Development - An Introduction*. http://www.new-paradigm.co.uk/complex-od.htm.

Senge PM (2006). *The Fifth Discipline: The Art and Practice of the Learning Organisation*. Random House, London.

Senge P, Kleiner A, Roberts C, Ross R, and Smith B (1999). *A Fifth Disciple Resource: The Dance of Change*. Nicolas Brealey Publishing, London.

Simon HA (1991). Bounded rationality and organizational learning. *Organization Science* 2(1): 125-134.

Smith MK (2005). *Learning in organizations*. Infed (the informal education homepage). Online: http://www.infed.org/biblio/organizational-learning.htm.

Sorrels-Jones J and Weaver D (1999). Knowledge workers and knowledge-intense organizations, Part 1: A promising framework for nursing and healthcare. *Journal of Nursing Administration* 29: 12-18.

Snowden D and P Stanbridge (2004). The landscape of management: Creating the context for understanding social complexity. *Emergence: Complexity and Organizations* 6(1-2): 140-148.

Snyder WM and Wenger E (2004). Our world as a learning system: a communities of practice approach. In: *Creating a learning culture. Strategy, technology and practice*. Conner ML and Clawson JG (Eds.). Cambridge University Press, Cambridge, UK, Chapter 2

Stafford Smith DM and JF Reynolds (2002). Desertification: a new paradigm for an old problem. Pages 403-424. In *Global Desertification: Do Humans Cause Deserts?* JF Reynolds and DM Stafford Smith (Eds.) Dahlem Workshop Report 88. Dahlem University Press, Berlin.

Stein EW (1995). Organizational memory: review of concepts and recommendations for management. *International Journal of Information Management* 15(1): 17-32.

Sveiby KE (1997). *The New Organizational Wealth – Managing and Measuring Knowledge-Based Assets*. Berett-Koehler Publishers, Inc. San Francisco.

TBCS (1996). *Quality Services Guide VII - Benchmarking and Best Practices*. Treasury Board of Canada Secretariat.
Online: www.tbs-sct.gc.ca/tb/pubs/qual-mgt/ENG/8qgl-1e.html.

Thompson JD (1967). Organizations in action. McGraw-Hill. New York.

Walker B, L Gunderson, A Kinzig, C Folke, S Carpenter, and L Schultz (2006). A Handful of Heuristics and Some Propositions for Understanding Resilience in Social-Ecological Systems. *Ecology and Society* 11(1):13. Online: http://www.ecologyandsociety.org/vol11/iss1/art13/

Walker B, CS Holling, SR Carpenter and A Kinzig (2004). Resilience, adaptability and transformability in social-ecological systems. *Ecology and Society* 9(2): 5.
Online: http://www.ecologyandsociety.org/vol9/iss2/art5/

Walters CJ (1997). Challenges in adaptive management of riparian and coastal ecosystems. *Conservation Ecology*. 1(2): 1. Online: http://www.consecol.org/vol1/iss2/art1

Wenger E (2004). Knowledge management as a doughnut: Shaping your knowledge strategy through communities of practice. *Ivey Business Journal* January/February: 1-8.

Westley F (1995). Governing Design: The Management of Social Systems and Ecosystem Management. Pages 391-427 in *Barriers and Bridges to the Renewal of Ecosystems and Institutions*. L Gunderson, Holling CS and Light S (Eds.). Columbia University Press, New York.

Zahra S and G George (2002). Absorptive capacity: A review, reconceptualisation, and extension. *Academy of Management Review* 27(2): 185-203.

Appendix A: Learning Audit Questionnaire

Interviewee(s): _____

Position(s): _____

Affiliation:

Interviewers: Dirk Roux, Ernita van Wyk & Kevin Murray **Date:**

Questionnaire: Effective organisational learning (Ver. 2)

Water Research Commission (Project K5/1689): Ultimate aims: To develop a philosophy, set of principles, indicators and a strategy that will enable the establishment of appropriate learning environments for good ecosystem governance

	Not applicable	*Don't know*	*Definitely not true*	*Partially true*	*Largely true*	*Definitely true*	
1							The majority in the unit accept the unit's mission
2							The majority in the unit understand how the mission is to be achieved
3							The unit's mission actively directs what members of the unit learn
							Learning principle: Prior knowledge engagement
4							There are abundant learning opportunities for people of diverse disciplines, cultures and levels of understanding
							Learning principle: Transdisciplinarity
5							Integration across the transdisciplinary hierarchy occurs vertically and horizontally
6							The unit has adequate knowledge at each level in the transdisciplinary hierarchy
7							The unit and the network has substantial knowledge depth in critical core disciplines
							Learning principle: Learning by doing
8							Individuals get extensive hands-on practical experience in the office environment (report writing, use of software, budgeting, etc.)
9							Individuals get extensive hands-on practical experience in the field (monitoring, social or ecological surveys, etc.)
10							The unit is actively influenced by the hands-on practical experience (in-office or in-the-field)
							Learning principle: Social knowledge sharing
11							Learning together in groups is common (gather round flip chart, brainstorming, etc.)
12							Individuals often learn directly from the most knowledgeable people in the network
13							The unit is actively influenced by participation in "communities of practice" that span organisational and international boundaries
							Learning principle: Patience
14							Considerable time is available to tackle complex problems in depth
15							Considerable time is available for reflection
16							The unit is actively influenced by learning gained from reflection
							Learning principle: Positive persistence
17							The majority in the unit are enthusiastic about acquiring new knowledge
18							The majority in the unit have the staying power to gain a good understanding no matter how difficult the challenge or how long it takes
							Learning principle: Empathy
19							There is a genuine ethic of mutual respect for different knowledge & reference systems (based on gender, age, culture, language, ability, etc.)

	Not applicable	*Don't know*	*Definitely not true*	*Partially true*	*Largely true*	*Definitely true*	
							Learning principle: Adaptability
20							There are frequent incremental improvements to the way things are done (like through quality control)
21							There is frequent reviewing and questioning of the principles and assumptions behind why things are done in the way they are
22							Most individuals in the unit are able to adapt readily to change in their work environment
							Learning principle: Synergism
23							The unit frequently investigates different ways of improving team work
24							Individuals frequently achieve more from team work than working as individuals
							Learning principle: Experimentation
25							The unit is very comfortable with regarding new strategies as experimental (i.e. success not guaranteed)
26							The unit encourages some degree of exploratory learning (trying radical ideas)
27							Some individuals in the unit are regarded as mavericks (i.e. non-conformist, unorthodox, independent) and valued as such
							Organisation ability: Deal with Threats to sustainability
28							The unit is able to respond successfully to unexpected loss of key individuals
29							Learning frequently occurs from examples of ecosystem failure
30							There is considerable debate about the extent to which experiments on ecosystems should take place
							Organisation ability: Deal with Change
31							There is significant knowledge in the unit about change in the social-ecological system (what changes, how it changes and when it changes)
							Organisation ability: Deal with Complexity
32							There is significant knowledge about, and appreciation for, the complexities of social-ecological inter-relationships
							Organisation ability: Deal with Information overload
33							Most individuals in the unit feel that they can cope well with the amount of information they are exposed to (i.e. they are not overloaded)
							Organisation ability: Deal with Significant decision making
34							The unit is able to confidently make defensible decisions that have far-reaching consequences regarding people and their livelihoods
							Enabling objective: Tacit knowledge processing
35							Individuals frequently engage relevant theory
							Enabling objective: Information processing
36							A significant number of reports or publications are produced that synthesis available data or information
37							There are frequent profound insights that influence thinking henceforth
38							There is extensive exposure to new information (either long-existing or cutting edge)
39							There is extensive sharing of technical information between members of the unit
							Enabling objective: Data processing
40							There is extensive good quality data collection by the unit (e.g. monitoring)
41							There is extensive good quality data received from external sources
42							The data the unit acquires can be efficiently found and extracted for processing
							Enabling objective: Leadership
43							Excellent leaders exist in the unit who are committed to creating space for learning

Appendix B: SANParks Learning Audit Results

SANParks - KNP

Questionnaire: Effective organisational learning

INDICATOR RESPONSES

11-12 September 2006

No.	*Not applicable*	*Don't know*	*Definitely not true*	*Partially true*	*Largely true*	*Definitely true*	
							Learning principle: Common future focus
1				1	2	4	The majority in the unit accept the unit's mission
2			1	3	3		The majority in the unit understand how the mission is to be achieved
3			1	2	4		The unit's mission actively influences what is learned in the unit
							Learning principle: Prior knowledge engagement
4				2	3	2	Learning interventions and opportunities (training courses etc.) are well tailored to cater for diverse knowledge contexts and levels of understanding
							Learning principle: Transdisciplinarity
5			1	4	2		The unit has adequate knowledge at each level in the transdisciplinary hierarchy
6				6	1		Integration across the transdisciplinary hierarchy occurs
7					2	5	The unit and the network has substantial knowledge depth in critical core disciplines
							Learning principle: Learning by doing
8					4	3	Individuals get extensive hands-on practical experience in the office environment
9					3	4	Individuals get extensive hands-on practical experience in the field
10				1	2	4	The unit is actively influenced by the hands-on practical experience (in-office or in-the-field)
							Learning principle: Social knowledge sharing
11			2	1	2	2	Learning together in groups is common
12				1	4	2	Individuals often learn directly from the most knowledgeable people in the network
13				1	4	2	The unit is actively influenced by participation in "communities of practice" that span organisational and international boundaries
							Learning principle: Patience
14			2	2	3		Considerable time is available to tackle complex problems in depth
15			2	4	1		Considerable time is available for reflection
16			1	2	2	2	The unit can be actively influenced by the learning gained from reflection
							Learning principle: Positive persistence
17					4	3	The majority in the unit are enthusiastic about acquiring new knowledge
18				2	3	2	The majority in the unit have the discipline to persist with learning no matter what
							Learning principle: Empathy
19				2	3	2	There is a genuine ethic of mutual respect for different knowledge & reference systems (cultures, languages, abilities, etc.)

	Not applicable	*Don't know*	*Definitely not true*	*Partially true*	*Largely true*	*Definitely true*	
							Learning principle: Adaptability
20			1	3	2	1	Single-loop learning occurs frequently (incrementally changing how things are done, like through quality control)
21			1	2	4		Double-loop learning occurs frequently (policy, design, assumptions, principles are reviewed)
22			4	1	2		Most individuals in the unit are able to adapt readily to change in their work environment
							Learning principle: Synergism
23			1	1	3	2	The unit actively encourages investigation of team-based problem solving strategies
24				1	4	2	Teams frequently come together and solve complex problems
							Learning principle: Experimentation
25				6	1		The unit is very comfortable with regarding new strategies as experimental (i.e. success not guaranteed)
26				3	3	1	The unit encourages some degree of exploratory learning (trying radical ideas)
27			1	1	2	3	Some individuals in the unit are regarded as mavericks
							Organisation ability: Deal with Threats to sustainability
28			2	4	1		The unit is able to respond successfully to unexpected loss of key individuals
29			3	3		1	Learning frequently occurs by intentionally testing the limits of ecosystems (i.e. thresholds are exceeded) and actually causing failure
30					1	6	There is considerable debate about the extent to which experiments on ecosystems should take place
							Organisation ability: Deal with Change
31				5	2		There is significant knowledge in the unit about change in the social-ecological system
							Organisation ability: Deal with Complexity
32				2	4	1	There is significant knowledge about, and appreciation for, the complexities of social-ecological inter-relationships
							Organisation ability: Deal with Information overload
33			4	2	1		Most individuals in the unit feel that they are not excessively overloaded with new information
							Organisation ability: Deal with Significant decision making
34				1	5	1	The unit is able to confidently make defensible decisions that have far-reaching consequences regarding people and their livelihoods
35				3	4		The unit is able to respond with integrity and equity when wrong decisions are made and individuals need to be held accountable
							Enabling objective: Information processing
36			1	3	2	1	A significant number of reports or publications are produced that assess available data or information
37			1	6			There are frequent conscious "light bulb" events (moments creating new insights that influence thinking henceforth)
38					5	2	There is extensive exposure to new information (either long-existing or cutting edge)
39			2	2	2	1	There is extensive transfer of new information between members of the unit
							Enabling objective: Data processing
40				2		5	There is extensive good quality data collection (e.g. monitoring)
41			1	2	3	1	There is extensive good quality data received from external sources
42			1	2	3	1	Data can be efficiently found and extracted for processing

No.	*Not applicable*	*Don't know*	*Definitely not true*	*Partially true*	*Largely true*	*Definitely true*	
							Learning attribute: Time for acquiring deep understanding
14			2	2	3		Considerable time is available to tackle complex problems in depth
15			2	4	1		Considerable time is available for reflection
							Organisational attribute: Supportive work environment
8					4	3	Individuals get extensive hands-on practical experience in the office environment
9					3	4	Individuals get extensive hands-on practical experience in the field
42			1	2	3	1	Data can be efficiently found and extracted for processing
							Organisational attribute: Institutional memory
28			2	4	1		The unit is able to respond successfully to unexpected loss of key individuals
36			1	3	2	1	A significant number of reports or publications are produced that assess available data or information
							Learning attribute: Benefiting from external knowledge
13				1	4	2	The unit is actively influenced by participation in "communities of practice" that span organisational and international boundaries
41			1	2	3	1	There is extensive good quality data received from external sources
							Learning attribute: Potential for cognitive development
7					2	5	The unit and the network has substantial knowledge depth in critical core disciplines
12				1	4	2	Individuals often learn directly from the most knowledgeable people in the network
17					4	3	The majority in the unit are enthusiastic about acquiring new knowledge
18				2	3	2	The majority in the unit have the discipline to persist with learning no matter what

SANParks - KNP

Questionnaire: Effective organisational learning

INDICATOR AVERAGES

11-12 September 2006

No.	Not applicable	Don't know	Definitely not true	Partially true	Largely true	Definitely true	
							Learning principle: Common future focus
1					■		The majority in the unit accept the unit's mission
2				■			The majority in the unit understand how the mission is to be achieved
3				■			The unit's mission actively influences what is learned in the unit
							Learning principle: Prior knowledge engagement
4					■		Learning interventions and opportunities (training courses etc.) are well tailored to cater for diverse knowledge contexts and levels of understanding
							Learning principle: Transdisciplinarity
5				■			The unit has adequate knowledge at each level in the transdisciplinary hierarchy
6				■			Integration across the transdisciplinary hierarchy occurs
7						■	The unit and the network has substantial knowledge depth in critical core disciplines
							Learning principle: Learning by doing
8					■		Individuals get extensive hands-on practical experience in the office environment
9						■	Individuals get extensive hands-on practical experience in the field
10					■		The unit is actively influenced by the hands-on practical experience (in-office or in-the-field)
							Learning principle: Social knowledge sharing
11					■		Learning together in groups is common
12					■		Individuals often learn directly from the most knowledgeable people in the network
13					■		The unit is actively influenced by participation in "communities of practice" that span organisational and international boundaries
							Learning principle: Patience
14				■			Considerable time is available to tackle complex problems in depth
15				■			Considerable time is available for reflection
16					■		The unit can be actively influenced by the learning gained from reflection
							Learning principle: Positive persistence
17					■		The majority in the unit are enthusiastic about acquiring new knowledge
18					■		The majority in the unit have the discipline to persist with learning no matter what
							Learning principle: Empathy
19					■		There is a genuine ethic of mutual respect for different knowledge & reference systems (cultures, languages, abilities, etc.)

	Not applicable	Don't know	Definitely not true	Partially true	Largely true	Definitely true	
							Learning principle: Adaptability
20				■			Single-loop learning occurs frequently (incrementally changing how things are done, like through quality control)
21				■			Double-loop learning occurs frequently (policy, design, assumptions, principles are reviewed)
22				■			Most individuals in the unit are able to adapt readily to change in their work environment
							Learning principle: Synergism
23					■		The unit actively encourages investigation of team-based problem solving strategies
24					■		Teams frequently come together and solve complex problems
							Learning principle: Experimentation
25				■			The unit is very comfortable with regarding new strategies as experimental (i.e. success not guaranteed)
26					■		The unit encourages some degree of exploratory learning (trying radical ideas)
27					■		Some individuals in the unit are regarded as mavericks
							Organisation ability: Deal with Threats to sustainability
28				■			The unit is able to respond successfully to unexpected loss of key individuals
29				■			Learning frequently occurs by intentionally testing the limits of ecosystems (i.e. thresholds are exceeded) and actually causing failure
30						■	There is considerable debate about the extent to which experiments on ecosystems should take place
							Organisation ability: Deal with Change
31				■			There is significant knowledge in the unit about change in the social-ecological system
							Organisation ability: Deal with Complexity
32					■		There is significant knowledge about, and appreciation for, the complexities of social-ecological inter-relationships
							Organisation ability: Deal with Information overload
33				■			Most individuals in the unit feel that they are not excessively overloaded with new information
							Organisation ability: Deal with Significant decision making
34					■		The unit is able to confidently make defensible decisions that have far-reaching consequences regarding people and their livelihoods
35					■		The unit is able to respond with integrity and equity when wrong decisions are made and individuals need to be held accountable
							Enabling objective: Information processing
36				■			A significant number of reports or publications are produced that assess available data or information
37				■			There are frequent conscious "light bulb" events (moments creating new insights that influence thinking henceforth)
38					■		There is extensive exposure to new information (either long-existing or cutting edge)
39				■			There is extensive transfer of new information between members of the unit
							Enabling objective: Data processing
40					■		There is extensive good quality data collection (e.g. monitoring)
41					■		There is extensive good quality data received from external sources
42					■		Data can be efficiently found and extracted for processing

No.	Not applicable	Don't know	Definitely not true	Partially true	Largely true	Definitely true	
							Learning attribute: Time for acquiring deep understanding
14				■			Considerable time is available to tackle complex problems in depth
15				■			Considerable time is available for reflection
							Organisational attribute: Supportive work environment
8					■		Individuals get extensive hands-on practical experience in the office environment
9						■	Individuals get extensive hands-on practical experience in the field
42					■		Data can be efficiently found and extracted for processing
							Organisational attribute: Institutional memory
28				■			The unit is able to respond successfully to unexpected loss of key individuals
36				■			A significant number of reports or publications are produced that assess available data or information
							Learning attribute: Benefiting from external knowledge
13					■		The unit is actively influenced by participation in "communities of practice" that span organisational and international boundaries
41					■		There is extensive good quality data received from external sources
							Learning attribute: Potential for cognitive development
7						■	The unit and the network has substantial knowledge depth in critical core disciplines
12					■		Individuals often learn directly from the most knowledgeable people in the network
17					■		The majority in the unit are enthusiastic about acquiring new knowledge
18					■		The majority in the unit have the discipline to persist with learning no matter what

Indicator Averages Page 3 of 3

SANParks - KNP

Questionnaire: Effective organisational learning

INDICATOR RANGES

11-12 September 2006

No.	*Not applicable*	*Don't know*	*Definitely not true*	*Partially true*	*Largely true*	*Definitely true*	
							Learning principle: Common future focus
1				■	■	■	The majority in the unit accept the unit's mission
2			■	■	■		The majority in the unit understand how the mission is to be achieved
3			■	■	■		The unit's mission actively influences what is learned in the unit
							Learning principle: Prior knowledge engagement
4				■	■	■	Learning interventions and opportunities (training courses etc.) are well tailored to cater for diverse knowledge contexts and levels of understanding
							Learning principle: Transdisciplinarity
5			■	■	■		The unit has adequate knowledge at each level in the transdisciplinary hierarchy
6				■	■		Integration across the transdisciplinary hierarchy occurs
7					■	■	The unit and the network has substantial knowledge depth in critical core disciplines
							Learning principle: Learning by doing
8					■	■	Individuals get extensive hands-on practical experience in the office environment
9					■	■	Individuals get extensive hands-on practical experience in the field
10				■	■	■	The unit is actively influenced by the hands-on practical experience (in-office or in-the-field)
							Learning principle: Social knowledge sharing
11			■	■	■	■	Learning together in groups is common
12				■	■	■	Individuals often learn directly from the most knowledgeable people in the network
13				■	■	■	The unit is actively influenced by participation in "communities of practice" that span organisational and international boundaries
							Learning principle: Patience
14			■	■	■		Considerable time is available to tackle complex problems in depth
15			■	■	■		Considerable time is available for reflection
16			■	■	■	■	The unit can be actively influenced by the learning gained from reflection
							Learning principle: Positive persistence
17					■	■	The majority in the unit are enthusiastic about acquiring new knowledge
18				■	■	■	The majority in the unit have the discipline to persist with learning no matter what
							Learning principle: Empathy
19				■	■	■	There is a genuine ethic of mutual respect for different knowledge & reference systems (cultures, languages, abilities, etc.)

	Not applicable	*Don't know*	*Definitely not true*	*Partially true*	*Largely true*	*Definitely true*	
							Learning principle: Adaptability
20			■	■	■	■	Single-loop learning occurs frequently (incrementally changing how things are done, like through quality control)
21			■	■	■		Double-loop learning occurs frequently (policy, design, assumptions, principles are reviewed)
22			■	■	■		Most individuals in the unit are able to adapt readily to change in their work environment
							Learning principle: Synergism
23			■	■	■	■	The unit actively encourages investigation of team-based problem solving strategies
24				■	■	■	Teams frequently come together and solve complex problems
							Learning principle: Experimentation
25				■	■		The unit is very comfortable with regarding new strategies as experimental (i.e. success not guaranteed)
26				■	■	■	The unit encourages some degree of exploratory learning (trying radical ideas)
27			■	■	■	■	Some individuals in the unit are regarded as mavericks
							Organisation ability: Deal with Threats to sustainability
28			■	■	■		The unit is able to respond successfully to unexpected loss of key individuals
29			■	■	■	■	Learning frequently occurs by intentionally testing the limits of ecosystems (i.e. thresholds are exceeded) and actually causing failure
30					■	■	There is considerable debate about the extent to which experiments on ecosystems should take place
							Organisation ability: Deal with Change
31				■	■		There is significant knowledge in the unit about change in the social-ecological system
							Organisation ability: Deal with Complexity
32				■	■	■	There is significant knowledge about, and appreciation for, the complexities of social-ecological inter-relationships
							Organisation ability: Deal with Information overload
33			■	■	■		Most individuals in the unit feel that they are not excessively overloaded with new information
							Organisation ability: Deal with Significant decision making
34				■	■	■	The unit is able to confidently make defensible decisions that have far-reaching consequences regarding people and their livelihoods
35				■	■		The unit is able to respond with integrity and equity when wrong decisions are made and individuals need to be held accountable
							Enabling objective: Information processing
36			■	■	■	■	A significant number of reports or publications are produced that assess available data or information
37			■	■			There are frequent conscious "light bulb" events (moments creating new insights that influence thinking henceforth)
38					■	■	There is extensive exposure to new information (either long-existing or cutting edge)
39			■	■	■	■	There is extensive transfer of new information between members of the unit
							Enabling objective: Data processing
40				■	■	■	There is extensive good quality data collection (e.g. monitoring)
41			■	■	■	■	There is extensive good quality data received from external sources
42			■	■	■	■	Data can be efficiently found and extracted for processing

No.	Not applicable	Don't know	Definitely not true	Partially true	Largely true	Definitely true	
							Learning attribute: Time for acquiring deep understanding
14			■	■	■		Considerable time is available to tackle complex problems in depth
15			■	■	■		Considerable time is available for reflection
							Organisational attribute: Supportive work environment
8					■	■	Individuals get extensive hands-on practical experience in the office environment
9					■	■	Individuals get extensive hands-on practical experience in the field
42			■	■	■	■	Data can be efficiently found and extracted for processing
							Organisational attribute: Institutional memory
28			■	■	■		The unit is able to respond successfully to unexpected loss of key individuals
36			■	■	■	■	A significant number of reports or publications are produced that assess available data or information
							Learning attribute: Benefiting from external knowledge
13				■	■	■	The unit is actively influenced by participation in "communities of practice" that span organisational and international boundaries
41			■	■	■	■	There is extensive good quality data received from external sources
							Learning attribute: Potential for cognitive development
7					■	■	The unit and the network has substantial knowledge depth in critical core disciplines
12				■	■	■	Individuals often learn directly from the most knowledgeable people in the network
17					■	■	The majority in the unit are enthusiastic about acquiring new knowledge
18				■	■	■	The majority in the unit have the discipline to persist with learning no matter what

Indicator Ranges Page 3 of 3

SANParks - KNP

Questionnaire: Effective organisational learning

ATTRIBUTE AVERAGES

11-12 September 2006

No.	Not applicable	Don't know	Definitely not true	Partially true	Largely true	Definitely true	
					■		**Learning principle: Common future focus**
1							The majority in the unit accept the unit's mission
2							The majority in the unit understand how the mission is to be achieved
3							The unit's mission actively influences what is learned in the unit
					■		**Learning principle: Prior knowledge engagement**
4							Learning interventions and opportunities (training courses etc.) are well tailored to cater for diverse knowledge contexts and levels of understanding
					■		**Learning principle: Transdisciplinarity**
5							The unit has adequate knowledge at each level in the transdisciplinary hierarchy
6							Integration across the transdisciplinary hierarchy occurs
7							The unit and the network has substantial knowledge depth in critical core disciplines
					■		**Learning principle: Learning by doing**
8							Individuals get extensive hands-on practical experience in the office environment
9							Individuals get extensive hands-on practical experience in the field
10							The unit is actively influenced by the hands-on practical experience (in-office or in-the-field)
					■		**Learning principle: Social knowledge sharing**
11							Learning together in groups is common
12							Individuals often learn directly from the most knowledgeable people in the network
13							The unit is actively influenced by participation in "communities of practice" that span organisational and international boundaries
				■			**Learning principle: Patience**
14							Considerable time is available to tackle complex problems in depth
15							Considerable time is available for reflection
16							The unit can be actively influenced by the learning gained from reflection
					■		**Learning principle: Positive persistence**
17							The majority in the unit are enthusiastic about acquiring new knowledge
18							The majority in the unit have the discipline to persist with learning no matter what
					■		**Learning principle: Empathy**
19							There is a genuine ethic of mutual respect for different knowledge & reference systems (cultures, languages, abilities, etc.)

	Not applicable	Don't know	Definitely not true	Partially true	Largely true	Definitely true	
							Learning principle: Adaptability
20							Single-loop learning occurs frequently (incrementally changing how things are done, like through quality control)
21							Double-loop learning occurs frequently (policy, design, assumptions, principles are reviewed)
22							Most individuals in the unit are able to adapt readily to change in their work environment
							Learning principle: Synergism
23							The unit actively encourages investigation of team-based problem solving strategies
24							Teams frequently come together and solve complex problems
							Learning principle: Experimentation
25							The unit is very comfortable with regarding new strategies as experimental (i.e. success not guaranteed)
26							The unit encourages some degree of exploratory learning (trying radical ideas)
27							Some individuals in the unit are regarded as mavericks
							Organisation ability: Deal with Threats to sustainability
28							The unit is able to respond successfully to unexpected loss of key individuals
29							Learning frequently occurs by intentionally testing the limits of ecosystems (i.e. thresholds are exceeded) and actually causing failure
30							There is considerable debate about the extent to which experiments on ecosystems should take place
							Organisation ability: Deal with Change
31							There is significant knowledge in the unit about change in the social-ecological system
							Organisation ability: Deal with Complexity
32							There is significant knowledge about, and appreciation for, the complexities of social-ecological inter-relationships
							Organisation ability: Deal with Information overload
33							Most individuals in the unit feel that they are not excessively overloaded with new information
							Organisation ability: Deal with Significant decision making
34							The unit is able to confidently make defensible decisions that have far-reaching consequences regarding people and their livelihoods
35							The unit is able to respond with integrity and equity when wrong decisions are made and individuals need to be held accountable
							Enabling objective: Information processing
36							A significant number of reports or publications are produced that assess available data or information
37							There are frequent conscious "light bulb" events (moments creating new insights that influence thinking henceforth)
38							There is extensive exposure to new information (either long-existing or cutting edge)
39							There is extensive transfer of new information between members of the unit
							Enabling objective: Data processing
40							There is extensive good quality data collection (e.g. monitoring)
41							There is extensive good quality data received from external sources
42							Data can be efficiently found and extracted for processing

No.	Not applicable	Don't know	Definitely not true	Partially true	Largely true	Definitely true	
				■			**Learning attribute: Time for acquiring deep understanding**
14							Considerable time is available to tackle complex problems in depth
15							Considerable time is available for reflection
					■		**Organisational attribute: Supportive work environment**
8							Individuals get extensive hands-on practical experience in the office environment
9							Individuals get extensive hands-on practical experience in the field
42							Data can be efficiently found and extracted for processing
				■			**Organisational attribute: Institutional memory**
28							The unit is able to respond successfully to unexpected loss of key individuals
36							A significant number of reports or publications are produced that assess available data or information
					■		**Learning attribute: Benefiting from external knowledge**
13							The unit is actively influenced by participation in "communities of practice" that span organisational and international boundaries
41							There is extensive good quality data received from external sources
					■		**Learning attribute: Potential for cognitive development**
7							The unit and the network has substantial knowledge depth in critical core disciplines
12							Individuals often learn directly from the most knowledgeable people in the network
17							The majority in the unit are enthusiastic about acquiring new knowledge
18							The majority in the unit have the discipline to persist with learning no matter what

Attribute summary

11-12 September 2006

11 Learning Principles
27 Indicators

	Not applicable	Don't know	Definitely not true	Partially true	Largely true	Definitely true	Total
Totals:	**0**	**0**	**18**	**52**	**73**	**46**	**189**
1	0	0	1	7	11	8	
2	0	0	6	6	6	9	
3	0	0	2	7	14	4	
4	0	0	2	9	12	4	
5	0	0	3	9	8	7	
6	0	0	1	7	10	9	
7	0	0	3	7	12	5	

5 Organisation abilities
8 Indicators

	Not applicable	Don't know	Definitely not true	Partially true	Largely true	Definitely true	Total
Totals:	**0**	**0**	**9**	**20**	**18**	**9**	**56**
1	0	0	1	1	4	2	
2	0	0	2	4	1	1	
3	0	0	2	2	3	1	
4	0	0	0	4	3	1	
5	0	0	1	4	2	1	
6	0	0	2	3	2	1	
7	0	0	1	2	3	2	

2 Info. & Data Processing
7 Indicators

	Not applicable	Don't know	Definitely not true	Partially true	Largely true	Definitely true	Total
Totals:	**0**	**0**	**6**	**17**	**15**	**11**	**49**
1	0	0	0	2	2	3	
2	0	0	3	1	1	2	
3	0	0	0	4	2	1	
4	0	0	0	2	4	1	
5	0	0	3	1	2	1	
6	0	0	0	4	2	1	
7	0	0	0	3	2	2	

18 ALL
42 Indicators

	Not applicable	Don't know	Definitely not true	Partially true	Largely true	Definitely true	Total
Totals:	**0**	**0**	**33**	**89**	**106**	**66**	**294**
1	0	0	2	10	17	13	
2	0	0	11	11	8	12	
3	0	0	4	13	19	6	
4	0	0	2	15	19	6	
5	0	0	7	14	12	9	
6	0	0	3	14	14	11	
7	0	0	4	12	17	9