MONASH University

Department of Management

SYSTEMS THINKING:

PHILOSOPHY, METHODOLOGY AND

APPLICATIONS TO KNOWLEDGE MANAGEMENT

A thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

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Break the pattern which connects the items of learning and you necessarily destroy all quality.

Gregory Bateson, *Mind and Nature: A Necessary Unity* (1979).

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ABBREVIATIONS

CP *Collected Papers of Charles Sanders Peirce,* edited by C. Hartshorne, P. Weiss (volumes 1-6), and A. Burks (volumes 7-8) (Cambridge, Mass.: Harvard University Press, 1931-58), followed by volume and paragraph number

BDAL Business Driven Action Learning

CST Critical Systems Thinking

DIKW Data, Information, Knowledge, Wisdom Hierarchy

DP 1 Design Principle 1

DP 2 Design Principle 2

GST General Systems Theory

IAM Intangible Assets Monitor

IC Intellectual Capital

IS Information Space

KIST Knowledge Intensive Systems Thinking

KM Knowledge Management

MVA Market Value Added

OST Open Systems Theory

SD System Dynamics

SECI Socialization, Externalization, Combination, Internalization

SOSM System of Systems Methods

SSM Soft Systems Methodology

VSM Viable Systems Methods

OUTLINE

This thesis reviews the history and methodology of systems thinking and its importance to framing ideas. It concludes that systems thinking is central to scientific method and, supported by the logic of the C19th pragmatist philosopher, Charles Sanders Peirce, provides a rigorous framework for the management of knowledge in organisations.

The thesis is presented in two parts:

Part 1: Foundations:

In Part 1, the history of the systems concept is explored from antiquity to its contemporary interpretation as a field of study (Chapter 1). This exploration reveals a view of the systems concept where it is central to the development of meaning and the framing of knowledge. It also reveals the systemic nature of the thought of giants of science such as Newton and Descartes and challenges the way popularised introductions to systems thinking start from the premise that these people are extreme reductionists.

The thesis also reviews the contribution of von Bertalanffy to systems thinking and, while acknowledging von Bertalanffy's creativity and genius, argues that the emphasis on von Bertalanffy has inadvertently helped to marginalise systems thinking in science. This has occurred because his open systems concept was strongly linked to the paradigm wars in biology and was overshadowed by Darwin's evolutionary theory. In the paradigm wars, in which von Bertalanffy played a seminal roll in defeating vitalism, systems thinking became synonymous with synthesis, and analysis with reductionism. This thesis argues that systems thinking involves *both* analysis *and* synthesis and that the true enemies of science are extreme reductionists, *and* extreme holists.

Furthermore, von Bertalanffy's admirable attempt to make "systems of knowledge" more scientific through General Systems Theory (GST) and to draw the systems field together, came with the considerable baggage of the post WW2 systems scientists' attempts to apply their ideas of optimisation and central control to the management of social systems. This has led to the rejection of systems thinking and GST in the social sciences.

This thesis supports the contemporary shift towards pluralism in systems thinking but argues the need for a more rigorous framework within which to adopt pluralism. It is argued that this can be achieved by accepting the cognitive basis of the systems concept and the role of metaphor in conceptualising systems. In this respect, it is argued that Pepper's (1942) "World Hypotheses" provide a useful starting point, and that three generic systems frames *each* have importance in systemic thinking albeit with different levels of explanatory power: the closed system, the input-output system, and the open system.

While the above addresses the problem of systems ontology, epistemological aspects are addressed by first recognising the importance of human fallibilism and the need to develop an epistemology rooted in *experiential* learning and "checks and balances". Consequently, an epistemology is proposed based on interpreting science as a dialectic involving synthesis *and* analysis where systems frame this dialectic, and where an inferential logic is provided by Peirce's application of abductive, deductive, and inductive processes.

These arguments are supported by a discussion of the cognitive basis of systems thinking (Chapter 2) and of Peirce's pragmatist philosophy, its significance in the philosophy of science, and its importance in the history of systems thinking (Chapter 3).

Part 1 concludes with Chapter 4 which integrates the previous themes and defines the role of systems thinking in science[1].

Part 2: Applications to Knowledge Management.

Part 2 addresses the challenge posed by Cavaleri (2005):

> It would appear that many of the great systems theorists were going in the right direction by trying to combine action learning with systems methodologies. However, the missing link, so to speak would appear to be the important role played by pragmatic knowledge-creating processes. I wish to call to the attention of systems theorists the emerging task of designing a next generation of pragmatic knowledge-intensive systems methodologies. (p. 395)

[1]A slightly abridged version of this Chapter has been published- (Barton and Haslett, 2007) Barton was the principal author of this paper.

In an attempt to address Cavaleri's challenge, the foundations established in Part 1 are applied to develop a rigorous, systemic approach to managing knowledge in organisations. This is done in four stages:

- Clarifying the issues relating to knowledge management in business and establishing a coherent set of definitions that distinguish between data, information, and knowledge. An important outcome is the development of new tools for creating knowledge maps, the measurement of intangibles, and modelling the impact of intangibles on business performance (Chapter 5.2).
- The development of an organisational model of knowledge management that illustrates the importance of using an "engineering" closed systems approach as a bridge to more normative "open systems" approaches (Chapter 5.3).
- Reviewing developments in action learning and action research and demonstrating the manner in which the scientific method described in Chapter 4 supports action research as a rigorous, scientific approach to organisational learning (Chapter 6)[2].
- The application of the action research model described in Chapter 6 to improve the rigor and consistency of System Dynamics methodology (Chapter 7)[3].

The thesis concludes with the observation that dialectic thought has emerged as an integrating theme to this thesis, further emphasising the importance of its linkage with systems thinking.

[2] An earlier version of this Chapter was presented at the 2003 ANZSYS Conference in Melbourne.
[3] An earlier version of this Chapter was presented at the 2006 International System Dynamics Conference in Nijmegen, The Netherlands.

DECLARATION

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other institution and affirms that to the best of my knowledge the thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

John Barton

19 June, 2007

ACKNOWLEDGEMENTS

My conscious journey into systems thinking started over 25 year's ago when, studying the "behavioural theory of the firm", I was introduced to Jay Forrester's seminal work in "Industrial Dynamics", later to become known variously as "System Dynamics", "Business Dynamics" and "Strategy Dynamics". This journey has culminated in the development of this thesis. Consequently, many people have contributed to it.

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I owe a profound gratitude to the late Professor Fred Emery for introducing me to the work of Stephen Pepper and the pragmatist philosophy of Charles Sanders Peirce, and of course, to the beauty of Fred and Merrelyn Emery's Open System Theory. Merrelyn continues to be a source of inspiration and support for my attempts to appreciate the significance of open systems thinking.

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DEDICATION

This thesis is dedicated to:

Matthew

Richard

William, and

Jack

A new generation of systems thinkers.

Part 1: Foundations.

The most profitable discussion is, after all, a study of other minds- seeing how others see, rather than the dissection of mere propositions. The re-statement of fundamental doctrines in new connections affords a parallax of their philosophical stand-point, which adds much to our knowledge of another's thought.

Chauncey Wright

Letters of Chauncey Wright, 124. To F.E.Abbot, Cambridge, October 28, 1867.

Chapter 1. Systems Thinking.

1.1 Introduction: What is Systems Thinking?

Reflecting on her attempts to answer the question, "*what is 'systems thinking'?"* Hammond writes:

> In the process of my research on the history of systems thinking it became increasingly obvious that systems theory meant vastly different things to different groups of people, depending upon their disciplinary and occupational perspectives.

(Hammond, 2002, p. 431).

Consequently, the new entrant is likely to be introduced to the field of systems thinking through a particular discipline. For example:

- Engineering and information sciences- supporting engineering or "hard" systems approaches, and, by contrast "soft systems methodology.
- Cybernetics and feedback control systems– supporting viable systems and system dynamics.
- Biological sciences- supporting classification systems ("systematics"), open systems, autopoietic systems, and much of complexity theory.
- Pragmatist philosophy associated with Peirce, James, Dewey, Singer and others- supporting open, purposeful systems and related systems of inquiry.
- Psychology, supporting psychodynamics, socio-technical systems, and social ecology.
- Critical theory and sociology, supporting critical systems thinking.

Interdisciplinary studies such as management are likely to take a wider approach and study a variety of systems approaches such as those presented by Flood (1999); Gharajedaghi (1999); and Jackson (2003).

However, when our newcomer steps outside his/her discipline, he/she will be exposed to a bewildering array of definitions and concepts reflecting diverse world views. In fact, probably enough to drive him/ her back into their discipline in search of refuge. Some examples of definitions illustrate this:

- Angyal (1941, p. 243): "Our scientific thinking consists prevalently in the logical manipulation of relationships...the structure of wholes cannot be described in terms of relations...there is a logical genus suitable to the treatment of wholes. We propose to call it system.…. Usually one designates by system any aggregate of elements considered together with the relationships holding among them.....the type of connexions in a whole is very different from the connexions which exist in aggregate.... The term 'system' for our discussion is holistic organization. The parts of a system are *organised* as distinct from being *arranged* and exist within a dynamic context. Their meaning results from the emergent properties and how people react to these".
- Churchman (1968, p. 11): "Systems are made up of sets of components that work together for the overall objective of the whole. The systems approach is simply a way of thinking about these total systems and their components".
- Weiss (1969, pp. 11-12): "Pragmatically defined, a system is a rather circumscribed complex of relatively bounded phenomena, which, within those bounds, retains a relatively stationary pattern of structure in space or of sequential configuration in time in spite of a high degree of variability in details of distribution and inter-relations among its constituent units of lower order".
- Von Bertalanffy (1975, p. 159): "A system may be defined as a set of elements standing in interrelationship among themselves and with the environment".
- Lilienfeld (1978, p. 9): "The world is seen as an unlimited complex of change and disorder. Out of this total flux we select certain contexts as organizing Gestalts or patterns that give meaning and scope to a vast array of details that, without the organizing patterns, would be meaningless or invisible".
- Checkland (1981, p. 318): "Systems Thinking: An *epistemology* which, when applied to human activity is based upon the four basic ideas: *emergence*, *hierarchy*, *communication*, and *control* as characteristics of systems. When

applied to *natural* or *designed systems* the crucial characteristic is the *emergent properties* of the whole".

- Ackoff (1994, p. 18) (Extending his 1981, p. 15, definition): "A system is a whole that contains two or more parts that satisfy the following five conditions:
    - The whole has one or more defining functions
    - Each part in the set can affect the behaviour or properties of the whole.
    - There is a subset of parts that is sufficient in one or more environments for carrying out the defining function of the whole; each of these parts is separately necessary but insufficient for carrying out this defining function.
    - The way that the behaviour or properties of each part of a system affects its behaviour or properties depends on the behaviour or properties of at least one other part of the system.
    - The effect of any subset of parts on the system as a whole depends on the behaviour of at least one other subset.

….Summarizing and oversimplifying, *a system is a whole that cannot be divided into independent parts*".

- Senge (1990, p. 7): "Systems thinking is a conceptual framework, a body of knowledge and tools that has been developed over the past fifty years, to make the full patterns clearer, and to help us see how to change them effectively".
- Fred Emery (quoted in Emery and Purser (1996, p. 75)): "A system is *unitas multplex*. Only if we can identify the system principle that explains this unity can we demarcate the system".
- Levins (1998, p. 387): "Dialectical 'wholes' are not defined by some organizing principle such as harmony or balance or maximization of efficiency. In my view, a system is characterized by its structured set of contradictory processes that gives meaning to its elements, maintains the temporary coherence of the whole and also eventually transforms it into something else, dissolves it into another system, or leads to its disintegration".
- Nelson and Stolterman (2003, p. 80): "Systems thinking is both a very new and very ancient approach to meaning making. Meaning making is essentially the creation of relationships of understanding, specifically between that which

is experienced and the one that experiences. These relationships form a belief system, inclusive of the real, the true and the ideal, that informs actions, reflection and imagination in specific situations".

These definitions emphasise two interpretations:

- Systems as an organised whole distinct from an environment and with emergent properties.
- Systems as means of framing complexity to provide meaning.

More generally, systems definitions range from the traditional whole-part etymology of the word "system", to the teleological notion of purposeful system defined in terms of a systems principle, systems as "organising gestalts", and epistemology that acknowledges the emergent and related characteristics of complex systems. In recent years we have witnessed a shift in emphasis from a strongly objectivist view of systems thinking that articulates into the type of structural-functionalist framework advanced by Parsons (1951), to a constructivist position that emphasises the role of learning and raises questions concerning "ethics, power and pluralism" (Midgley, 2003).

In a survey of definitions, Backland (2000) concludes that most common definitions emphasise *relationships,* but that they are generally imprecise. He attempts to remove this imprecision by defining systems in terms of mathematics. Accordingly, he follows the structure of Ackoff's (1981) definition and proposes what he claims is a more rigorous, mathematically expression:

A system consists of a set, *M*, and a non-empty set of relations on *M*, R, satisfying the following conditions:

1. $|M| \geq 2$.
2. From every member of M there is a path to every other member of *M*.

(Backland, 2000, p. 448).

(Backland also provides detailed mathematical expressions defining what is meant by a “path”).

Backland explains “(S)imply put, a system has to consist of at least two elements. Since a system is not an aggregate, there must be connections between them….The second condition ensures that there cannot be any independent subgroups” (p. 448).

One can observe that it would be possible that each of the above examples of definitions can be translated into mathematical form and achieve increased precision, nothing is added in terms of the *essence* of the definition and something can be lost in the readability of the definition. Inevitably, no preference for one definition can be expressed over another without consideration of the wider context within which the definition is used. That is, the definition is part of a wider systemic construct or theory and must be considered as such.

While this diversity of definitions may be simply reflecting the proposition that it will never be possible to describe the variety of nature of the systems concept with a single perspective, the new entrant to the field faces a dilemma: does one succumb to the arguably simpler route of working within the constraints of a particular field and adopt their preferred definition, and ignore the methodological pluralism advocated by the “Hull School”, or does one attempt to work across the disciplines and embrace pluralism?

Eventually, our new entrant will start to recognise that the systems concept is ubiquitous and, as a field of study, includes:

- The *conceptualization* of systems (Frameworks for problem formulation and structuring knowledge)
- Systems of *knowledge* (Architectonics)
- The *design* of systems (System design)
- The *analysis* of systems (System inquiry)
- *Changing* systems (System intervention)
- The study of systems *theory* and *methods* (System science)

- The study of isomorphism across disciplines (General Systems Theory)
- The philosophy of systems (System philosophy).

Given the extent of the systems field, and the extent to which the word "system" is commonly used, it appears almost paradoxical that the systems movement continues to face the reality of Checkland's observation made some 25 years ago that: "'Systems Thinking' is not yet a phrase in general use" (Checkland, 1981, p. 31).

This is a statement that is still repeated in one form or another in on-line discussions and at systems conferences, and occasionally elaborated in articles such as Bawden (2005). Sadly, as Bawden, McKenzie, and Packham (2007) conclude, and anecdotal evidence supports, systems thinking is not easily accommodated within the academy.

Taking a lead from Nelson and Stolterman's statement that "systems thinking is both a very new and ancient approach to meaning making" (Nelson and Stolterman, 2003, p. 80), Part 1 of this thesis seeks some answers to the current confusions over the definition and status of systems thinking. It attempts to do this by exploring the development of the systems concept and its role in the history of science. In doing so, questions are raised concerning the veracity of many of the current "textbook" introductions to systems thinking that assert that systems thinking is something "new" and represents a position opposing "mechanistic", or "reductionist thinking". In the process, this journey uncovers some surprising insights (at least to the author) regarding the nature of systems thinking and its history.

1.2 Systems Thinking: From Antiquity to von Bertalanffy.

In discussing rock art dating back some 250-300,000 years ago, Bednarik (1998) concludes that:

> Rock art also represents our earliest evidence of the development of systems of symbols. Present day writing systems and alphabets derive, at least in part, from simplification of drawings of objects. This process is one of reduction of the image to a simple geometric representation. Numerous symbolic geometric

symbols and dots and lines are found along with the better known representational paintings of the Palaeolithic cave art goes back to antiquity.

(Bednarik, 1998, p. 4).

Such examples of what we might loosely describe as "systemic thinking" clearly predate the etymology of the word "system". Two origins of the word "system" are evident: Greek usage that emphasizes wholes (Greek: *sustema* = whole), for example, Zeno (334-262 BC) applied the concept to groups of physical objects (systema mundi), and early 17th Century French usage (French: *système* = organised or connected group of objects) (*The Shorter Oxford English Dictionary on Historical Principles*, 1973).

The systems idea clearly spans diverse cultural boundaries. For example, Churchman (1979) cites the second millennium BC Chinese document which we know as the "I Ching" as an example of systemic thought. Churchman explains that the I Ching categorises decision making into sixty-four basic possibilities, the selection of the appropriate possibility being left to the interpretation by a person with the necessary wisdom and insight of the way "yarrow sticks" fall when thrown according to a ritual. Churchman identifies the following characteristics of the I Ching that can be associated with what was considered during the 1970s to be a normative systems approach:

- The I Ching consists of a comprehensive set of models of reality.
- An expert is required to decide which model should be used.
- I Ching recognises "an explicit way of gathering information and a computational technique based on the information to decide which model holds".
- The I Ching "assumes that it is essential to describe not only what model is applicable but also the *mood* of the situation".

(Churchman, 1979, pp. 32-33).

Systemic thought is central to Greek philosophy and science. Thales of Miletus (640 BC), described as the world's first scientist or mathematician, raised the question of categories of thought: "At a fundamental level is the world made out of water, or air, or fire, or earth, or a combination of some or all of these?" (Kenny, 2004, p. 2). Thales is also reputed to have argued that you do not genuinely know something unless this knowledge is made systematic. In this sense, Euclid's elements, probably compiled by a team of mathematicians working at Alexandria with Euclid of Alexandria (325 -265 BC) and continuing after his death, was identified by Leibniz as the exemplar for developing a system of knowledge. While Euclidian geometry is concerned with describing the physical world, Leibniz's goal was to emulate this in philosophy (Rescher, 1981).

Collins (1998) also explains the importance of the systems concept in Greek philosophy, particularly that associated with Aristotle (384-322 BC) and his systems of classification. This is reflected in Aristotle's works which fall under three headings: (1) dialogues and other works of a popular character; (2) collections of facts and material from scientific treatment; and (3) systematic works. The systematic works are further categorized as:

- Logic
- Physical works
- Psychological works
- Works on natural history
- Philosophical works

Collins observes:

> Aristotle's creativity lay in finding a device for synthesis, and thereby for reducing the surfeit of contending schools of his day. The most important result was his fourfold classification of causes as material, formal, efficient, and final, and his distinctions of potency and act, substance and accident.

(Collins, 1998, p. 102).

The only Roman emperor who was also a philosopher, Marcus Aurelius (AD 121-180) wrote his meditations (Aurelius, 2006, p. 95) emphasising the fundamental importance of the "whole" in developing a systemic worldview:

> Whether atoms or a natural order, the first premise must be that I am part of the Whole which is governed by nature: the second, that I have some close relationship with the other kindred parts. With these premises in mind, in so far as I am a part I shall not resent anything assigned by the Whole. Nothing which benefits the Whole can be harmful to the part, and the Whole contains nothing which is to its benefit. All organic natures have this in common, but the nature of the universe has this additional attribute, that no external cause can force it to create anything harmful to itself.

(Aurelius, Book 10).

Collins (1998) traces the path by which Greek philosophy and evidence of systems thinking was translated into Islamic thought. This development was led by Al-Farabi, "an independently wealthy individual living quietly without court patronage" who "surveyed all the available Greek works and enumerated all the natural sciences" (Collins, 1998, p. 410). Riesman (2005, p. 52) describes Al-Farabi as being "above all a systematic and synthesizing philosopher; as such, his system would form the point of departure on all the major issues of philosophy in the Islamic world after him".

What we might now describe as the "multiple perspectives" approach in systems thinking (Linstone, 1984), was a fundamental feature of Indian Jainism culture. Described by de Bary (1958, p. 70) as the "Doctrine of Manysidedness", Jain philosophy of the 3rd and 4th centuries AD, was characterized by the kindred doctrines of "Viewpoints" (*nayavāda*) and "Maybe" (*syādvāda*). De Bary observes that these ideas existed "at least in embryo at the time of Mahāvira and the Buddha" and contrast with the law of excluded middle (either *a,* or not-*a*) that we use in western logic. (The Jain doctrine of many-sidedness is preserved today in the Indian parable of the blind men and the elephant).

Although brief, these examples illustrate that the concept of a system as a means of framing knowledge and establishing meaning spreads across early cultures. However, the primary interest in this Chapter is to trace the development of the systems concept in Western thought.

Systems Thinking in Western Thought.

Following the Greek period, the mediaeval years witnessed attempts to systematize religious thought and, in association with this, to start to distinguish between knowledge and belief. Collins (1998, p. 479) describes St Thomas Aquinas (1225-1274) as “the great systematizer of philosophical and theological doctrine”. Aquinas reconciled the philosophy of Aristotle with Christian doctrine (Stokes, 2003, p. 51). Kenny (2005, p. 167) argues that “Aquinas’ distinction between faith and reason and between natural and revealed theology marked a turning point in medieval epistemology….Aquinas’ work sharpened the distinction between knowledge and belief”.

This was an essential pre-requisite for two enormous forces that shaped the history of science after this period. The first was the emergence of Copernicus’ new “worldview” (Copernicus, 1472-1543), and its articulation into physical laws by Galileo (1564-1642). The second force was the continuation of the separation of science and religion. This opened the door to the enlightenment period (1680s to 1790s), with fundamental challenges to thinking about the creation of knowledge and the search for truth. This was led by Francis Bacon (1561-1626) in Britain, and Descartes (1596-1650) in France. Shortly before his death Descartes wrote: “advancing in the search for truth” remained “the principal good in life” (Rodis-Lewis, 1995, p. xvii).

Bacon confirmed the importance of the separation of science and religion in the strongest of terms: “Bacon indeed warns his readers of the dire consequences of confusing divinity with natural science” (Briggs, 1996, p. 172). This allowed Bacon to develop a purely scientific approach to hypothesis formation and testing and one of the first attempts at achieving a rigorous approach to epistemology. Following the observation made earlier, this thesis will argue that the systems concept is essential to this process- hypotheses can only be framed within a systemic context.

Rescher (1981, pp. 3-6) identifies the system concept as being used with a “renewed currency” in the renaissance. Rescher describes developments from this period into the post-renaissance period during which the systems concept was adopted by philosophers:

> At first it functioned here too in its ancient applications in its broad sense of a generic composite. But in due course, it came to be adopted by Protestant theologians of the sixteenth century to stand specifically for the comprehensive exposition of the articles of faith, along the lines of a medieval summa: a doctrinal compendium.
>
> By the early years of the seventeenth century, the philosophers had borrowed the term "system" from the theologians, using it to stand for a synoptically comprehensive and connected treatment of a philosophical discipline: logic, rhetoric, metaphysics, ethics, etc…..And thereafter the use of the term was generalized in the early seventeenth century to apply to such a synoptic treatment of any discipline whatever.

(Rescher, 1981, p. 6).

Before proceeding, it is interesting to note a little heralded systemic aspect of Descartes’ thought revealed by Garber (2001). Firstly, Garber presents the more common view of Descartes’ thought that it “must be understood in the context of the attempt to reject Aristotelian physics”, which emphasises the “irreducible tendencies bodies have to behave ….. as embodied in their substantial forms” (e.g, “some bodies naturally fall”), and replace it with a “mechanistic conception of nature” (Garber, 2001, pp. 1-2) and where investigation must be premised on an assumption of universal doubt.

Broughton (2002, pp. 11-13) argues that universal doubt was a device for hiding certain controversial aspects of his advocacy of “mechanistic corpuscularianism”, and possibly the result of a Renaissance "fascination" with "ancient scepticism". Others argue that it was a simple reaction to personal experience, and a method of inquiry. Perhaps it was an extension of the assumption of universal guilt (sin) that strongly characterised Christian religion during medieval times (and continues to this day!).

In a similar vein, Hampden-Turner and Trompenaars (1997, p. 13), speculate that Descartes' separation of mind and body "was probably religious piety. The mind was the seat of the immortal soul, thought for many years to be the pineal gland in the brain. The mind was therefore to be left to the church, while accumulation of external facts was the province of scientific investigation".

In fact, Descartes' method of inquiry involves a two-stage process which we can identify as involving analysis *and* synthesis- the popular reductionist conception of Cartesianism only emphasises the first stage:

> This rule is observed exactly if we reduce involved and obscure propositions step by step to simpler ones, and thus from an intuition of the simplest we try to ascend by those same steps to a knowledge of all the rest.

Descartes as quoted in Garber (2001, p. 35).

Nevertheless, as Garber argues, Descartes realised that this method was in conflict with the more basic assumption that all knowledge is interconnected. Consequently,

> …what we should be doing is not solving individual problems, but constructing the complete system of knowledge, the interconnected body of knowledge that starts from intuition and comes to encompass everything capable of being known….Unlike others, Galileo, for example, Descartes' strategy is to start not with individual questions but to start at the beginning, with intuitively graspable first principles that ground the rest, and progress step by step from there downward to more particular matters. No longer a problem solver, Descartes has become a system builder.

(Garber, 2001, pp. 48-49).

As a result, Garber argues, this is one way in which the "the evolution of the Cartesian program led to the demise of method" and led to a struggle for Descartes in which he realised that "intuition cannot be taken for granted and must be validated and that this is the essential preliminary to any system of knowledge" (Garber, 2001, p. 50).

In addition to emphasising that Descartes' method involved both analysis and synthesis, and the revelation that Descartes was a "system builder", Garber's observation of Descartes' recognition of the role of intuition and validation in the formation of hypotheses as a precursor to developing a system of knowledge, is most illuminating. (A discussion of the formation of hypotheses as part of systemic thought constitutes a major component of Chapter 4).

Primarily as the result of Leibniz (1646-1716), the systems concept in this period shifted from being purely associated with physical entities to embracing "systems of knowledge":

> This post-Renaissance redeployment of the term system had a far-reaching significance. In the original (classical) sense, a system was a physical thing: a compositely structured complex. In the more recent sense, a system was an organically structured body of knowledge not a mere accumulation or aggregation or compilation of miscellaneous information (like a dictionary or encyclopaedia), but a functionally organized and connectedly articulated exposition of a unified discipline……
>
> Moreover, a system is not just a constellation of interrelated elements, but one of elements assembled together in an "organic" unity by linking principles within a functionally ordered complex of rational interrelationships. The dual application of systems-terminology to physical and intellectual complexes thus reflects a longstanding and fundamental feature of the conception at issue.

(Rescher, 1981, p. 6).

(Note that Rescher is identifying the emergence of the "systems principle" as an organizing concept).

By the second half of the seventeenth century, Rescher observes that:

> …."system" came to be construed as a particular approach to a certain subject, a particular theory or doctrine about it as articulated in an organized complex of concordant hypotheses, a "nexus veritatum",

(Rescher, 1981, p. 8).

Finally, Rescher concludes that:

> From antiquity to Hegel and beyond, cognitive theoreticians have embraced this ancient ideal that our knowledge should be developed architectonically and should be organized within an articulated structure that exhibits the linkages binding its component parts into an integrated whole and leaves nothing wholly isolated and disconnected…..Thus as the seventeenth century moved towards its end, the system was now understood as a doctrine or teaching in its fully comprehensive (i.e., systematic) development. And Leibniz was the first who explicitly applied this terminology to a body of philosophical teachings.

(Rescher, 1981, p. 8)

So, emphasising the importance of establishing an a-priori systems principle, Leibniz, had succeeded where Descartes struggled, and had developed a sophisticated argument against Descartes' "interactionism" (the relationships between parts), replacing it with his "doctrine of pre-established harmony" (the organising principle) (Garber, 2001, p. 135).

In the philosophy of science, Leibniz is recognised as one of the greatest of systems builders: "The history of philosophy has recognised him as one of the greatest systems-builders" (Morris, 1934, p. vii). Jolley (1995) describes Leibniz's approach thus: "the entire tendency of his philosophy is to seek synthesis and reconciliation wherever possible". Rescher describes Leibniz's systemization as the core to his work, and Martin (1960, p. 66) notes that Leibniz realized that "it was the specific achievement of Greek mathematicians to have been the first to observe this coherence" (of scientific truths).

Along with Descartes' "reductionist method", it is Newton's (1642-1727) mechanistic worldview that draws the ire of contemporary systems thinkers. "Newtonian science looked upon the *physical universe* (my emphasis) as an exquisitely designed giant mechanism, obeying elegant deterministic laws of motion" (Laszlo, 1972b, p. 11). The implication being that it is inappropriate to use this (metaphor?) when considering *living* systems. In discussing the nature of organisations Gharajedaghi (1999) refers to the application of this worldview as "a mindless mechanical tool" and contrasts it with "an unminded biological being and, finally to a multi minded organized complexity… exemplified by social organizations" (Gharajedaghi, 1999, p. 10). (Gharajedaghi's preference is for the latter perspective which exhibits human purposeful behaviour- a preference supported in Chapter 4).

Unfortunately, quotations such as these are quite confusing and confound a number of things including the role of metaphor in the conceptualisation of systems and the distinction between ontological and epistemological processes. One result is to identify contemporary systems thinking with the biological metaphor and the process of synthesis, and, in ignorance, to identify Descartes and Newton only with analysis and reductionism ignoring the systemic nature of their thought.

In contrast with such perspectives, Gregory (1931) describes Newton as the "great systematizer" and Holton (1998 b) remarks:

> …no historic case is more inviting than that exemplar of all successful scientific syntheses, the so-called "Newtonian Synthesis," the historic unification of celestial and terrestrial physics.

(Holton, 1998 b, p. 114)

Similarly, rather than presenting the simplistic (ontological) view of Newton's mechanistic model of the universe described above, Nobel Prize winner in physics, Steven Weinberg articulates Newton's methodological purpose in strongly epistemological terms. He does this by describing "Newton's dream":

> Newton's dream, as I see it, is to understand all of nature, in the way that he was able to understand the solar system, through principles of physics that could be expressed mathematically. That would lead through the operation of mathematical reasoning to predictions which should in principle be capable of accounting for everything. I do not know of an appropriate place in the corpus of Newton's writings to look for a statement of this programme. Newton scholars share with me the feeling that Newton had this aim, but the closest to an explicit statement of it I have found is in the preface to the first edition of the Principia, written 301 years ago, in 1686: "I wish we could derive the rest of the phenomena of nature (that is, the phenomena which are not covered in the Principia) by the same kind of reasoning as for mechanical principles. For I am induced by many reasons to suspect that they may all depend on certain forces." He wanted to go on beyond the Principia and explain everything.

(Weinberg, 1988, p. 96).

Note that this *not* saying that all entities are machines, but is expressing the hope that a rigorous approach to other knowledge can be found involving central organising "forces" in the sense of organising principles. Newton demonstrates this in his later attempts to find such phenomenon in religion and mysticism. He did not use the machine metaphor in this ultimately failed exercise.

Weinberg (1988) traces the development of physics through to the early 20th Century and notes that, while the "tradition of atomism" goes back to Greek times, "Newton was the first to show how it would work - to show with the example of the solar system how one could explain the behaviour of bodies mathematically and make predictions which would then agree with experiment….. The Newtonian approach - the Newtonian success - had no predecessors and it left physicists with the challenge of carrying it further" (Weinberg, 1988, p. 97). Significantly, Weinberg interprets Maxwell's development of field theory and eventually the new quantum synthesis as all part of Newton's dream.

Consequently, we can observe that the development of the physicist's explanation of natural phenomena, moves through a number of phases involving analysis *and* synthesis, in which three "grand syntheses" (Holton, 1998 b) emerge- Newton's Principia, Maxwell's fields, and Einstein's quantum physics.

In Chapter 4, it will be argued that this process, which involves the analysis-synthesis dialectic, is shaped using systemic frames and constitutes the essence of systems thinking.

(One consequence is that the possible and problematic application of these frames as metaphors for explaining other than "natural" phenomena should not detract from the systemic essence of "Newton's Dream").

Newton's methodology was also distinguished by its grounding in action and observable data. Emphasising the importance of material universals in Newtonian epistemology, Cassirer (1951, p. 8), comments that the Newtonian methodology with its emphasis on observation producing the "datum of science …… characterizes all eighteenth century thought. The value of system, the "esprit systématique" is neither underestimated nor neglected; but it is sharply distinguished from the love of system for its own sake, the "esprit de système".

Significantly, Cassirer observes that Newtonian science warns against developing "such 'reason' in the form of a closed system; one should rather permit this reason to unfold gradually, with ever increasing clarity and perfection, as knowledge of the facts progresses" (Cassirer, 1951, p. 9).

This view is supported by Newton-Smith (2000) who describes Newton's synthesis as a conceptual framework involving space, time, and mechanics, and involving:

> …four most salient features….fertility, axioms, mathematics, and explanation…By 'fertility' I mean to draw attention to the fact that Principia provides not a closed and finished theory but an open and ongoing research program.

(Newton-Smith, 2000, p. 20).

Consequently, a picture of Newtonian methodology emerges from an atomistic ontology and moving to field concepts and a quantum worldview, with systemic syntheses rooted in observable facts, and an epistemology based on open systems learning! Consequently, it is not a methodology grounded in extreme reductionism, as some portray it.

Newtonian thought, and perhaps more particularly Cartesian thought, is accepted as the key characteristic of the enlightenment belief in rational explanation. Systemic thought is complicit in this. Nevertheless, these developments were not without their critics. On the one hand, the Church saw such rationalism as a threat to its authority, and on the other, there were the sceptics who believed that man could not be reduced to systems and mathematics, and proffered the importance of pluralism.

In an insightful essay "The Counter-Enlightenment", Isaiah Berlin provides an account of the "(O)pposition to the central ideas of the French Enlightenment, and its allies and disciples in other European countries" (Berlin, 2001, p. 1). Berlin cites the Neapolitan philosopher Vico (1668-1744) as someone who articulates this perspective better than most:

> With extraordinary originality Vico maintained… that the Cartesians were profoundly mistaken about the role of mathematics as the science of sciences, that mathematics was certain only because it was a human invention. It did not, as they supposed, correspond to an objective structure of reality, it was a method and not a body of truths; with its help we could plot regularities - the occurrence of phenomena in the external world – but not discover why they occurred as they did, or to what end. This could be known only to God…

(Berlin, 2001, p.1).

Instead, Vico insisted on:

> …the plurality of cultures and on the consequently fallacious character of the idea that there is one and only one structure of reality which the enlightened philosopher can see as it truly is, and which he can (at least in principle) describe in logically perfect language….

(Berlin, 2001, pp. 4-6)

Berlin cites German theologian J.G. Hamann (1730-1788) as presenting the more extreme view and a vehement opposition to “systems”:

> 'God is a poet, not a mathematician', and it is men who, like Kant, suffer from a 'Gnostic hatred of matter' that provide us with endless verbal constructions – words that are taken for concepts, and worse still, concepts that are taken for real things. Scientists invent systems, philosophers rearrange reality into artificial patterns, shut their eyes to reality, and build castles in the air. 'When *data* are given you, why do you seek for *ficta* ? Systems are mere prisons of the spirit, and they lead not only to distortion in the sphere of knowledge, but to the erection of monstrous bureaucratic machines, built in accordance with the rules that ignore the teeming variety of the living world, the untidy and asymmetrical inner lives of men, and crush them into conformity for the sake of some ideological chimera unrelated to the union of spirit and flesh that constitutes the real world.

(Berlin, 2001, p. 8).

So, opposition to the systems concept is not new!

It is arguable that the systematisation of philosophy reached its zenith with Kant (1724-1804). Rescher describes the manner in which Kant used a “fundamentally biological analogy” to describe the systemization of his philosophy:

> In accordance with reason’s legislative prescriptions, our diverse modes of knowledge must not be permitted to be a mere rhapsody, but form a system … By a system I understand the unity of the manifold modes of knowledge under

> the one idea. This idea is the concept, provided by reason, of the form of a whole … (which) determines a priori not only the scope of its manifold content, but also positions which the parts occupy relatively to one another. The scientific concept of reason contains, therefore, the end and form of that whole which is congruent with this requirement. The unity of the end to which all the parts relate and in the idea of which they all stand in relation to one another, makes it possible for us to determine from our knowledge of the other parts whether any part be missing, and to prevent any arbitrary addition, or in respect of its completeness to discover any indeterminateness that does not conform to the limits which are thus determined a priori. The whole is thus an organised unity (articulatio), and not an aggregate (coacervio). It may grow from within (per intussusceptionem), but not by external addition (per appositionem). It is thus like an animal body.

(Rescher, 2000, p.66).

Rescher goes on to cite Kant's observation in The Metaphysics of Morals of the difficulties inherent in determining the structure of such a cognitive system:

> The deduction of the division of a system, i.e., the proof of its completeness as well as of its continuity, namely, that the transition from the concept being divided to each member of the division in the whole series of subdivision takes place without any gaps (divisio per altum), is one of the most difficult conditions for the constructor of a system to fulfil.

(Rescher, 2000, p.66).

In summary to this point, what we observe is that the idea of a "system" or the systematization of entities, goes back to antiquity, with many of the early examples concerned with systems of classification (Greek formism) and the synthesis of religious concepts. With the breaking of the nexus between science and religion, Newton's "grand synthesis" and its associated open systems, fact-based epistemology emerged and dominated 18th Century thought, Descartes is revealed as a "closet" systems thinker, realising that his "analytic method" alone is insufficient for constructing a system of knowledge.

By the end of the 18th Century the systems concept had moved from systems of physical entities to systems of knowledge which are capable of "organic growth"; in Kant's terms, "a system of reason".

Fuenmayor, (1997, p. 12) concludes: "This is how systems thinking, contrary to what is common belief in our present systems community, was the hallmark of modern thinking".

The final episode in the discussion of the evolution of the systems concept prior to the current era, relates to Darwin's theory of natural selection published in 1859 (Darwin (1809 – 1882). It will be shown that Darwin's theory and the subsequent "major intellectual movement of the 1930s and 1940s, called by Julian Huxley the 'modern synthesis'" (Gould, 2006, p. 221), sits almost in opposition to systems ideas advanced by Weiss and von Bertalanffy in the 1930s, and which are often referred to as the basis of the contemporary era in systems thinking.

Gould cites Darwin's description of his life work as being divided into achieving two major goals: "to demonstrate the fact that evolution had occurred, and to promote the theory of natural selection as its primary mechanism" (Gould, 2006, p. 221). Gould comments that: "In the first quest, his success was abundant, and he now lies in Westminster Abbey, at the feet of Isaac Newton, for his triumph". This is contrary to Kant's assertion that there would never be a "Newton of a blade of grass"! "Living things, he believed, are examples of 'natural purposes', entities organized so purposefully that we cannot explain them altogether through the blind causality we apply to inanimate nature" (Grene and Depew, 2004, p. xv).

Darwin created a mechanism for evolution based on three propositions:

- Individuals within species vary in physiology, morphology, and behaviour: the principle of variation.

- Offspring resemble their parents on average more than they resemble unrelated individuals: the principle of heredity.
- Different variants leave different numbers of offspring: the principle of natural selection.

(Levins and Lewontin, 1985, p. 32).

Like Newton, a large part of Darwin's fame is associated with his ability to bring together a previously disconnected set of ideas and facts under a general theory. But Darwin recognised his theory was incomplete- his explanation of how and why species originate and the apparent paradox between describing evolution as a continuous process while recognising that species were distinct, suggesting discontinuity. These issues were essentially resolved by Mayr (1904-2005) and others whose work resulted in the "modern synthesis"- the synthesis of Darwin's theory of natural selection with the Mendelian genetic theory of variation and inheritance (Grene and Depew, 2004, pp 247 -289; Mayr, 1942).

It is also interesting to note that Mayr adopted a terminology that had emerged in the 1930s referred to as the "new systematics". New systematics replaced the

> …purely morphological species definition that had traditionally been used in museum work, by a biological one, which takes ecological, geographical, genetic, and other factors into account…..the new systematist tends to approach his material more as a biologist and less as a museum cataloguer. He shows a deep interest in the formation of generalizations, he attempts to synthesize and to consider the describing and naming of species only as a preliminary step of a far-reaching investigation.

(Mayr, 1942, p. 7).

This suggests the importance and levels of sophistication that can be achieved by starting with arguably the simplest of systemic frames- classification systems.

Apart from the formation of a "grand synthesis" that places Darwin alongside the philosophical treatises of "Aristotle, Spinoza and Kant; the scientific syntheses of Euclid, Descartes (*Principles*), Newton (*Principia*) …….Maxwell, Mendeleyev, Freud, Einstein; and in our day, groups responsible for the unification of biochemistry and genetics (e.g. Watson and Crick) and of evolutionary biology (e.g. Dobzhansky and Mayr)" (Holton, 1998 b), Darwinian theory is particularly significant to systems thinkers because of its influence on epistemology and its contrast with von Bertalanffy's open systems theory.

While we may be particularly aware of Darwin's creation of a "grand synthesis", Darwin also applied the analytic method: "far from avoiding deliberately isolated and precise measurements, he was brought in large measure to the formulation of his doctrine by his detailed observation of small portions of the ecology, indeed of the precise shapes of the beaks of finches" (Holton, 1998 b, p. 263).

The following account of the first Darwin Lecture delivered in Cambridge by Sir Karl Popper in 1977, captures something of the significance to worldviews of Darwin's contribution. Popper, commenting on the Darwin's interest in "the problem of design" stated that:

> It is almost unbelievable how much the atmosphere changed as a consequence of the publication, in 1859, of the *Origin of Species*. The place of an argument that really had no status whatever in science has been taken by an immense number of the most impressive and well-tested scientific results. Our whole outlook, our picture of the universe, has changed, as never before.

(Popper, 1987, p. 141).

Despite the evidence presented above that, for example, Newton advocated that his methodology should not be considered as a closed system, what he didn't have was the well-defined metaphor provided by Darwin's theory of natural selection, nor of course, the detailed rigour provided by Popper based on this metaphor, to fully articulate his methodology in evolutionary terms.

In the history of science, it is evident that evolutionary theory changed the course of history, more so than von Bertalanffy's demonstration against vitalism and the development of GST.

Ernst Mayr (1904 -2005), described as the "grand old man of evolutionary biology", and the pre-eminent contributor to developing a "philosophy of biology" (Mayr, 1942, 1988, 2001, 2004), makes only two references to von Bertalanffy, each nothing more than a brief mention; one favourable, one not so! Mayr states:

> I think it is fair to state that biologists like Rensch, Waddington, Simpson, Bertalanffy, Medawar, Ayala, Mayr, and Ghiselin have made a far greater contribution to a philosophy of biology than the whole older generation of philosophers, including Cassirer, Popper, Russell, Bunge, Hempel, and Nagel. It is only the generation of youngest philosophers (Beckner, Hull, Munson, Wimstatt, Beatty, Brandon) who are finally able to get away from the obsolete biological theories of vitalism, orthogenesis, macrogenesis, and dualism or the positivist-reductionist theories of older philosophers.

(Mayr, 1942. p. 75).

But, referring to von Bertalanffy as an early "autonomist" (in the sense of biology being an independent science), Mayr (1988, p. 14) argues that von Bertalanffy supports his position with "vague arguments as dynamics, energy gradients, formative movements, and so on, that did not enhance the credibility of the new movement".

It has been evolutionary theory that has provided the stark contrast against the mechanical world view of the physical sciences and biology, not systems theory as we associate it with von Bertalanffy. But clearly systemic thought was central to evolutionary theory. Despite broad concurrence with evolutionary theory, von Bertalanffy adopted a position which, while it may have merit, further isolated him from the evolutionary school. Von Bertalanffy disagreed with the common belief among biologists that the theory of selection is:

> … based on the assumption that the laws of physical science plus natural selection can furnish a complete explanation for any biological phenomenon, and that these principles can explain adaptation in general and in abstract and any particular example of an adaptation.

(von Bertalanffy, 1969, p. 64).

More particularly, von Bertalanffy challenged Darwin's assumptions about the "accidental nature of evolution", that remains unchanged in the later "Synthetic Theory" (von Bertalanffy, 1969, p. 66).

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While von Bertalanffy emphasises that he is not attempting to "refute neo-Darwinism as a scientific theory…The question raised here refers to the 'nothing-but' claim of synthetic theory, that is, the statement that the theory is *in principle* capable of furnishing a complete explanation of evolution". He adds:

> I think that a theory so vague, so insufficiently verifiable and so far from the criteria otherwise applied in "hard" science, has become a dogma, can only be explained on sociological grounds.

(von Bertalanffy, 1969, p. 66).

Von Bertalanffy concludes:

> It appears, therefore, that the synthetic theory of evolution is not a complete explanation and that the problem needs a new approach. This ought to conclude exploration of organismic systems beyond the molecular level; regularities in evolutionary processes; the "grammar" of the genetic code; thermodynamics and informational considerations; a theory of dynamic hierarchical order; generally speaking, the consideration of evolution as not completely "outer-directed" but co-determined by laws at the organismic levels.

(von Bertalanffy, 1969, p. 75).

Gould (2006) refutes the position of von Bertalanffy and his Viennese contemporary, Arthur Koestler, by claiming that:

> They charge that Darwinism cannot be correct because a world so ordered as ours cannot be built by random processes. But they fail to understand that Darwinism invokes randomness only to generate raw materials.

(Gould, 2006, p. 224).

Despite the merits of von Bertalanffy's arguments, and the popular belief in contemporary systems literature that von Bertalanffy is the "father" of the modern era in systems thinking, there is no doubt that evolutionary theory has become a more recognised worldview than the open systems concept. By identifying with von Bertalanffy, systems thinking in the current era would seem to have "backed the wrong horse"!

Conclusion.

In this survey of the development of science to the 1930s, it is clear that systems thinking plays a critical role in shaping the direction of science and the structuring of knowledge. It is also clear that some of the greatest constructors of the "grand syntheses" understood the basics of an evolutionary epistemology involving both analysis and synthesis in the pursuit of systems of knowledge. We also witness the opposition to systems because it characterises rational thought, and the need to be cognizant of the importance of pluralism if we are to avoid the excesses of monism.

But towards the end of this journey, we see the emergence of a new era in thought. On the one hand, physics became "dematerialised" and a quantum era of thought places Newtonian mechanics into a new context. On the other, we see the emergence of a powerful new worldview based on evolutionary theory. These developments led Alfred North Whitehead to make a "U- turn" in his own career in science and mathematics and propose a new "process" philosophy as a way of understanding these developments (Whitehead, 1925).

Throughout these developments, the ideas of systems and systems of meaning have been central to the debates. How is it then, that we now find ourselves where sentiments reminiscent of J.G. Hamann cited earlier, appear to prevail, and the roles of analysis and synthesis in relation to systems thinking have become so confused? How is it that in quite recent times, systems theory was described as “an ideology” that was strong on promises but fundamentally flawed to the extent that nothing could really be delivered?

> As a philosophy, systems theory is meretricious, adding nothing to our present condition; as a social theory, it is sterile, a mere repetition of old ideas dressed in new terminology- it is simply a disguised version of an older “organic” image of society, which sees social institutions as knit together in a manner analogous to the organs of the body, with individual “cells” of this body-social, an image going back at least to the middle ages.

(Lilienfeld, 1975, in Midgley, 2003, Vol. II, p.349).

Why is it that Checkland’s (1981) observation that “‘systems thinking’ is not yet a phrase in general use”, is still accurate?

Why is it that developments in systemic thought need to be taken “outside the academy” (Bawden et al, 2007)?

To start to attempt to answer these questions, we need to further consider the era of Ludwig von Bertalanffy (1901-1972) and General Systems Theory, and the later developments in systems thinking.

1.3. Systems Thinking: von Bertalanffy and General Systems Theory (GST).

As a student of biology at the University of Vienna in the 1920s, von Bertalanffy found himself in the midst of a long and intense debate about the application of "mechanistic" thinking in biology.

This debate, which traces back to Aristotle, had at its core the "vitalist's" claims, described by a publisher's description of a book by the celebrated neo-vitalist Hans Driesch (1861-1941), first published in 1908 (Driesch, 1914), that vitalism:

> … marks the end of the materialistic or mechanical conception of the universe in each of its possible forms. Philosophy shows that causality is not necessarily mechanical, and science that life is not explainable in terms of physics and chemistry[4].

Although, Hammond (2003, p. 34), describes Driesch's work as providing "inspiration for von Bertalanffy's conception of organismic biology", it is more likely that von Bertalanffy was primarily influenced by his interaction with Paul Weiss and Arthur Koestler, and in the formation of what Drack and Apfalter (2006) refer to as the "Viennese School of Systems Theory".

Later, Weiss captures the intent of these times when he advocates that "certain basic controversies about the nature of organisms and living processes" "readily vanish in the light of realistic studies of natural phenomena, described in language uncontaminated by preconceptions". He advocates the acceptance of the "*principle of hierarchic order* in living nature" as revealing "a demonstrable descriptive fact, regardless of the philosophical connotations that it may carry", and further, the necessity to "accept organic entities as systems subject to network dynamics in the sense of systems theory, rather than as bundles of micro-precisely programmed linear chain reactions" (Weiss, 1969, p. 4).

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[4] Ironically, the book carrying the advertisement was J.C Gregory's *A Short History of Atomism*! (A&C Black, London, 1931).

Interestingly, while demonstrating the inadequacies of the mechanistic "rationalisations" of animal behaviour, Drack and Apfalter (2006, p. 2) note that Weiss "saw a way of reconciling his findings fully with the then flourishing epistemology of modern physics", suggesting that Weiss at least had moved on from the original vitalist war against mechanism.

Von Bertalanffy's seminal contribution was to show that recourse to vitalism was unnecessary if you introduce the concept of an open biological system in which an organism can maintain itself in a state of disequilibrium through continuous interaction with its environment. (Miller, 1965; Hammond, 2003, p. 105). Von Bertalanffy achieved this outcome by resolving a number of dilemmas using the concept of an open system and the applying the mathematics of the "transport equation" to describe the way a system transforms inputs from the environment into outputs. Key dilemmas resolved by von Bertalanffy (1968, p.39) include:

The principle of equifinality- the idea that the final state of any living system can be reached from different initial conditions (Miller, 1978: 41). In any closed system the final state is uniquely determined by a specific set of initial conditions, but in open systems, the same final position can be produced from different initial conditions. Driesch (1914) argued that this apparent contradiction can only be explained by the presence of a "soul-like vitalist factor which governs the processes in foresight of the goal" (von Bertalanffy, 1968: 39). Von Bertalanffy showed that equifinality was in fact, a property of an open system insofar as it can achieve a steady state through interaction with its environment.

The apparent conflict between "the law of dissipation in physics" in which the second law of thermodynamics infers that the physical world moves towards states of increasing disorder and a "levelling of differences", and the "*law of evolution in biology"* in which complexity increases (von Bertalanffy, 1968, p. 40).

Apart from the obvious triumph of rational thought over vitalism, von Bertalanffy's seminal contribution emphasised the importance of differentiating between the physical sciences and the biological sciences in terms of closed and open systems.

However, it needs be recognised that soon after, systems thinkers associated open systems more with field theory and Gestalt psychology than with biological science (Bohm, 1980; De Greene, 1982; Lewin, 1942/1997).

A key outcome of the "Viennese School" was that the old mechanistic- organicist debate took on a new lease of life with the logic of science on the side of the biologists. It promised a new era of anti-reductionist studies in biology (Koestler & Smythies, 1969; Weiss, 1969) and the prospect of translating across disciplines using the open systems concept as an integrating concept. However, this new era has met with limited success. In biology, molecular biology underpinned the giant strides made in 20th century biology and evolutionary theory provided a new world view.

Reflecting on 20th century biology, eminent biologist J.T. Bonner (1996) writes:

> My life as a biologist has spanned sixty years, and the changes during those years have been staggering. I was there to watch its many metamorphoses unfold right in front of my eyes. Among the milestones there is one overall trend that is striking. When I began, most of biology was about big things. For instance, if one follows the course of how we have thought about Darwinian natural selection, we see that in the 1930s evolutionary biologists were involved with whole populations; later natural selection was applied primarily to individual organisms, and even more recently to their genes. Although I am a firm believer in looking at the living world in a grand, overall, holistic manner, it is clear that in our great progress in most of the fields of biology during these three score years there has been a simultaneous progressive spreading into reductionism.
>
> Many of the answers we have sought and found have involved explanations at a lower level of analysis; some great successes have come from atomizing biology. Even though this is where much of the excitement lies, we can only appreciate and fully understand the great lessons of this reductionist revolution and its applications to all of biology, including applied fields such as medicine, if we examine how the reduced parts fit together to make the beautiful whole.

(Bonner, 1996, p. 117).

Any strongly dichotomous views between reductionism and holism are further questioned when one looks at the actual practice of biological science over the 20th century. For example, Nobel Laureate, Francis Crick demonstrated the importance of both reductionism and holism in the following description of mainstream scientific method ("reductionist science") and the phenomenon of emergence (Crick, 1994, pp. 7-8, 11):

> ….. many people are reluctant to accept what is often called the "reductionist approach"- that a complex system can be explained by the behavior of its parts and their interactions with each other. For a system with many levels of activity, this process may have to be repeated more than once that is, the behavior of a particular part may have to be explained by the properties of its parts and their interactions. …
>
> Where does this process end? Fortunately there is a natural stopping point. This is at the level of the chemical atoms……
>
> There have been a number of attempts to show that reductionism cannot work. They usually take the form of a rather formal definition; followed by an argument that reductionism of this type cannot be true. What is ignored is that reductionism is not the rigid process of explaining one fixed set of ideas in terms of another fixed set of ideas at a lower level, but a dynamic interactive process that modifies the concepts at both levels as knowledge develops…..

(Crick, 1994, p. 11).

Two aspects of Crick's statement need emphasising. Firstly, that he starts with a "system" before entering the analysis stage; and secondly, that the reductive stage "has a natural stopping point".

Crick proceeds to argue that "emergence" of a system can be understood from a knowledge of the parts, *plus* the knowledge of how they interact:

> … much of the behavior of the brain is "emergent" that is, behavior does not exist in its separate parts, such as the individual neurons. An individual neuron is in fact rather dumb. It is the intricate interaction of many of them together that can do such marvellous things.
>
> There are two meanings of the term emergent. The first has mystical overtones. It implies that the emergent behavior cannot in any way, even in principle, be understood as the combined behavior of its separate parts. I find it difficult to relate to this type of thinking. The scientific meaning of emergent, or at least the one I use, assumes that, while the whole may not be the simple sum of the separate parts, its behavior can, at least in principle, be understood from the nature and behavior of its parts plus the knowledge of how all these parts interact.

(Crick, 1994, p. 11).

In the history of biological science, it seems even more bizarre that, despite von Bertalanffy's breakthrough, the impact of Darwin's evolutionary theory, and the dramatic changes in physics, biology continued to emphasise the reductionist path. Indeed, Morowitz (1982) observed that:

> Something peculiar has been going on in science for the past 100 years or so. Many researchers are unaware of it, and others won't admit it even to their own colleagues. But there is strangeness in the air. What has happened is that biologists, who once postulated a privileged role for the human mind in nature's hierarchy, have been moving relentlessly toward the hard-core materialism that characterized nineteenth-century physics. At the same time, physicists, faced with compelling experimental evidence, have been moving away from strictly mechanical models of the universe to a view that sees the mind as playing an integral role in all physical events. It is as if the two disciplines were on fast-moving trains, going in opposite directions and not noticing what is happening across the tracks.

(Morowitz, 1982, p. 34).

More recently, Capra (2007) suggests that this situation is resolved by the observation that biology is shifting emphasis from "the structure of genetic sequences to the organization of metabolic networks. It is a shift from reductionist to systems thinking." He elaborates:

> The issue, simply stated, is this: to understand the nature of life, it is not enough to understand DNA, proteins, and other molecular structures that are building blocks of living organisms, because these structures also exist in dead organicisms, e.g., in a dead piece of wood or bone.
>
> The difference between a living organism and a dead organism lies in the basic process of life … this process of life is called "metabolism". It is the ceaseless flow of energy and matter through a network of chemical reactions, which enables a living organism to continually generate, repair, and perpetuate itself.

(Capra, 2007, p. 5).

In this sense, we can see that von Bertalanffy's idea of an open system was ahead of its time. Nevertheless, von Bertalanffy continued on, shifting his emphasis from biology to the creation of the interdisciplinary field of General Systems Theory. In this theory the biological metaphor was applied across disciplines and linkages made with Whitehead's "process philosophy". The outstanding example of this is James Grier Miller's seminal *Living Systems* (Miller, 1965).

Von Bertalanffy's input-output notion of open systems has been challenged on two fronts: Emery's socio-ecological model (discussed later) and Maturana's autopoietic systems model.

Mingers (1995) describes autopoiesis as:

> … the idea that certain types of systems exist in a particular manner- they are *self-producing* systems. In their operations they continuously produce their own constituents, their own components, which then participate in these same

> production components. Such an autopoietic system has a circular organization, which closes itself, its outputs becoming inputs. This gives it an important degree of independence or autonomy from its environment since its own operations ensure, within limits, its future continuation.

(Mingers, 1995, p. ix).

The concept of "autopoiesis" was developed by Humberto Maturana in an attempt to reconcile two issues- one arising from attempting to answer a "central" question raised by his medical students: "What is proper to living systems that had its origin when they originated, and has remained invariant since then in the succession of their generations?". The other arising from research into colour vision in which there was a rejection of the idea that colour vision involved "a mapping of a colourful world on the nervous system" and a need to find "an understanding of the participation of the retina (or nervous system) in the generation of the color space of the observer (Maturana and Varela, 1980, p. xii).

Maturana described his new conceptualisation of living systems as a rejection of a prevailing "open systems" view:

> I had to stop looking at living systems as open systems defined by an environment, and I needed a language that would permit me to describe an autonomous system in a manner that retained autonomy as a feature of the system or entity specified by the description. In other words, any attempt to characterize living systems with notions of purpose or function was doomed to fail because these notions are intrinsically referential and cannot be operationally used to characterize any system as an autonomous entity. Therefore, notions of purpose, goal, use or function, had to be rejected.

(Maturana and Varela, 1980, p. xiii).

Mingers further elaborates the relationship between an autopoietic organization and its environment:

> Organizational closure does not imply interactive closure or isolation from the environment. Clearly such organizations do, necessarily, interact with their environment. The point is that such interactions also continue the ongoing process of autopoiesis; otherwise they would not occur…..Organizations that interact recurrently with an environment or with other organisms and which have a plastic or changeable structure develop a relationship of structural coupling.

(Mingers, 1995, pp. 206-207).

A principal implication of autopoiesis is the "embodiment of mind" (Lakoff and Johnson, 1999).

Unfortunately, Maturana does not precisely define what he means by an "open system". His reference to input-output transformations suggests he is referring to von Bertalanffy's construct, as distinct from the social ecology model proposed by Emery and Trist (1973). Indeed, despite Maturana's emphasis on "closed systems", there appear to be significant similarities between his model and Emery and Trist's. For example, both reject the input-output version of an open system, both emphasise structures that can be known, Maturana's description of the relationships between elements of a systems structure and elements in the systems environment is similar to Sommerhoff's "fields of directive correlations" that support Emery's model, both involve information structures within the system and its environment, and both are co-evolutionary. The outstanding differences appear to be Maturana's insistence on his autopoietic system not being referentially dependent on the environment, although he describes his systems as existing in a "context of meaning", and Emery and Trist's emphasis on *active*-adaptation, compared to Maturana's *passive*-adaptation. This difference is a reflection on Maturana's emphasis on biological systems and Emery and Trist's emphasis on human systems.

General Systems Theory (GST).

In a manner reminiscent of Giddens' interpretation of sociology as the study of modernity, a definition used to avoid sociology from being just another synonym for the social sciences (Giddens & Pierson, 1998), the advent of GST was an attempt by von Bertalanffy to move the systems concept on from its hitherto philosophical basis to its articulation as a program in search for isomorphism across scientific disciplines (that is, systems of knowledge):

> Here is the reason why, even though the problems of "systems" were ancient and had been known for many centuries, they had remained "philosophical" and did not become a "science". This was so because mathematical techniques were lacking against any change in the fundamental paradigm of one-way causality and resolution into elementary units….The quest for a new "gestalt mathematics".

(von Bertalanffy, 1972a, p. 411).

That is, von Bertalanffy, cognisant of the development of "systems of knowledge" sought to go to another level, in which it was possible to compare systems and leverage off isomorphism. But to do this, von Bertalanffy required a common structural basis- the open systems concept.

While this suggests an emphasis on conceptual monism around organicism, in fact von Bertalanffy recognised the importance of multiple developments, and perhaps even methodological pluralism, as part of the process of the evolution of knowledge:

> Thus there is indeed a great and perhaps puzzling multiplicity of approaches and trends in general systems theory. This is understandably uncomfortable to him who wants a neat formalism, to the textbook writer and the dogmatist. It is, however, quite natural in the history of ideas and of science, and particularly in the beginning of a new development. Different models and theories may be apt to render different aspects and so are complementary. On

the other hand, future developments will undoubtedly lead to further unification.

(von Bertalanffy, 1972a: p. 424).

But, the outcomes were not those anticipated by von Bertalanffy and the other founders of GST. By the end of the 20th Century, Checkland observed that the hope that GST would "provide a meta level language and theory in which problems in many disciplines could be expressed and solved" and so "help to promote the unity of science", has not materialized. "Looking back from 1999 we can see that the (GST) project has not succeeded" (Checkland, 2000, p. S 11).

What could have gone wrong? A number of reasons are offered:

- **The "crowding out" of the open systems concept and GST by evolutionary theory.**

  Despite the fact that von Bertalanffy's case against Darwin and the "modern synthesis" may have merit, it clearly has not stopped evolutionary theory becoming part of the mainstream of thought and a fundamental metaphor for business and other social phenomena.

- **"Bad Press" resulting from the naive application of closed system thinking to social policy:**

  Because GST became synonymous with "systems thinking" it was identified with the application of engineering system thinking and optimization theory in social policy and a fear of centralist control from scientific "elites" (Hoos, 1972, Thayer, 1972, Lilienfeld, 1978). In addition, GST became identified with Parson's structural-functionalist sociology (Midgley, 2003a).

- **The marginalisation of systems thinking in science**.

  This is an unintended outcome of von Bertalanffy's attempt to associate system thinking with organicism and its consequent anti-reductionist stance in the age-old debate in biology between "reductionism" and "holism" As the earlier examples illustrate, mainstream scientific method involves both reductionism *and* holism. In biology, for example, the major breakthroughs have been in the area of *molecular* biology. However, almost paradoxically, social systems failures usually are the result of reductionist dogma. These problems arise when the complementary processes of reductionism and holism become separated and degenerate into "extreme reductionism" and "extreme holism".

  Even worse, the marginalisation of system thinking from the mainstream of the scientific method is certainly not what von Bertalanffy expected. The resolution of the debate between mechanism and organicism by identifying machines with closed systems and biological systems with open systems, each with there own logics, seems to have been lost in the renewed hyperbole of the paradigm wars- contemporary systems texts seem more often than not to simply adopted the rhetoric of vitalists in introducing systems thinking.

  In fact, the logics associated with the "closed" mechanistic view of the world, and the "open" biological systems view are both important, and, as noted by Ackoff (1981), it is this distinction that leads to Singer's articulation of "cause and effect" logic for closed systems and "producer-product" logic for open systems (Singer, 1959, pp. 273-296).

  - **The exclusion of other themes and contexts of importance to system thinking.**

  It is generally accepted that contemporary system thinking is based on emergence and hierarchy- a direct result of von Bertalanffy's organicism, and communication and control- reflecting post World War 2 developments in servomechanism theory and cybernetics (Checkland, 1981; Richardson, 1983). While these provide very important defining characteristics of modern systems thinking, their emphasis has excluded a number of other significant themes that can help define systems thinking.

Two important examples illustrate this:

- Systems of Knowledge: Despite the origins of GST in understanding and using systems of knowledge, attempting to redefine systems thinking in terms of GST appears to have reduced the historical importance of systems of knowledge as described earlier. As history reveals, the systemic framing of knowledge affects the direction of science, and influences the dominant metaphors used in social policy; the way systems are framed is critical to the way debates are constructed in both science and social policy (Lakoff, 2004).

- Pragmatist Philosophy: The contribution of pragmatist philosophy with a lineage that connects Charles Sanders Peirce, William James, John Dewey, Edgar Arthur Singer, C. West Churchman and, through Churchman, a whole generation of systems thinkers and beyond (Britton and McCallion, 1994; Ulrich, 1988; Matthews, 2005). This lineage further extends to Fred and Merrelyn Emery's contributions to social ecology and open systems theory (Trist and Murray, 1993, Trist et al., 1997; Emery, 1999).

- **The Inability of the Input-Output open systems concept to meet the comprehensibility criteria as an organising concept for a *General* Systems Theory**.

Von Bertalanffy's biologically-based input-output representation of open systems does not describe the structure of environments. Consequently, it is not sufficient to describe human purposeful systems and active adaptation (Emery and Emery, 1997), nor Maturana and Varela's autopoietic systems.

> This can be achieved by using an ecologically-based framework in which the "causal textures" of environments are defined and in which relationships within and between the systems and its environment become key attributes (Emery & Trist, 1965). Such an open systems concept can be used as a device to describe other system ontologies. For example, input-output systems describe a special case. Consequently, GST has not produced the anticipated benefits in the development of interdisciplinary thinking.

Can von Bertalanffy's GST Agenda be Revived?

Mulej et al. (2004) raise the issue of what might be required to restore "Bertalanffian systems thinking". Similarly, Drack and Apfalter (2006) raise the question of the current validity of "Paul Weiss' and Ludwig von Bertalanffy's Systems Thinking" and describe the foundation of the "Bertalanffy Centre for the Study of Systems Science" based in Vienna with particular access to a recently discovered archive of von Bertalanffy's papers.

Given the preceding discussion, it would seem that GST as it has developed does not have a future except as one part of a broader conception of the systems field. Midgley (1996) goes further and, based on Kuhn's argument that "science develops through changes in the use of language" suggests that the "idea of a common systems language based around the concept of isomorphism is antithetical to this". Alternatively, Midgley proposes that the pursuit of unity is:

> …an 'ideal'- a theoretical construct that can be used to guide critical reflection…..Now, systems scientists think of systems inquiry as being an approach in which study areas are not differentiated through reference to conventions of disciplinary boundaries, but develop and change through the on-going practice of defining and redefining systems.

(Midgley, 1996, pp. 26-28).

In this context, the proposals of Mulej et al. (2004) are well wide of the mark, but improved access to von Bertalanffy's papers as outlined by Drack and Apfalter

(2006), supplemented by Hammond's detailed description of the development of GST (Hammond, 2003), may, amongst other things, throw further light on von Bertalanffy's pluralist intentions.

1.4 From GST to Pluralism- The Contemporary View of Systems Thinking.

Most associate the origins of contemporary systems thinking with von Bertalanffy's organismic models characterised by "a rejection of the atomism and reductionism of physics and chemistry", and the subsequent development of GST (Hammond, 2003).

In recent years the systems community has been privileged to a number of important publications that trace the history and development of contemporary systems thinking. Foremost amongst these is Midgley (2003) who provides an edited set of papers, the majority of which were originally published in the period 1970–2000. (Midgley's volumes will be used as a basis for discussion in this section).

In categorising some seventy-six papers, Midgley (2003) has chosen four themes to characterise the transition from GST to the current emphasis on pluralism:

- General Systems Theory (GST), Cybernetics and Complexity
- Systems Theories and Modelling
- Second Order Cybernetics, Systemic Therapy and Soft Systems Thinking
- Critical Systems Thinking and Systemic Perspectives on Ethics, Power and Pluralism.

(Each corresponds to the chapter headings).

In the first period, corresponding to the mid-twentieth century and, as outlined previously, Midgley observes that GST grew out of the rejection of the Newtonian worldview in biology, in favour of a more holistic approach to the study of biological systems. GST rather quickly moved on to propose itself as a meta-approach based on certain systemic characteristics observed in a range of disciplines. It was also the time in which cybernetics and feedback control systems concepts became explicit and biological concepts of complexity were developed.

The second theme corresponds to a period in which systems techniques developed in the military during WW 2 started to find their way into planning and policy-making in business and public sector management. It was also the period of Parson's "structural functionalism" in which Parsons (1951) argued that social behaviour results from deep underlying social structures that are maintained and reproduced by functional behaviour. Consequently, individuals and social groups were deemed to have limited and largely deterministic futures.

In the same period Forrester's World Model (Forrester, 1971), the RAND Corporation's approach to planning, and Kast and Rozenweig's (1972) approach to framing organisations as a system all received prominence. However, these approaches drew heavy criticism and became associated with perceptions and fears of centralist control and threats to freedom (Hoos, 1972). Unfortunately, the criticism of systems thinking was indiscriminate and all approaches to systems thinking were tarred with the same brush.

The contents of Midgley's Volume 3 represent something of a reaction to Volumes 1 and 2 in which "second order" cybernetics is introduced where observers are recognised as purposeful systems and a perfectly objective view becomes an impossibility, family therapy recognizes the importance of "context", and "soft" systems methodology is developed in direct response to "hard" systems approaches (Checkland, 1981). This period also witnessed the wide acceptance of socio-technical systems, originally developed out of the Tavistock Institute (Trist and Murray, 1993) and popularised in the United States as part of a number of approaches that developed multiple perspectives (Linstone, 1984; Mitroff & Linstone, 1993) and large group search processes (Buncker and Alban, 1997; Weisbord, 1992; Weisbord and Janoff, 1995).

The fourth theme brings us to a current era that starts in the 1980s with the development of a number of critical thinking themes organised around the ideas of pluralism, complementarism (of systems approaches), ethical behaviour, and emancipation.

The development of pluralism in its widest sense was stimulated by Flood's (1990) manifesto for "liberating" systems thinking, Flood and Jackson's "Critical Systems Thinking" (Flood and Jackson, 1991; Flood and Romm, 1996 a, b, c, d), Ulrich's attempt to reposition systems thinking within a socially rational and ethical approach to planning (Ulrich, 1983), Midgley's discussion of pluralism (Midgley, 1992) and his concentration on ethical systems interventions (Midgley, 2003).

Consequently, Midgley's treatment of this era emphasises developments in the "Hull School", resulting in less attention to the continuing developments from the third era. In fact, developments in Beer's cybernetics, Ackoff's interactive systems, and Emery's open systems theory all continued to progress. In addition, organicism re-emerged around the concept of autopoiesis (Maturana and Varela, 1980), and, largely through the interdisciplinary efforts at the Santa Fe Institute, complexity theory became a better defined field (Holland, 1995; Kauffman, 1995).

In more recent times, there has been a significant contribution to the field of systems design (Nelson and Stolterman, 2003) and we have witnessed a significant growth in what might be described as the popularisation of systems thinking through more populist publications such as Senge's *The Fifth Discipline* (Senge, 1990), and Capra's *Web of Life* (Capra, 1996).

Midgley's arrangement is invaluable in meeting his stated purpose to "consolidate key writings on systems thinking for the benefit of future generations" while making available "the broadest possible range of systems ideas Midgley's (2003: xvii)". But, as Midgley points out- while assembling papers suggested by forty-seven "distinguished writers" reduces bias, the ultimate selection of seventy-six papers from a population of seven hundred will inevitably reflect the ideas of the editor:

> In my (Midgley's) view, it is an important task for current and future generations of systems thinkers to harness this diversity into a flexible and

responsible systems practice of wide spread applicability to the management of organizational, social and environmental change.

(Midgley, 2003: xviii).

Four Observations.

At least four observations can be made about Midgley's (2003) interpretation of the period:

Firstly, it is important to acknowledge the sheer wealth of material contained in the four volumes- the following comments are not an attempt to detract from this.

Secondly, as Midgley infers, there is no real attempt to consider the deeper origins of systems thinking, except by way of incidental comments made in individual papers (for example, in the contributions from Marchal, Bunge, and M'Pherson etc). This is not unreasonable given the intent of the volumes to consolidate more recent contributions of systems thinking and "follow in some distinguished footsteps" including those of Buckley (1965); Emery (1969, 1981); Beishon and Peters (1972); and Klir (1991). But it does mean that possible long-term appreciations of the importance of systems thinking are not discussed. For example, Luhmann (1995) suggests that over the past one hundred years, two fundamental changes have occurred in systems theory. The first change relates to the shift of emphasis from considering systems in terms of wholes and parts, to one concerning system and environment. This change corresponds to a change in thinking from entities as closed systems to open systems. The second change is from open systems theory to a theory of self-referential systems in which systems can only differentiate by reference to themselves. This latter point is further argued by Lawson (2001) who suggests that, while admitting the world as open and complex, we use language and meaning to form a closed systems view: "This process, the process of closure, is the means by which we are able to identify things from the flux of the world and therefore create a reality which we can understand and manipulate" (Lawson, 2001: x). Such a process is inherently self-referential but not autopoietic in the sense of Maturana and Varela.

It is more consistent with the way System Dynamics constructs a closed system model as a tool of inquiry.

Thirdly, despite the wide net cast, there is no reference to the developments in open systems theory in the sense of social ecology. While the foundations of the socio-ecological approach were set down in Emery's volumes (Emery, 1971, 1981) they continued to be developed at the Tavistock Institute and at Wharton. These developments are recorded by Trist, Emery, and Murray (1997), Ackoff and Emery (1972), and in more recent publications including Emery (1999) and the October, 2000 special issue of *Systemic Practice and Action Research* devoted to the Emery Open System Theory.

The ***fourth*** reaction is to Midgley's advocacy of a pluralist "worldview", more about which will be discussed below.

Clearly, the eclectic nature of the papers published reflects a commitment to "methodological pluralism" (Midgley, 1996, p. 12) and the avoidance of "methodological myopia" (Bawden, 2003), and, at a deeper level, the "Ethical Critique of Boundary Judgements" (Midgley, 1996, p. 12; 2000; 2003).

Consequently, from Midgley's perspective, contemporary systems thinking has moved on from the perceived monism of GST to a position of pluralism, in which the goal of a GST-type framework is regarding as setting an "ideal". (Midgley, 1996, p. 28).

This is a very significant outcome that emerges from nearly 50 years of emphasis on the epistemology of systems thinking, initially dominated by Checkland's SSM, and, most importantly, addressing the criticisms cited earlier by Hoos, Lilienfeld, and others.

Pluralism in Systems Thinking.

Pluralism is part of the post modernist reaction against the enlightenment. It is not surprising, therefore, that it has found its way into the discussion of systems thinking, particularly since systems thinking was perceived by many in the 1960s as a vehicle for centralist control.

Midgley (1992) identifies Jackson and Keys' (1984) proposal for a *System of System Methodologies* (SOSM) as the first step towards pluralism in systems thinking. This is later associated with Jackson (1987) and Flood's (1989) "challenge against isolationism in systems thinking" in which there is "the belief that there can be only one correct approach to systems science, or that there is only one valid systems methodology" Midgley (1992) .

Midgley (1992) provides the first comprehensive case for pluralism and this was followed by a useful extension and survey by Flood and Romm (1996c) and a special issue of *Systems Practice*, also in 1996. In particular, three contributions provide a useful introduction to pluralism: Midgley (1996)- summarising Midgley (1992); Gregory (1996); and Flood and Romm (1996c).

Midgley defines pluralism in systems thinking as:

> …viewing all methods as complementary, addressing different kinds of questions. However, it also involves the production of theories of knowledge (epistemology) and reality (ontology) to explain the methodological variety that is embraced. Pluralism is therefore not a superficial approach to methodology. On the contrary, it asks us to develop a coherent philosophical perspective that will allow us to overcome isolationism while retaining the variety inherent in the multiplicity of competing methodological paradigms available to us.

(Midgley, 1996, p. 32).

As part of this program, Midgley (1992) argues for broadening the usual interpretation of "natural world complexity", to one that embraces issues arising from "moral decision making and subjectivity" and cites examples involving the interdependence of "ecological harmony, social justice, and personal freedom".

Consequently, in Midgley's terms, pluralism implies a need to consider "value judgments".

Gregory (1996) demonstrates that there are several forms of "extant pluralism and argues that "discordant pluralism" offers a "distinctive and dynamic basis for Critical Systems Thinking". In describing discordant pluralism Gregory uses Bernstein's constellation metaphor (Bernstein, 1995) in which different nodal points represent "bright stars" in both modernist and postmodernist thinking. In a form of figure ground reversal, "different, competing and conflicting perspectives may intersect in a tension which lasts only a critical moment" (Gregory, 1996, p. 55).

After considering the relative merits of four possible vehicles for formulating pluralism in Critical Systems Thinking- pragmatism (not in the philosophical sense), isolationism, imperialism, and complementarism, Flood and Romm (1996 a, pp. 81-83) propose "complementarism", defined as a process:

> ….to reveal and critique the theoretical (ontological and epistemological) and methodological bases of systems approaches, and to reflect on the problem situations in which approaches can be properly employed and to critique their actual use", as offering "some promise in keeping alive the optimism and potentially nonrepressive nature of diversity.

Flood and Romm (1996a, p. 83) identify the critical dilemma faced by pluralists as starting with answering the question: "on what basis can choice be made between theories (and methodologies)?" This raises the question of "commensurability" that, "starts a process of slipping back, down the muddy bank into isolationism (through imperialism)". Flood and Romm identify a "triangle of dilemma" between commensurability, isolationism, and incommensurability, in which the "postmodernist world is characterised *inter alia* by dilemmas and differences" and is happy for this to remain unresolved, whereas "modernists' want to resolve dilemmas (Flood and Romm, 1996a, p. 84).

The question of whether or not it is possible to define a common basis for comparing systems methods, or more broadly, worldviews is illustrated by the following exchange between the biologist, Sir Karl Popper and the distinguished physicist, John Archibald Wheeler:

> Wheeler had just delivered a brilliant exposition of his interpretation of quantum mechanics. Popper turned to him and quietly said: "What you say is contradicted by biology". It was a dramatic moment. A hush fell around the table. The physicists present appeared to be taken aback. And then the biologists, including Sir Peter Medawar, the Nobel prizewinner who was chairing the meeting, broke into a delighted applause. It was if someone had finally said what they had all been thinking.

(Bartley III, 1987, p. 7).

After addressing a number of possible paths through this dilemma, including Gregory's adaptation of Bernstein's discordant pluralism as outlined above, Flood and Romm choose a path that retains a consciousness of the tensions between different theories and methodologies, and choose to "promote optimistic and demote pessimistic aspects of modernism and postmodernism" (Flood and. Romm, 1996a, p. 91). They term this approach "diversity management" (Flood and Romm, 1996a, b).

The core of diversity management involves processes of "reflexive consciousness" linked to three specific cycles of learning- triple loop planning: The first loop enables thinking about "design and structural" matters; the second, involves the enhancement of "intersubjectivity in society" by "mutual encounter" in which "our understanding of the world" is enriched through debate; and the third loop relates to the way knowledge and power "become entangled in practices of knowledge –construction in society" (Flood and Romm, 1996a, pp. 9-10).

In short, triple loop learning results by using a reflexive learning process largely based on applying Flood's four categories for "deepening systemic appreciation": systems of processes, systems of structure, systems of meaning, and systems of knowledge-power. (Flood, 1999, pp. 94-122).

In what is a more instrumental approach to managing plurality, at least in the sense of avoiding methodological “isolationism” Jackson and Keys (1984) describe a framework which attempts to link methodologies to problem types. The framework has gone through a number of revisions (Flood and Jackson, 1991; Jackson, 1995; Jackson, 2003), the most recent of which is shown in Table 1.1:

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="3">Participants</td></tr>
<tr><td>Unitary</td><td>Pluralist</td><td>Coercive</td></tr>
<tr><td rowspan="2">Systems</td><td>Simple</td><td>Hard systems thinking</td><td rowspan="2">Soft systems approaches</td><td>Emancipatory systems thinking</td></tr>
<tr><td>Complex</td><td>System dynamics
Organizational cybernetics
Complexity theory</td><td>Post modern systems thinking</td></tr>
</table>

Table 1.1. Jackson and Keys SOSM Framework. (Jackson, 2003, p. 24).

This framework classifies methodologies on two dimensions: the nature of the system within which the problem lies; and the nature of the decision makers, or in later versions, “participants”. These dimensions are further articulated into “mechanical” (simple) and “systemic” (complex) systems, and whether decision makers have unitary or pluralist objectives. Consequently, problem situations can be classified as “mechanical-unitary”, “systemic unitary”, “mechanical- pluralist”, and “systemic pluralist” and appropriate methodologies associated with each problem situation can be chosen.

Like all classification systems, this framework has the advantage of breaking down the complexity of methods and areas of application, but the disadvantage of being subject to debate over the definitions of primary classifications and the interpretation of entries.

In this case, a “simple” system is defined in terms having a small number of elements with few or at least regular patterns to there interactions. In contrast, a “complex” system will have a large number of highly interrelated elements. The inference is that simple systems are quite predictable, but complex systems are not. But we recognise that such definitions are quite naïve and very dependent on capabilities of the observer. For example, you can have small dynamic systems with few elements and well established relationships that exhibit outcomes that not easily predictable, at least intuitively (Booth Sweeney and Sterman, 2000). As Singer (1959) explains, even the idea of measuring the length of a line is complex. In essence, apart from machines, all biological and human systems exhibit complexity. The definitions of simplicity and complexity were made even more confusing when Jackson and Keys adopted Ackoff’s (1974) terms: “machine age” to represent simple systems, and “systems age” to represent complex systems. In this sense, Ackoff’s machine-age systems were:

> ... closed, had passive parts, were fully observable and could be understood using the reductionism of the traditional scientific method. The systems-age must concern itself with systems which are open, have purposeful parts, are only partially observable and cannot be understood using the methods of reductionism.

(Jackson and Keys, 1984, p. 476).

In Chapter 4 it will be demonstrated, that Ackoff’s terminology raises even more issues than the “simple-complex” terminology originally proposed by Jackson and Keys.

The criterion used for classifying decision makers in particular problem contexts as having either unitary of pluralist objectives is of itself not contentious, but the question must be asked as to whether these objectives are independent of the levels of problem complexity. That is, to what extent does the degree of pluralism affect the complexity of the problem context? Consequently, it can be argued that the basic axes of the classification framework are not independent; not “orthogonal”!

The final problem is associated with the actual allocation of methodologies. These allocations confuse the epistemological and ontological characteristics of individual methodologies and lead to poor classifications (for example, the classification of System Dynamics as “simple- unitary”). Furthermore, the various SOSM forms produced have consistently omitted any reference to the socio-ecological approaches and to autopoietic systems.

Flood (1989, pp. 85-89) provides a critical review of the SOSM grid and argues that the approach lacks rigor because it ignores the issue of theoretical and methodological commensurability discussed earlier. Consequently, the approach reduces to a version of pragmatism in which various methods and problem types are essentially linked by a try-it-and-see approach.

Rescher (1978a; 1985) provides a substantial review of the issue of pluralism in philosophy that has relevance to pluralism in systems thinking and provides a significant articulation of Midgley’s position outlined above. Rescher’s starting point is to acknowledge that:

> Every philosophical problem thus admits of a variety of conflicting solutions on whose behalf an impressively cogent case can be made out….The structure of philosophical issues is thus such that a positive argumentation in support of their resolution fosters rather than removes diversity.

(Rescher, 1978a, pp. 220-223).

Rescher dismisses the feasibility of making a judgement between arguments on the basis of any straightforward “intellectual cost-benefit” analysis, identifying that arguments are essentially “axiological”- embodying “certain value predispositions regarding the probative appraisal of theses and arguments” (Rescher, 1978, p. 226).

Rescher argues:

> We have no choice but to ‘agree to disagree’.. the best we can do on behalf of our own solutions….is to claim that they afford ‘the truth as we see it’,

> yielding a position that is bound to be accepted as correct by those who share our basic commitment to a particular probative-value orientation.

(Rescher, 1978a, p. 236).

Consequently, Rescher advocates what he calls “orientational pluralism” and positions it against scepticism, positivism, and indifference. Orientationalism is:

> … based on recognising the questions as meaningful, the issues are important, and inquiry is legitimate. The project is a serious one, and it is important that in pursuing it we do the best we can. But this does not mean that we can attain monolithic solutions in orientation-independent ways. Yet while accepting pluralism and relativism, we nevertheless stress their limits by noting the restricted variety of viable alternative probative-value orientations.

(Rescher, 1978, p. 238).

But Rescher is pragmatic enough to recognise that “in philosophy, we cannot really lock horns regarding fundamentals if we do not agree on the methodological first principles that form the framework of argumentation” (Rescher, 1978a, p. 232).

And, it is so in systems thinking. While the SOSM may have an initial appeal in this respect, as discussed above, it is easily discounted as a serious contender. Instead, systems thinkers could benefit from using the framework provided by Pepper’s World Hypotheses (Pepper, 1942) and consider the way Fred and Merrelyn Emery have used this framework in their advocacy of (Emery) Open Systems Theory (OST) (Emery and Emery, 1997; Emery, 1993).

Pepper’s “root metaphors” not only provide a legitimacy rooted in philosophy for particular forms of systems thinking associated with Greek formism, Newtonian mechanism, von Bertalanffian organicism, and Peirce’s contextualism, but invite an understanding of the way they can be compared on the basis of their explanatory power; that is, their requisite variety. Kolb (1984, pp 109-120) reinforces this argument when he links Pepper’s system of World Hypotheses to his learning structure- see Chapter 6.

While the arguments for pluralism presented so far are premised on a value set that emphasises mutual respect and the importance of dialogue as being important for the development of knowledge, Berlin (2001) provides an even more compelling and practical reason for embracing pluralism in systems thinking- as a means of recognizing human fallibility:

> Man is incapable of self-completion, and therefore never wholly predictable; fallible, a complex combination of opposites, some reconcilable, others incapable of being resolved or harmonised; unable to cease from his search for truth, happiness, novelty, freedom, but with no guarantee...of being able to attain them.

As cited in Gray (2006).

Observations and Conclusions.

This brief review of the history of systems thinking reveals the following:

1. The systems concept in one form or another can be traced to antiquity and across cultures. This suggests systems thinking is a natural part of human cognition for establishing meaning.
2. Systems thinking has played a central role in the history of science. While initial knowledge systems related to the physical world (Euclidean geometry is the exemplar, and Newton's grand synthesis arguably the most important example), Leibniz started a change aimed at achieving the same in philosophy. Kant's system of reason resulted from this and set the benchmark for philosophical architectonics. A complementary change occurred in biology as a result of Darwin and the Modern Synthesis in biology and evolutionary theory.
3. The "straw men" of systems thinking- Descartes and Newton, are revealed as the authors of "grand syntheses" in which processes of *both* analysis and synthesis play important roles in systematising knowledge.

4. Bertalanffy's attempt to make the systems concept more scientific and to create a GST using the open systems concept as a primary framework for describing isomorphism across disciplines, whilst important in its own right, has not met expectations and has had unintended consequences including-
    a. The separation of systems thinking from its traditional role in science.
    b. Being burdened with "bad press" resulting from attempts to apply post WW 2 engineering systems and operational research approaches in the social sciences and in social policy.
    c. Little impact on the biological sciences, compared to molecular theory and evolutionary theory.
    d. Helping to perpetuate the polemics of the vitalist- mechanist debates so that systems thinking is only associated with organicism and defined as the opposite to "reductionism".
5. The systems concept has been subject to a long history of opposition because of its identification with rational thought, and in sociology, with centralist control.
6. The explosive development of systems methods and approaches over the past 50 years has more or less happened via "isolationalism" (see Barton et al, 2004). Attempts to introduce pluralism confront difficulties in identifying a common framework (such as proposed by GST) with which systems methodologies can be discussed and compared. Simple, "fix-it" approaches have a more pragmatic appeal. Reflective processes and exposure of philosophical and cognitive bases provides a more demanding, but responsible approach.
7. Despite significant advances in system thinking that address the difficulties of hard systems in the 1960s systems inquiry (Checkland, 1981; Flood and Jackson, 1991); systems intervention (Midgley, 2000; Flood and Romm, 1996); the learning organization (Senge, 1990); and group model building (Vennix, 1996), nothing much seems to have changed in the lack of any widespread acceptance of systems thinking over the past 25 years (Atwater, Kannan, & Stephens, 2005; Bawden, 2005; Hammond, 2002). Checkland's (1981) question remains to be addressed**.**

These observations lead to the proposition of a number of hypotheses including:

- Systems thinking is essentially cognitive.
- For systems thinking to return to its central place in science, and re-gain widespread acceptance, we need to return to some fundamentals, including the relationship between analysis, synthesis, systems thinking, and the role of metaphor in framing systems.
- Evolutionary epistemology needs to clearly embraced by systems thinkers and practised in a rigorous, reflective manner.
- Systems thinkers need to understand the importance of human fallibility in the development of systems methodologies and relate this to the importance of pluralism.

Chapters 2, 3 and 4 will further explore these hypotheses by considering the cognitive aspects of systems thinking, the possible importance of the pragmatist philosophy in seeking answers, and finally, the proposition that systems thinking is best defined as the way in which the analysis and synthesis dialectic is framed within the scientific method.

Chapter 2. Systems Thinking and Cognition: A Research Agenda.

2.1 Systems Thinking, Cognition and Adult Learning.

The history of systems thinking supports Nelson and Stolterman's (2003) description of systems thinking with its emphasis on "meaning-making". The systems concept in one form or another appears throughout time and across cultures and has a strong association with the creation of knowledge; Rescher (1981) describes the field of knowledge systems associated with the great philosophers as "cognitive systems".

Gestalt psychology makes the relationship between systems thinking and meaning-making even more specific. This is demonstrated by the system definition cited by Lilienfeld (1978):

> The world is seen as an unlimited complex of change and disorder. Out of this total flux we select certain contexts as organizing Gestalts or patterns that give meaning and scope to a vast array of details that, without the organizing patterns, would be meaningless or invisible.

(Lilienfeld, 1978, p. 8).

More contemporary definitions, for example, Senge (1990) refer to systems thinking as a "conceptual framework". Other definitions are more explicit in describing the form of the systems construct (for example, in terms of parts and wholes, and relationships), while others emphasising the pragmatist concept of meaning (Peirce, 1877; 1878), define the system in terms of its purpose (defined by outcomes); its "system principle": "A system is *unitas multiplex*. Only if we can identify the system principle that explains this unity can we demarcate the system" (Fred Emery, as quoted in Emery and Purser, 1996, p. 75).

The intimate relationship between the systems concept, cognition, and meaning-making, raises the question of whether recent developments in cognitive science can better explain the systems thinking process, and hence provide ways of improving systems thinking capabilities.

Even a cursory look at "popular" publications reveals a bewildering array of theories and hypotheses linking these topics. For example, Cohen (2005) provides evidence to suggest that systems thinking capabilities may improve with aging and reports on what he refers to as "advanced developmental intelligence", characterised by three types of thinking and reasoning (Cohen, 2005, pp 36-37):

- Relativistic thinking- recognizing that knowledge may be relative and not absolute
- Dualistic thinking- the ability to uncover and resolve contradictions in opposing and seemingly incompatible views; and
- Systematic thinking- being able to see the larger picture, to distinguish between the forest and the trees.

.

Goldberg (2005) identifies an increased size of the brain's left hemisphere with aging as meaning that as we age we accumulate more patterns and so enhance our abilities to think systemically using a variety of patterns (metaphors). Goldberg associates this change with the development of "wisdom".

Nisbett (2003) observes that Asians perceive more of a given scene or context than Westerners do; and adopt a more holistic, dialectic, middle way approach to problems. Nisbett concludes:

> ….cognitive aspects of holistic, dialectic approaches….are so embedded in perception, philosophy, and even temperament that it seems doubtful that much in the way of change (in western thought) could be achieved.

(Nisbett, 2003, p. 212).

Entering the technical literature in these fields is even more daunting, and one concludes that developing anything like a clear roadmap to guide us through these areas is both too ambitious in the context of this Thesis and possibly premature given the range of controversies that exist. Instead, this Chapter attempts the more limited objective of considering a sample of these topics and seeks to generate a series of hypotheses that may assist future discussion.

The obvious problem in considering the cognitive science literature is that it is not always clear what writers mean by "systems thinking". However, looking forward to Chapter 4 where it will be argued that systems thinking is best described as the way in which we frame the analysis-synthesis dialectic, approximate criteria can be used in the selection of topics. An important part of this argument is that in open systems, abductive inference leads to hypotheses upon which action occurs. This approach is also described as "inference to the best explanation" and it is in this sense that Lipton (2004) explains that:

> We are forever inferring and explaining, forming new beliefs about the way things are and explaining why things are as we have found them to be. These two activities are central to our cognitive lives, and we usually perform them remarkably well. But it is one thing to be good at something, quite another to understand how it is done or why it is done so well……Still, epistemologists do the best they can with their limited cognitive endowment, trying to describe and justify our inferential and explanatory practices.

(Lipton, 2004, p. 1).

This statement is significant in at least two respects. Firstly, it highlights the importance of the relationship between inference and explanation, and hence between explanation and understanding, and secondly, because it pretty well sums up the nature of the challenge of trying to describe systems thinking in cognitive terms.

To move forward, this Chapter reviews some literature concerning system thinking skills and concludes that these studies do little more than develop a list of loosely related skills relevant to a specific systems methodology. They have little other systemic basis. It will be shown that such a basis can be provided by linking systems thinking to stages of development of adult learning. This linkage points further towards considering what contemporary cognitive science can tell us. But what constitutes the new field of cognitive science? Fortunately, authors including Sternberg (1999b), and Lakoff and Johnson (1999), provide useful histories and perspectives to guide us.

With this background, it is time to enter the water proper. Eight related areas of literature appear initially attractive in our quest to gain a deeper understanding of systems thinking:

- Systems thinking skills.
- Adult learning.
- Meaning-making.
- Cognitive science.
- Brain asymmetry
- Gestalt psychology and meaning-making
- Fallibility
- Consciousness

On this basis, a number of hypotheses are proposed that help define a research agenda for the future.

Systems Thinking and Cognitive Skills.

Most of the contemporary systems methodologies make explicit connections to some area or other of cognitive science. For example, Beer's viable systems model is heavily based on a cybernetic model of brain function, (Beer, 1995); Flood and Carson (1988) describe the importance of "mental models", as does Senge (1990). Sterman (2000) argues that System Dynamics methodology helps overcome "bounded rationality"; and Emery's open systems theory is heavily influenced by Gestalt psychology. But attempts to explain systems thinking in cognitive terms are few. Richmond (1993) suggested that System Dynamicists require seven skills:

1. Dynamic thinking (behaviour over time).
2. An endogenous view of the causation of system effects (internal structure generates behaviour).
3. Contextual thinking (understanding purpose).
4. Operational thinking (explaining how systems work through analysis).
5. Closed loop thinking (thinking of processes in feedback/ feed forward terms).
6. Quantitative thinking.
7. Scientific thinking (treating models as hypotheses).

Again in the context of System Dynamics, Doyle (1997) and Doyle and Ford (1999) identify the following topics for research in support of improving systems thinking skills:

- Memory- the claim that systems thinking frameworks can increase knowledge retention by identifying organizing contexts.
- Analogical transfer- structural similarities between systems leads to the idea that knowledge gained in one area is transferable to another.
- The elicitation and representation of mental models.
- The degree to which intuition and decision making is error prone in dynamic systems.
- Human-computer interactions- the role of computer simulation in developing insight.
- The studies of how current practitioners have gained their skills.

From the perspective of human fallibility Sterman (1989) and Booth Sweeney and Sterman (2000) demonstrate the failure of intuition to correctly predict the dynamic behaviour of relatively simple stock-flow-feedback processes. Consequently, they question the reliability of intuition in decision-making and so justify the importance of simulation modelling. They provide dramatic evidence of the effects of this problem in public policy debates like climate change (Sterman and Booth Sweeney, 2007).

Clearly, examples such as these emphasise the broad range of skills involved in applying the system dynamics methodology. In these terms, systems thinking is not just about synthesis and holism, for example, but involves skills ranging from the perception of dynamic behaviour to interactions with computer simulation modelling.

On this basis, it is relatively easy to identify areas of cognitive science that may explain individual components of a methodology, but more difficult to integrate these into a systemic explanation. For example, and again in reference to System Dynamics, we can reconstruct lists like those cited above by Richmond (1993), Doyle (1997), and Doyle and Ford (1999). For System Dynamics, the starting point is to consider the structuralist underpinnings of its methodology described in Figure 2.1. In this methodology, an event is observed that attracts your attention, further investigation reveals a pattern to these events, and a causal explanation is sought that adequately describes this pattern. In system dynamics, physical and informational stocks and flows, feedback processes, and delays describe this structure. This logic applies within a team learning construct.

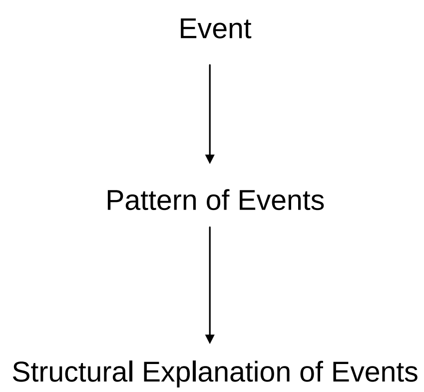

Figure 2.1. Underlying System Dynamics Logic

Table 2.1 correlates parts of the methodology with possible areas of cognitive science that may prove helpful to understanding the method.
Using the definition of systems thinking developed in Chapter 4 and cited above, a more generic table can be constructed (Table 2.2).

Component of the Methodology	Area of Cognitive Science
Recognition of an event	Perception
Recognition of a patterns over time	Pattern recognition
Conceptualisation of overall model structure	Metaphor; memory; bounded rationality; multiple perspectives
Conceptualisation of underlying structure in stock flow terms; articulation of different categories of stocks and relevant transformations from one state to another	Metaphor; identity and difference
Mapping of systems in stock flow terms	Cognitive mapping
Simulation modelling	Mind- machine interaction
Results analysis	Single–loop learning; identity and difference
Evaluation of process/ outcomes	Reflection; consciousness
Taking further action	Inference to the best explanation; reflexivity

Table 2.1: Correlating Components of System Dynamics Methodology with Areas of Cognitive Science

Systems Thinking Component	Possible Cognitive Topic/ Issue
Recognition of an event;	Perception; meaning-making
Pattern recognition; systems framing; generation of hypotheses (abduction and retroduction)	Metaphor; selection of a hypothesis from a wide range of options; intuition; memory.
Dialectic; analysis/ synthesis	Brain asymmetry; understanding and explanation
Pluralism/ ambiguity	Wisdom
Fallibility	Bias; error in decision making; maladaptive responses to complexity.
Action	Reflexivity
Learning and evaluation	Reflection; consciousness

Table 2.2: Systems Thinking and Cognition

While identifying some specific aspects, such an approach fails to develop an integrated view. Such a view needs to better integrate ontological and epistemological processes. For example, Atkins (2002) argues that system thinking (again primarily associated with System Dynamics) is associated with a set of attitudes to ontology, epistemology, problem solving, and personal agency consisting of cognitive and emotional components that in turn determine behaviour. In providing this argument, Atkins draws on the work of neo-Piagetian Robert Kegan's work on meaning-making (Kegan, 1982) and Basseches' dialectic approach to adult learning as an integrating framework (Basseches, 1984).

Hypothesis 1. Training based on improving individual systems thinking skills is unlikely to improve systemic thinking skills.

Adult Learning as an Integrating Framework for Understanding Systems Thinking.

Using adult learning as an integrating framework for understanding systems thinking has two implications. Firstly, it integrates ontological and epistemological aspects of systems thinking from the start, and avoids the tendency to associate systems thinking only with holistic ontologies and brain asymmetry. Secondly, it emphasises the importance of dialectic and multiple perspectives as critical components in the dynamics of learning and development.

In this respect Salner (1986) and Basseches (1984) provide useful insights.

Salner reviews a number of theories of cognitive processing and argues for a more explicit and definitive systems epistemology. She cites Peter (1979) as making a particular contribution to this point by prescribing the following tasks that are central to systems inquiry and related competencies:

1. Holistic understanding;
2. Seeing the organization of components in a situation, often where it has not been seen before; distinguishing one system from its environment and from other systems;
3. Abstracting from a situation key features and presenting them in some simplified form, e.g., diagrams, mathematics, or concepts; and

4. Using systems concepts to produce hypothetical and real plans.

While this does not provide much of an advance on the identifying different components of systems thinking with aspects of cognition, Salner goes on to identify a broader organising context:

> (B)ehind these tasks stands a way of thinking about the world. Implied in "holistic understanding" is an assumption of the relational nature of things. It is context-oriented and context-dependent. "Seeing the organization" and "distinguishing one system from another" tap a similar epistemic orientation in that structural complexity cannot be grasped if one tends to reduce one's ultimate allegiance to either brute data, which is supposed to resolve ambiguity, or to personal perception.
>
> Abstracting from a situation involves drawing on a keen awareness of the dialectical relationship between theories, or humanly generated models of reality, and reality itself "since our theories are constitutive of the known world but not of the world".

(Salner, 1986, p.230).

Basseches' (1984) provides detailed discussion of the importance of dialectical thinking to adult learning. This is particularly relevant to the interpretation of systems thinking provided in Chapter 4.

Basseches describes dialectical thinking as a "third alternative" to "universalistic formal thinking", which assumes "there are fixed universal truths and there is a universal order to things", and to "relativistic thinking" in which "there is not one universal order to things, but…many orders…Thus order in the universe is entirely relevant to the people doing the ordering". In dialectical thinking, "the evolution of the order in the universe is viewed as an on-going process" (Basseches, 1984, pp. 10-11).

Basseches claims:

> … that dialectical thinking represents a development beyond Piaget's formal operations stage; i.e., that dialectical thinking describes a more epistemologically powerful way of making sense of the world than the structure of formal operations by itself provides.

(Basseches, 1984, p. 13).

Emphasizing the links between holistic ontologies and evolutionary epistemologies, Basseches views the dialectical perspective as:

> … comprising a family of world-outlooks, or views of the nature of existence (ontology) and knowledge (epistemology). These world-outlooks, while differing from each other in many respects, share a family resemblance based on three features- common emphases on change, on wholeness, and on internal relations.

(Basseches, 1984, p. 21).

Hypothesis 2: Systems thinking skills need to integrate holistic ontologies and dialectic epistemologies within an adult learning framework.

Systems Thinking and Meaning-Making.

Nelson and Stolterman (2003) define meaning-making in terms of the relationship between the entity of interest and its context:

> Things make sense only when connected and interrelated. If things occur without connection in a discontinuous way, there is no inherent meaning present. Meaning is only attributed to that which is put into relationships in context.

(Nelson and Stolterman, 2003, p. 75).

Nelson and Stolterman illustrate this definition within the design field and argue that:

> … this is what a systems perspective does for design. Design is a process of meaning making because it is engaged in creation from a systems perspective, holistically and compositionally" (p. 75) ... The making of meaning is not an activity embraced by science; however, as a designer, it is vital to your process.... To design is not to create things that make the world more fundamentally true, rather to *create a world that has more meaning.* (p. 157)……A design has *meaning* when we can see how it is connected to other things that we value.

Nelson and Stolterman, 2003, p.273).

William Perry cited in Kegan (1982, p. 11), emphasises the distinctiveness of human consciousness when he states that "what an organism does…is organize; and what a human organism organizes is meaning". Citing Fingarette (1963), Kegan observes that meaning is used in English speaking philosophy and psychology and continental thought in two different ways:

> Thus, Fingarette concludes, the individual's presumed meaning-making may refer to a "scientific process of developing a logical, reliably interpretable and systematically predictive theory," or to an "existential process of generating a new vision which shall serve as the context of a new commitment"

(Kegan, 1982, p. 11).

Kegan (1982, p. 12) concludes that "(W)e are left, then, with a rigorous but reductionistic approach to meaning-making on one hand, and a vague but richer conception of psychological activity on other" and comments that "(N)o psychology has ever successfully integrated these two conceptions of meaning making".

Kegan demonstrates the integration of these two interpretations of meaning by understanding them in terms of dialectic involving what he describes as the two "Big Ideas" – the idea of "constructivism" (in which reality is constructed) and "developmentalism", where "organic systems evolve through eras according to regular principles of stability and change" (p. 8).

These phases correspond (and hence triangulate) the proposal in Chapter 4 to interpret systems thinking as framing the analysis–synthesis dialectic, informed by Peirce's three modes of inference. Consequently, in cognitive terms, we can clearly define systems thinking as "meaning-making". The "existential process" is associated with abduction and synthesis, and the development of a "predictive theory" is associated with deduction and induction, and the analysis phase.

The importance of this process in the history of science is summarized by Kegan (1982, p. 13):

> This shift from entity to process, from static to dynamic, from dichotomous to dialectical is a shift which H. K. Wells (1972) notices in the historical development of modes of scientific thought. The first step is one of classification: botany and biology spent 2,500 years in taxonomic attention to plants and animals, astronomy classified the heavenly bodies, and so on. But the next step, after classification, is ontogeny; the attention turns to the origins, development, and direction of the phenomenon. In just the last 150 years, Wells says, nearly every social and natural science has made this transformation from a taxonomic, entity-oriented perception of the phenomena of investigation to a developmental, process-oriented perception: in astronomy with La Place (1832); in geology with Lyell (1833); in logic with Hegel (1892) and Feuerbach (1846); in history and political economy with Marx (1931); in biology with Darwin (1889), and in psychology with Freud and Jung.

(Kegan 1982, pp. 13-14).

While the above argument explains the macro-dynamics of meaning-making and its links to systems thinking and science in general, Kegan's developmental model tells us more about the micro-skill basis of systems thinking. Building on the work of Piaget (1896-1980), Kegan (1982: p. 107) defines two fundamental "yearnings" relating to human experience- the desire to be “included” and the desire to be “independent or autonomous”. Human development is then related to achieving temporary resolutions of successively higher order of “tension” between these two yearnings. Kegan describes the way in which the individual develops different levels of meaning-making as you move through a helix of evolutionary truces (Figure 2.2). This framework is then used to describe and synthesize other developmental theories including those of Piaget, Maslow, and Eriksen (p86).

Stages 0-1 are characterized by reflexive and impulsive behaviour, while stages 2-3 see a growing awareness of needs and mutuality, while stronger societal and value driven characteristics, including dialectical skills are associated with stages 4 and 5. Within this context, systems thinking as a way of establishing meaning is more associated with stages 4 and 5.

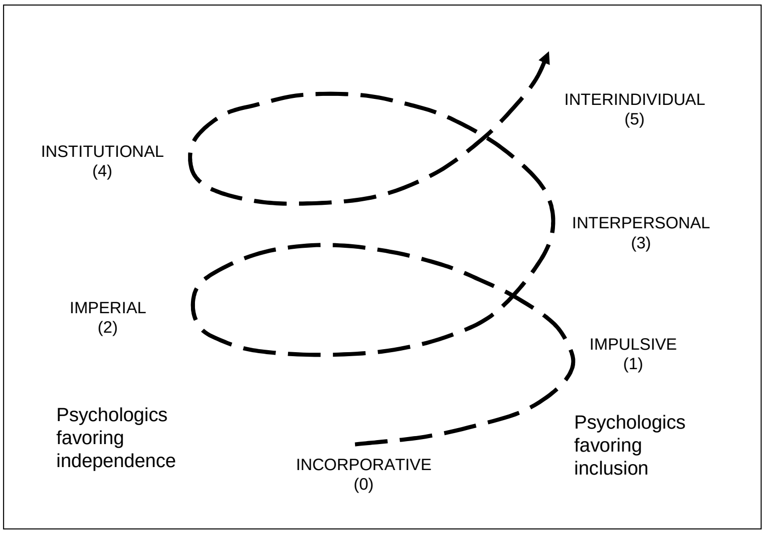

Figure 2.2. Kegan’s “helix of evolutionary truces” (Kegan, 1982, p. 109)

Hypothesis 3: Systems thinking, when defined in terms of dialectic, constitutes “meaning-making” as understood in psychology, and, reinforcing Hypothesis 2, can be associated with Kegan’s development model.

2.2 Cognitive Science and Theories of Perception: Implications for Systems Thinking.

Sternberg (1999a; pp. 64-75) traces the history of cognition back through its psychological roots. Again, dialectic is used to describe the evolution of the study of cognition.

Starting with the work of Wilhelm Wundt (1832-1920), Sternberg describes structuralism as the first major school of thought in psychology. Structuralism's goal was to "understand the structure (configuration of elements) of the mind by analysing the mind into its constituent components or contents". (Sternberg also observes that this highly analytic approach also characterised scientific studies in other fields at that time).

While structuralism was very much a German intellectual movement, Sternberg identifies functionalism as its "countermovement". Functionalism was strongly associated with American psychologists including Angell (1869-1949) who "suggested three fundamental precepts of functionalism:

- the study of mental processes
- the study and uses of consciousness, and
- the study of the total relationship of the organism to its environment".

Continuing his dialectic theme, Sternberg identifies "pragmatism" as an "outgrowth" of functionalism. "Because functionalists believed in using whichever methods best answered the researcher's questions, it seems natural for functionalism to have led to pragmatism. Pragmatists believe that knowledge is validated by its usefulness: what can you *do* with it?". Sternberg correctly associates this form of pragmatism with William James (1842-1910), as distinct from what Peirce defined in his pragmatic maxim (See Chapter 3).

Sternberg's next phase in the development of psychology is "associationism". While structuralism and functionalism-pragmatism provide the thesis and antithesis, associationism is the synthesis. Sternberg describes associationism as examining "how events or ideas can be associated with one another in the mind, to result in a form of learning. This focus on high-level mental processes runs exactly counter to Wundt's insistence on studying elementary associations". So for example, as Sternberg elaborates, having identified concepts such as thesis, antithesis, and synthesis, and (possibly having studied these separately), the use of these three terms in association with each other, leads to their inextricable association with the other. Henceforth it makes less sense for them to be studied independently.

Associationist's such as Thorndike (1874-1959) attempted to show that "satisfaction" was the key to understanding associationism. This resulted in stimulus-response experimentation leading to the development of behaviourism:

> …..an American school of psychology….which focuses entirely on the association between environmental contingencies and emitted behaviour. Behaviourism was born as a dialectic reaction against the focus on personally subject mental states found in both structuralism and functionalism. Instead, behaviourism asserts that psychology should only deal with observable behaviour. According to strict ("radical") behaviorists, any conjectures about internal thoughts and ways of thinking are nothing more than speculation.

.

(Sternberg, 1999a: p. 71).

Radical behaviourism is associated with John Watson (1878-1958) and B.F. Skinner (1904-1990).

Sternberg identifies Gestalt psychologists as the most critical of behaviourism and traces its origins to the work of the German psychologist Max Wertheimer (1880-1943). "…according to Gestalt psychology, we best understand psychological phenomena when we view them as organized, structured wholes, not when we break them down to pieces" (Sternberg, 1999a, p. 74).

This movement was:

> … not only an antithetical reaction against the behaviorist tendency to break down behaviors into stimulus-response units, but also against the structuralist tendency to analyse mental processes into elementary sensations. The maxim "the whole is different from the sum of the parts" aptly sums up the Gestalt view.

(Sternberg, 1999a, p. 74).

Sternberg concludes with a statement that is important to a central theme in this thesis:

> Given some of the criticisms of the vagueness of the Gestalt perspective, many psychologists now believe that the most fruitful approach to understanding psychological phenomena is to synthesise analytic and holistic strategies. Cognitivists are among the many who use both analytic and holistic strategies.

(Sternberg, 1999a, p.75).

(Because of its important relationship to systems thinking the Gestalt period will be further discussed later, particularly in relation to theories of perception).

Sternberg (1999a) identifies cognitivism as the next development:

> Cognitivism is the belief that much of human behaviour can be understood if we understand first how people think. The contemporary cognitivist examines the elementary structuralist contents of thought, and the Gestaltist holistic results of thinking. The cognitivist, like the Gestaltist, may well conclude that indeed the whole is different from the sum of the parts. At the same time however, cognitive psychologists attempt to determine precisely which mental mechanisms and which elementary elements of thought make that conclusion true….. In the 1960s cognitivism was just coming of age, and behaviourism seemed to be on the way out"

(Sternberg, 1999a, pp. 75-76).

Cognitive science is an extension of cognitivism. Stimulated by the information processing revolution of the 1950s and 60s, early cognitive science placed special emphasis on the computational aspects of brain behaviour and as a consequence, on the manipulation of symbols and the development of language, and through this, problem solving (Posner, 1993). Hunt (1999) identifies this era as the first of two recent "revolutions" in the study of cognition in which new ideas about cognition started to be explored in psychology. The second was in the 1990s when new data became available as a result of new biotechnologies and techniques for exploring the operation of the brain.

Lakoff and Johnson (1999) refer to this first era as a "revolution" and as the first generation of cognitive science. Reflecting its strong base in analytic philosophy, it was characterised by an assumption that "reason was disembodied and literal" (Lakoff and Johnson, 1999: p. 75):

> The mind from this "functionalist" perspective was seen as metaphorically as a kind of abstract computer program that could be run on any appropriate hardware….That is, the peculiarities of the body and brain contributed nothing to the nature of human concepts and reason. This was philosophy without flesh. There was no body in the conception of mind.

(Lakoff and Johnson, 1999, pp.75-76).

But by the mid 70s, empirical research such as those involving neurological patients with brain damage (Damasio, 1994) demonstrated that that the mind was in fact "embodied". Lakoff and Johnson, drawing in part on Maturana and Varela's autopoietic model (Maturana & Varela, 1980), describe this evidence as being of two kinds:

- A strong dependence of concepts and reason upon the body, and

- The centrality to conceptualization and reason of imaginative processes, especially metaphor, imagery, metonymy, prototypes, frames, mental spaces, and radical categories.

(Lakoff and Johnson, 1999, p. 77).

In summary, Lakoff and Johnson claim that the following three findings of this second generation of cognitive science resolve “more than two millennia of a priori philosophical speculation”:

- The mind is inherently embodied.
- Thought is mostly unconscious.
- Abstract concepts are largely metaphorical.

(Lakoff and Johnson, 1999, p. 3).

Starting with an outline of how these conclusions change our understanding of reasoning, Lakoff and Johnson (1999: p. 5) then present a set of challenging conclusions:

- The Cartesian person, with a mind separate from the body does not exist.
- The Kantian person, capable of moral action according to the dictates of universal reason, does not exist.
- The phenomenological person, capable of knowing his or her body entirely through introspection alone, does not exist.
- The utilitarian person, the Chomskian person, the poststructuralist person, the computational person, and the person defined by analytic philosophy all do not exist.

Instead, Lakoff and Johnson show that the science of the mind offers radically new and detailed understandings of what a person is. They call their philosophy “embodied realism”.

At first sight, Lakoff and Johnson's arguments call into question the efficacy of much of what we refer to as contemporary systems thinking, but further inspection reveals that this is not entirely the case. For example, Lakoff and Johnson's ability to identify the metaphorical structure underlying different modes of thought and how a corresponding metaphysics (logic) flows from its metaphor is demonstrated by the application of Pepper's "World Hypotheses" and corresponding "Root Definitions" in systems thinking (Lilienfeld, 1978; Pepper, 1942; Kolb, 1984). Similarly, Singer's (1959) association of "cause and effect" logic with closed systems and the "producer–product" logic with open systems, demonstrates this point.

Lakoff and Johnson (1999) argue that spatial relations "are at the heart of our conceptual systems" (p. 30) and therefore depend on neural structures found in the brain's visual system. Given the strong emphasis on the use of cognitive maps in systems thinking, this comes as no surprise and it emphasises the primary importance of systems maps to systems thinking. Indeed, the systems map is possibly the most frequently observed artefact across systems methodologies. Lakoff and Johnson observe that we use spatial relations concepts unconsciously, "and we impose them via our perceptual and conceptual systems. We just automatically and unconsciously 'perceive' one entity as *in, on, or across from* another entity". (Lakoff and Johnson, 1999: 31). Furthermore, spatial "logics" result as a direct result of the structure of spatial relationships. For example, "(G)iven two containers, A and B, and an object, X, if A is *in* B and X is *in* A, then X is *in* B" (p 31).

Similarly, Lakoff and Johnson identify a "source-path-goal schema" that also leads to a source-path logic; a logic that underpins causal path analysis, as used in System Dynamics.

While spatial metaphors and their associated logics might provide a normative framework for reasoning, Lakoff and Johnson demonstrate that actual reasoning is in fact much more complicated.

They argue that:

- Reasoning is not disembodied, as tradition has largely held, but arises from the nature of our brains, bodies and bodily experience ... Thus, to understand reasoning we must understand the details of our visual system, our motor system, and the general mechanisms of neural binding. In summary, reason is not, in any way, a transcendent feature of the universe or of the disembodied mind. Instead it is shaped crucially by the peculiarities of our human bodies, by the remarkable details of the peculiarities of our human bodies, by the remarkable details of neural structure of our brains, and by the specifics of everyday functioning in the world.
- Reasoning is evolutionary, in that abstract reason builds on and makes use of forms of perceptual and motor inference present in "lower" animals ... Reason is thus not an essence that separates us from animals; rather, it places us on a continuum with them.
- Reason is not "universal" in the transcendental sense; that is, it is not part of the universe. It is universal, however, in that it is a capacity shared universally with all human beings.
- Reason is not completely conscious, but is mostly unconscious.
- Reason is not purely literal, but largely metaphorical and imaginative. Reason is not dispassionate, but emotionally engaged.

(Lakoff and Johnson, 1999, p. 4).

Consequently, within systems thinking, while we will be concerned to apply sound logic, we will want to do this within a framework that recognises the "human nature of reasoning". This is the essence of experiential learning (Kolb, 1984) and action research (Chapter 6) and reinforces the importance of double and triple loop learning (Argyris and Schon, 1996; Flood and Romm, 1996 a, b, c).

The cognitive framework outlined by Lakoff and Johnson, embraces human fallibility- people can make ("honest") mistakes. The systems literature has embraced this in many ways, for example, the assumption of "bounded rationality" as a motivation for applying the System Dynamics methodology (Sterman, 2000), and the identification of "maladaptive behaviour" by Emery (1999).

Lakoff and Johnson's "embodied realism" has profound implications for systems thinking and suggests the following hypotheses:

Hypothesis 4: Cognitive maps, metaphor, spatial logics, including "source-path logic", are essential aspects of systems thinking.

Hypothesis 5: System conceptualisation and framing is an "embodied" process, involving unconscious processes, and metaphor.

Hypothesis 6: Systems thinking needs to be evolutionary and manage fallibility (it should be noticed that the evolution of psychology and cognitive science itself, is an extraordinary example of systems thinking at work within mainstream science).

Brain Asymmetry.

Traditionally, systems thinking skills, at least those concerning synthesis, holism and innovation have been associated with brain asymmetry and Jungian archetypes. The "right-brain" is thought of as being essentially creative and the "left-brain dominantly logical. Miller (1985) provides a succinct summary of this approach using four cognitive styles based on combinations of analytic- holistic and objective- subjective dimensions. He then links these styles to Mitroff and Kilmann's (1978) classification of epistemological and political attitudes of NASA scientists. This classification identifies analytical scientists, systems theorists, humanist, and mystics. Miller then argues that these different cognitive styles lead to different approaches to formulating "messy" problems, and the maladaptive response of scientists accepting a "cursory attempt at problem formulation followed by a retreat to the disciplines in which experts work on that part of the 'problem' amenable to his disciplinary methods (and styles)" (Miller, 1985, p. 26).

Better known are the commercial applications of Jungian archetypes such as those described by Leonard and Straus (1997, pp. 114-115). The most popular of these is the Myers-Briggs Type Indicator (MBTI®) which classifies people on the basis of dichotomies such as "extraversion" (E) and "introversion" (I) and "sensing" (S) and "intuition"(N), "Thinking "(T) and "Feeling" (F); and, "Judging" (J) and "Perceiving"

(P). Consequently, we might be tempted to suggest that a person with an "INTJ" profile for example, may have good systems thinking skills because they are quick to find meaningful patterns as well as having good critical, analytical skills. However, Ackoff (1989a) recounts some earlier collaborative research with Churchman in which they demonstrated that a range of tests supposedly based on Jungian concepts, gave inconsistent results! Returning to Jung's writings they discovered that the principal dichotomy used by Jung was not introversion and extroversion, but the effects of the environment on the individual, and the effects of the individual on the environment. They developed scales for measuring these effects and identified four basic personality types- introverts and extroverts, and two of mixed types. Testing demonstrated that most people were of a mixed type!

In a remarkable trilogy, Chevalier (Chevalier, 2002a; b; c) lays bare the half brain theory and describes a "3-dimensional model" in which lateral (right and left hemispheres) and vertical (cortical-subcortical) dimensions of brain interact, complementing and supplementing each other.

> Some sign actions produce effects of convergence and do so through a prevalence of RH (right hemispheric) syncretic processing, as in the language of Metaphor (Christ is like lamb). Others generate effects of divergence achieved through predominantly LH (left hemi-spheric) diacritic processing, as when we speak of dualities (Christ battling against Antichrist). Over and beyond this distinction, however, brain and sign activity involves a bimodal reticulation of similarities and differences.
>
> …. the axial plane…. that divides and connects the upper (prefrontal, normative) and lower (limbic, emotive) structures of brain and sign processing… draws lines and projections between right and wrong, pleasure and pain, the practical and the impractical, the lawful and the lawless. The cortical-subcortical axis also involves differences in levels of attentionality, ranging from the full awareness of "higher-order faculties" to the autonomic impulses of "lower" brain and body activity.

(Chevalier, 2002c, pp. 3 - 16).

Hellige (2007) undertakes a similar exercise to Chevalier and concludes that the right-brain – left-brain model is "far too simplistic".

Hypothesis 7: Brain asymmetry is not a good predictor of systems thinking skills. More complex theories emphasizing whole brain function may prove more fruitful.

Gestalt Psychology and Perception.

Describing the role of the Gestalt psychologists, Simon and Kaplan (1993) explain:

> In contrast to the experimental psychology, which "focussed on relatively simple cognitive performance, with emphasis on sensory and motor processes such as rote verbal learning, tracking tasks requiring hand-eye coordination, memory tasks involving relatively short-term retention, and the attainment of simple concepts. The intelligence of rats and pigeon's received as much attention as the intelligence of people. It was left to the Gestalt psychologists to develop theories of human cognitive processes, especially for complex cognitive performances like concept formation and problem solving…. Experimental psychology brought a host of information about the speed and limitations of simple sensory, perceptual, motor, and memory processes. Gestalt psychology brought hypotheses about the processes that occur in complex thinking.

(Simon and Kaplan, 1993, p. 3).

Some versions of Gestalt psychology were criticised for their vagueness, something often associated with other forms of holism. Ash (1985) observes that Kurt Lewin (1890-1947) was also a critic. Lewin was educated in an era when the structuralist Wilhelm Wundt's influence was strong and who prescribed that "no one should be allowed to teach in psychology 'who is a mere experimenter and not at the same time a psychologically and philosophically educated man, filled with philosophical interests'" (Ash, 1985, quoted in Gold 1999, p. 7).

Gold (1999) explains that Lewin:

> ….incorporated holism into his explanations of how the relationships among such psychological conditions and needs, wishes, intentions, and opportunities affected behaviour. He and his Gestalt colleagues at Berlin became dissatisfied, however, merely to refer to relationships; espoused at the time in the humanities and by scientists other than Gestalt psychologists, holism often seemed to consist only of waiving one's arm broadly in explanation of a puzzling phenomenon. Influenced by Cassirer's attribution of the successes of contemporary physics to its specific formulations, Lewin aimed to express effective psychological relationships as well in precise, logical forms; hence, formulas such as $cons(A) = F(Po(S^A))$, or " the constructiveness of play of Situation A is a function of the potency of the situation (S) related to the activity (A), appeared in Lewin's writings"

(Gold, 1999, p. 9).

The importance of making Gestalt theories "scientific" is demonstrated in the theory of perception by Heider's (1930) demonstration that "the environment had an informational structure at the level of objects and their causal interactions, and that the human perceptual systems were evolved to detect and extract that information" (Emery and Emery, 1997, pp. 130-131). This is a profound result for systems thinking and lays a cognitive foundation for the primacy of the open systems construct (in the sense of a socio-ecological open system).

To some extent, Heider was pre-empted by the 19th century mathematician Bernhard Riemann's demonstration in 1866 that "systems" are best understood by first asking questions about their purpose, which can only be determined by making observations in the system's environment. Consequently, in his study of the "The Mechanism of the Ear" he advocated first asking questions about the purpose of the ear, gleaned from contextual information, and was critical of the immediate adoption of Helmholtz's anatomical approach (Ritchey, 1996).

Gibson's (1979) ecological explanation of perception built on Heider's result (Emery and Emery, 1997) and set itself in contrast with the "inferential" theory of perception which asserts that "the visual system infers the perceptual world on the basis of both sensory information and assumptions, biases, and knowledge inherent to the perceiver" (Proffitt, 1999, pp. 448-449). For Gibson "no inferences are required to account for perception because the purpose of perception is not to achieve a mental representation of distal objects" but to "control purposive actions…perceptions can be based entirely on optical information if, and only if, the observer is allowed to move and explore the environment" (Proffitt, 1999, p. 449).

Significantly, and illustrating the theme that analytic processes attempt to explain how something works, while synthesis attempts to establish understanding of purpose, Proffitt reconciles the two approaches to perception by pointing out that the inferential approach addresses the question of how optical information is transferred into representations of the world, while the ecological approach addresses the question of understanding what we perceive. (Proffitt, 1999, p. 471).

The strands of socio-ecological systems- the idea of environments having "causal textures" (Emery and Trist, 1965, 1973; Trist, Emery, and Murray, 1997) and associated information fields (Johnson, 1996), the nature of purposeful systems (Ackoff and Emery, 1972), and their synthesis within the frame of Pepper's contextualist world view and more explicitly Peirce's pragmatist architectonic (Hausman, 1993; Parker, 1998) constitute a major advance in contemporary systems thinking. Key elements are summarised in Emery and Emery (1997) and Emery (1999; 2000).

Hypothesis 8: Gestalt psychology and contemporary theories of perception provide a cognitive basis for the primacy of the socio-ecological open systems construct.

Fallibility, Irrational Behaviour and Error.

The "Environmental Complexity Thesis" states that the purpose of cognition "is to enable the agent to deal with environmental complexity" (Godfrey-Smith, 1998, p. 3). This leads to the structuring of meaning that becomes the basis for action. However, Crombie, (1997) and Emery (1997) alert us to the problems of "maladaptive" responses to complexity, including for example, the tendency to ignore it, or split problems into "manageable parts" and treat them separately. More generally, Kahneman and Tversky (2000) have described human fallibility in relation to judgements made under uncertainty, Simon (1945) explains the phenomenon of "bounded rationality" which can be linked to Churchman's (1979, pp. 4-6) "environmental fallacy", Sterman (1989) and as previously cited, Booth Sweeney and Sterman (2000), Sterman and Booth Sweeney (2007) have described problems relating to intuition in managerial and policy decision making where the dynamics of stocks and flows, and feedback are involved.

This helps inform us about two ways of conceptualising systems: the Gestalt framework that identifies a system as an organising Gestalt for making sense of complexity, and the autopoietic framework that derives from mind embodiment (Maturana and Varela, 1980). Research on human rationality emphasises cognitive limitations in decision-making and defines the need for epistemological processes to incorporate checks and balances.

The studies by Sterman and others cited previously dramatically illustrate the problem of human error in reacting to complexity and the importance of systems thinking to provide a rational response to this problem.

First generation cognitive scientists defined a rational response to a situation as referring to the:

> …harmony between a description of a belief or action relevant to the achievement of a goal and a theory of how that goal is best achieved… Three attributes of this definition of rationality are noteworthy. First, it assumes a goal. The rationality of a system cannot be defined if we have no idea what the system is trying to accomplish…Second, the definition assumes that we have some idea of the best way to achieve the goal; this is often called a *normative* theory….Finally, rationality refers to a relation between theories: a descriptive (psychological) theory and a normative theory… Note that unlike rationality of process, rationality of response does not imply that a normative theory

> serves as a basis for thought in any sense. A person's responses could be rational even if the person had no knowledge (conscious or unconscious) of the relevant normative theory.

(Sloman, 1999, p. 558).

Sloman points out that most analyses of human behaviour concern error in the sense of deviations from optimal behaviour and provides two explanations as to why people make errors (Sloman, 1999, pp. 573-575):

- Bounded rationality: (Herbert Simon). "People make errors because they operate with limited cognitive resources. Our short-term memories have limited capacity; we can perform only a limited number of operations at any one time; we have limited energy; indeed we are limited in every way". In addition, problems can involve great computational complexity, therefore, "instead of deriving optimal strategies that are completely satisfactory, we resort to strategies that are satisficing, reasonable but not necessarily optimal" (Simon, 1981).

- Natural assessment methods associated with Kahneman and Tversky (2000). Here, "people make errors because they make judgements and decisions using heuristics (rules of thumb) that are quick and easy for people and that usually provide reasonable and adequate answers but fail under particular conditions". They are called "natural assessment methods because they draw on "the human cognitive machinery" such as the reliance on similarity with other experiences, and memory of past experiences. "but these heuristics also lead to certain biases in reasoning and judgement". Whereas bounded rationality assumes that people are using a *rational* inference procedure, albeit within the limits of their knowledge and abilities, the natural assessment approach assumes that people are "using an *arational* procedure that approximates rational inference".

The Nobel Prize winning work of Kahneman and Tversky challenges the assumption of rational behaviour in the neo-classical economic theory. One important criterion for rational choice is that consistent preferences are achieved irrespective of the way the issue is framed. But Kahneman and Tversky demonstrate that risk situations framed in a positive way lead to risk *aversion* while situations framed in a negative way lead to risk *seeking*. This leads to deep ethical problems for the advisors such as medical professionals and demonstrates that people do not make rational decisions as prescribed in normative theory[5].

This argument easily extends to systems thinking and stresses the importance of systems frames and the setting of system boundaries. What we understand is the ill-conceived framing of complexity can be committing Churchman's "environmental fallacy", and lead to a variety of maladaptive responses.

Hypothesis 8: A criterion for measuring the success or otherwise of a systems methodology, is the extent to which it addresses issues of human fallibility.

Consciousness.

There are those that believe that consciousness will eventually be explained in terms of the mechanics of the mind (Churchland, 1995; Crick and Koch, 1992; Dupuy, 2000), and others that believe that this is impossible (Chalmers, 1996; Popper and Eccles, 1977), and that consciousness is a fundamental entity (Chalmers, 1995b, 1996), and others that fit in between (Searle, 1992). Sometimes this spectrum is thought of as including the extremes of "conscious phenomena" (subjective) and "brain phenomena" (objective). The conundrum is whether or not it is possible to explain conscious phenomena in terms of brain phenomena. (Perhaps Ashby (1960) would suggest that brain phenomena does not have the requisite variety to explain something in terms of itself).

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[5] Kahneman and Renshaw (2007) (Foreign Policy Jan-Feb, 2007) illustrate how "hawkish" policy advisors can be more persuasive than they should be, by framing issues in such a way as to make people risk averse.

One thing all agree with is that "(C)onsciousness *is* puzzling" (Churchland, 1995, p. 188). "Consciousness is the biggest mystery. It may be the largest outstanding obstacle in our quest for a scientific understanding of the universe" (Chalmers, 1996, p. xi).

In part this is because, as Block (2002, p. 206) describes it, it is a "mongrel concept". Block identifies two forms- "phenomenal" consciousness or experience; and non-phenomenal consciousness or "access-consciousness", i.e., consciousness that is "broadcast for free use in reasoning and for direct 'rational' control of action" (p. 208). Block warns against conflating the two. Chalmers (1996, pp. 26-27) refers to this second type as "psychological consciousness" including notions such as "awakeness", "introspection", "reportability", "self-consciousness", "attention", "voluntary control", and "knowledge". Chalmers explains that in each case, a "functional explanation seems to capture what is central", i.e., one would try to explain the process by which this occurs. And, to add to the intrigue, "…although these concepts have a psychological core, many or all of them are associated with phenomenal states". For example, "wherever there is phenomenal consciousness, there seems to be awareness" (p. 28).

Fortunately, Churchland (1995, pp. 187-226) provides a way through this apparent circularity of ideas by describing the problems in terms of a possible research perspective. He describes a number of "thought experiments" that have helped define this problem. The first was Leibniz's idea of asking what we would observe if we could shrink to the size of "the smallest mite" and enter the brain to observe thoughts and sensations insight the brain. In fact, Leibniz argued that we could never catch a glimpse of a "thought". Churchland counters this with the observation that, because we don't really know what we are looking for (not having seen a "thought" before) we would not recognise a "thought" even if it was in front of us.

Similarly, Churchland rejects the arguments based on extant versions of Leibniz's experiment. These include "Nagel's Bat" in which the thought experiment is to attempt to know what a bat experiences from a first person perspective (Churchland, 1995, p. 195). Nagel argues that this is impossible. The Australian philosopher Frank Jackson proposed a second thought experiment. In this example, a neuroscientist

(Mary) who knows everything there is to know about the human visual system but was born with a visual abnormality so that she can only see black and white is asked to explain the sensation of "redness" when she is confronted with a red object. Jackson concludes that this demonstrates the limitations of physical science and that "there must be a non-physical dimension to ones' conscious experience" (Churchland, 1995, p. 201).

Churchland argues that these arguments indicate that "the difference lies not in the character of the thing known; it lies in the distinct manner of the knowing" (Churchland, 1995, p. 199). There is a "conflation between different ways of knowing on the one hand and different things known on the other" (p. 201). Mary has been able to observe the sensation of redness in others, despite her inability to experience it herself.

> The existence of proprietary, first person epistemological access to some phenomenon does not mean that the accessed phenomenon is non-physical in nature. It means that someone possess an information-carrying causal connection that others lack.

(Churchland, 1995, p. 198).

Churchland (1995, pp. 213-214) proposes an alternate "thought experiment" when he proposes an alternate explanation of consciousness based on a neural model that (in theory) can provide the following salient features of consciousness:

- Conscious involves short-term memory.
- Consciousness is independent of sensory inputs.
- Consciousness displays steerable attention.
- Consciousness has the capacity for alternate interpretations of complex or ambiguous data.
- Consciousness disappears in deep sleep.
- Conscious re-appears in dreaming.

- Consciousness harbours the contents of several basic sensory modalities within a single unified experience.

This model features vector coding and parallel distributed processing within a large scale recurrent network. The essence of this network is that it contains a separate, short-term memory facility that is capable of monitoring and reporting on what brain functions are occurring.

(The idea, sometimes attributed to the ancients, that those reflective conversations in one's head are in fact messages from the "Gods", provides another explanation!)

As indicated earlier, Chalmers (1995b; 1996) argues that psychological properties like awareness will eventually be explained in physicalist terms. He refers to these aspects of consciousness as the "easy problems" in contrast to the "hard problems". Chalmers would argue that Churchland's thought experiment only addresses the "easy problems". He identifies "experience" as a "really hard problem" because its explanation doesn't appear to be "directly susceptible to the standard methods of cognitive science, whereby a phenomenon is explained in terms of computational or neural mechanisms" (Chalmers, 1995a, p. 200).

Drawing on the history of science in which electromagnetic phenomena could not be explained in known physics, Chalmers offers an alternate pathway by proposing that "conscious experience be considered as a fundamental feature, irreducible to anything more basic" (Chalmers, 1995b, p. 65). He then proposes that "psycho-physical laws" could be established that complement physical laws. He further speculates that these laws "may centrally involve the concept of information, which following Shannon, provides a "basic set of separate states with a basic structure of similarities and differences between them" (p. 67). Consequently, it may be that "information, or at least some information, has two basic aspects: a physical one and an experiential one…systems with the same organization will embody the same information" (67).

Consciousness is an important aspect of systems thinking and is the basis of reflection as it occurs in single and double loop learning. While the "cybernetic" model proposed by Churchland may provide some understanding of how this works- and Laszlo (1972a) has previously speculated on such a "cognitive system", Chalmers speculation concerning the importance of information structures corresponds to an important theme in the history of systems thinking. The dilemma facing the study of consciousness is largely to do with selecting appropriate systemic frames within which to develop hypotheses concerning the nature of consciousness. Consequently, much of the debate is about these frames.

Hypothesis 9: Systems thinking can make an important contribution to the consciousness debate.

Conclusions:

Emphasising the cognitive nature of systems thinking has several consequences. Firstly, it provides an increased level of clarity about the nature of systems thinking and its role in science; secondly, it suggests the need to *celebrate* the systemic contributions of the great scientists including those "reductionist straw men" like Newton and Descartes[6]. And thirdly, it recognizes that the common enemies of both systems thinkers and "reductionist" scientists are "extreme" holists, and "extreme" reductionists. That is, those parties who do not have a sense of where to stop in either of the complementary processes of synthesis and analysis.

However, the relationships between systems thinking, meaning-making, and cognitive science, open a vast reservoir of unanswered questions and opportunities for future research. Nine hypotheses have been proposed as a starting point.

To start to untangle these ideas, it is important to distinguish between the cognitive bases of systems ontology and systems epistemology. Systems ontology has been associated with theories of brain asymmetry, theories of perception, and more

[6] Note that we must be careful not to confuse systems thinking as a cognitive process for understanding complexity, with the philosophical underpinnings associated with different world views. For example, accepting Newton as a systemic thinker does not mean that one has to agree with the metaphysics of his mechanistic philosophy, particularly when inappropriately applied to social phenomena. For example, Peirce opposed Newton's philosophy because of its reliance on "nominalism". Similarly, one may disagree philosophically with Cartesianism, but one must admire Descartes' *system* for describing spatial relationships.

recently, with metaphors. On the other hand, systems epistemology involves reflexivity and reflection, and hence consciousness. But, we must understand that systems ontology and systems epistemology inform each other (Varela, 1993), and cannot be separated in logic.

The literature relating to these issues is extensive, but effectively falls into four areas:

- Empirical studies relating to systems thinking skills and adult learning.
- Recent developments in cognitive science, particularly relating to brain asymmetry.
- Cognitive responses to complexity, particularly relating to errors and maladaptive responses.
- Meaning making including understanding perception, semiotics, and abduction.

Noting the importance of thinking about cognitive aspects of both systems ontologies *and* systems epistemologies, the review of this literature supports the following propositions:

- While the conceptualisation of whole systems is often primarily associated with "right brain" thinking, it is more likely to be associated with the way brain hemispheres interact.
- An evolutionary epistemology based on analysis-synthesis dialectic provides the checks and balances necessary for managing human error, fallibility, and maladaptive practices associated with human responses to complexity.
- Theories of perception support the primacy of open systems models where information is obtained from a systems context.
- The semiotics of Charles Saunders Peirce (1839-1914) provides a basic theory of meaning of particular significance and application to systems thinking.

Chapter 3. *Peirce's Pragmatism and Systems Thinking.*

3.1 Systems Thinking and Philosophy:

When defining a pluralist approach to systems thinking, Midgley (1996) stresses the importance of identifying coherent philosophical support for any given systems approach:

> Pluralism is therefore not a superficial approach to methodology. On the contrary, it asks us to develop a coherent philosophical perspective that will allow us to overcome isolationism while retaining the variety inherent in the multiplicity of competing methodological paradigms available to us.

(Midgley, 1996, p. 32).

Johanssen and Olaisen (2005 a, b) identify the areas that any philosophical basis needs to address:

- Epistemology: "dealing with ways of forming constructs"
- Ontology: "dealing with the nature of the referents of constructs"
- Axiology: "concerned with the value concept and value judgements"
- Ethics: "concerned with the morality of the uses of social studies or politics".

In the recent history of systems thinking there have been some impressive attempts to meet this prescription. Churchman is the outstanding contributor with many articles and books including Churchman (1968, 1971, 1979).

Inspired by Whitehead's "philosophy of the organism", and demonstrating significant foresight into the relationship between systems thinking and cognition, Laszlo (1972a) builds and compares theories of natural *and* cognitive systems.

Philosophical contributions by Ulrich (1983), Flood (1990), Midgley (2000), and Mingers and Willcocks (2004) have defined the substantive basis to recent developments in systems thinking. However, there is a significant gap, and in places, gross misinterpretations of the nature and role of pragmatist philosophy in these contributions. This comes as something of a surprise given the strong pragmatist credentials that underpin Churchman's influence on these authors.

In this Chapter, the intention is to help redress this situation by considering the relevance of the pragmatist philosophy of C.S.Peirce (1839-1914) to systems thinking. The Chapter argues that, not only does pragmatist philosophy have a strong existing association with systems thinking, but it also satisfies the pluralist and logical requirements cited above.

Pepper's World Hypotheses.

Pepper (1942) provides a useful starting point in any discussion of the philosophical basis of systems theory, and provides a useful positioning of pragmatism within a hierarchy of other significant philosophies. If for no other reason, Pepper's world hypotheses provide a useful pedagogic device for relating philosophical traditions to systems approaches.

Pepper identified "two opposite extremities of cognitive attitude: utter scepticism, and dogmatism", but rejected both as not having any real practical value. Instead, Pepper chose a middle path of partial scepticism which he labelled as "world hypotheses" defined as:

> ..objects in the world- Among the variety of objects which we find in the world are hypotheses about the world itself. For the most part these are contained in books such as Plato's Republic, Aristotle's Metaphysics…. Dewey's Experience and Nature, and Whitehead's Process and Reality. These books are clearly different in their aim from such works as Euclid's Elements or Darwin's The Origin of the Species.

(Pepper, 1942, p. 1).

Employing the “root metaphor method” Pepper distilled the known world hypotheses down to four from which other metaphysical positions could be derived. He identified a root metaphor corresponding to each of the four hypotheses.

Importantly, these four world hypotheses and associated root metaphors define different systems approaches.

Pepper’s four world hypotheses and corresponding root metaphors are:

Formism, or realism, or Platonic realism, associated with Plato, Aristotle, the scholastics, neoscholastics, neorealists, and modern Cambridge realists. “Objects of experience are seen as copies of ideal forms, and a total world view can be built up along lines of such essences or categories” (Lilienfeld, 1978, p. 9). The root metaphor is *similarity*.

Mechanism, or naturalism or materialism, being associated with Democritus, Lucretius, Galileo, Descartes, Hobbes, Locke, Berkeley, Hume, and Reichenbach. The root metaphor is a *machine*, whether it be mechanical or electrical.

Contextualism, or pragmatism, associated with Peirce, James, Bergson, Dewey and Mead. The root metaphor is an *historical event*, but interpreted, not as an isolated past event, but as an “act in its context”.

Organicism, or absolute idealism, associated with Schelling, Hegel, Green, Bradley, Bosanquet, and Royce. The root metaphor is an *organism*, but noting that the term “organism” is “too much loaded with biological connotations, too static and cellular, and integration is only a little better”.

These are summarised in Table 3.1.

Pepper acknowledges that “some of the ascriptions are, no doubt, controversial”, and is at pains to emphasise that the four hypotheses are strongly inter-related. Formism

World Hypothesis (Metaphor)	Philosophical Basis	Systems Approach
Formism	Platonic realism associated with Plato, Aristotle, the scholastics, neo-scholastics, neo-realists and modern Cambridge realists	Classification Systems
Mechanism	Naturalism. Associated with Democritus, Lucretius, Galileo, Descartes, Hobbes, Locke, Berkeley, Hume, and Reichenbach	Physical/Engineering/Hard Systems
Organicism	Absolute idealism. Associated by Schelling, Hegel, Green, Bradley, Bosanquet, Royce.	Organic/Biological Systems, including complexity and chaos
Contextualism	Pragmatism. Associated with Peirce, James, Bergson, Dewey, and Mead	Open/ Purposeful Human Systems

Table 3.1: Pepper's World Hypotheses (Pepper, 1942).

and mechanism are *analytic* theories, while contextualism and organicism are *synthetic*. Mechanism and contextualism:

> ….complement each other in the sense that mechanism gives a basis and a substance to contextualistic analyses, and contextualism gives a life and a reality to mechanistic syntheses…. Yet when mixed the two categories do not work happily, and the damage they do to each other's interpretations does not seem to me in any way to compensate for an added richness. Furthermore, formism and contextualism are "*dispersive* theories"- showing inadequacy of precision, and mechanism and organicism are "*integrative* theories"- showing inadequacy of scope.

(Pepper, 1942, p. 147).

Pepper suggests that Dewey, for example, provides a little more emphasis on integration in his pragmatism, while Royce places less emphasis on final integration in organicism and called himself a "pragmatic idealist". Similarly, Rescher (1992) uses the terms "pragmatic idealism" to describe his synthesis of European continental idealism and American pragmatism.

However, not all agree with Pepper's root metaphor theory. For example, Hall (1936) argues that all Pepper's world hypotheses are false and have no cognitive value. But Pepper, admitting the inadequacy of all world hypotheses, argues that they are "the best we have in the way of world-wide knowledge" and therefore, "we had better keep them all for such cognitive value as they contain" (Pepper, 1936, p. 576).

Hartshorne (1984) is also critical of Pepper's world hypotheses. Amongst other things, he is critical of the use of metaphors because it assumes that we know what the metaphor means and it fails to recognise the possibility of differences of meaning within a metaphor: "(T)he quantum mechanical view of 'mechanism' is basically different from that of classical mechanics" (Hartshorne, 1984, p205).

Hoekstra (1945) raises the most significant objection to Pepper's hypotheses by questioning how we know that they cover all world views. One implication is that Pepper's hypotheses represent a naïve view of the complex range of world views. In part, Pepper addresses this issue by arguing that, on available evidence, each hypothesis passes a test of "adequacy" (Pepper, 1942, p. 115). There are only four root metaphors "capable of generating theories with a high degree of structural corroboration" (Pepper, 1942, p., 340). Within any one of these theories, there will be a "variety of descriptions of that type" (p. 340). But more particularly Pepper argues that Hoekstra's attempt to use a form of separate, objectively determined criterion for the admission of a world hypothesis is misconceived (Pepper, 1936).

Pepper's "root metaphor" process is essentially inductive, drawing out metaphors from "objects of the world" that are as close to being independent as possible; a process analogous to searching for "principal components" in statistics, or "eigenvalues" in mathematics. In addition, Pepper leaves the door open for new world hypotheses to be introduced using the root metaphor process, something he himself demonstrated in his later investigation of whether or not Whitehead's philosophy of organism constituted a fifth world hypothesis, and his subsequent attempt to establish "purposeful behaviour" as a new root metaphor (Pepper, 1966).

Given this, one will question how well Pepper's system copes with the split between analytic and Continental philosophies. Presumably, one would attempt to align contemporary analytic philosophies with formism and mechanism, and Hegelian aspects of Continental philosophy with organicism. But where would critical theory and deconstruction fit? Habermas' links to Peirce through the influence of Karl-Otto Apel (Aboulafia, Bookman, & Kemp, 2002) suggest that we may be able to relate critical thinking to a mixture of organicism and contextualism, but this is purely speculative.

Deconstruction, as a method of inquiry into text, sits above Pepper's metaphysical schema in addition to being applicable to each of the world hypotheses (Silverman, 1989). Perhaps it provides the type of independent view sought by Hoekstra. (Some cynics might suggest that deconstruction falls outside Pepper's middle way, and not far from utter scepticism!)

Clearly, there are obstacles to using Pepper's world hypotheses in a technical philosophical way. But the average systems thinker in business, for example, is a long way from this level of sophistication. The question is whether it is better to "leave them in the dark", or to attempt to bring them along a path away from their current methodological isolationism and across the bridge to pluralism, both in the sense of complementarity of methods and exposure to the underlying philosophical and ethical positions. Pepper's framework can play a significant role in this.

Furthermore, given the scope of contemporary approaches to systems thinking, an alignment of Pepper's root metaphors with mainstream systems approaches is obvious: traditional, objectivist approaches to systems thinking relate to the Pepper's first two hypotheses, contemporary, constructivist approaches relate to the third and fourth. Note that while the first two are analytic theories, the third and fourth, are synthetic (Figure 3.1**).** As we read down the columns of Table 3.1, the first two logics increase in analytic power and the second two in synthetic power. Rather than see these characteristics as being irreconcilable, Kolb (1984) relates the tension that exists between them as being creative and a framework for learning. Kolb concludes with a statement of great significance for understanding the way Pepper's world hypotheses can be used as a basis to pluralism in systems thinking:

> (Pepper's) system is perhaps best treated in the framework of contextualism- as a set of hypotheses to be verified, as useful tools for examining knowledge structures in specific contexts.

(Kolb, 1984, p. 119).

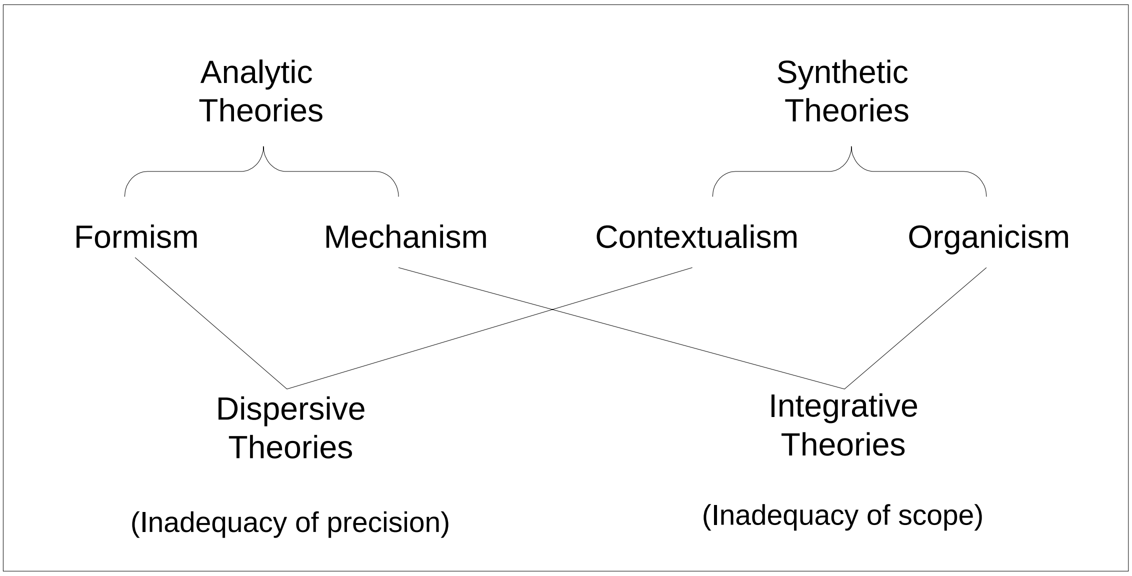

Figure 3.1. Scheme of World Hypotheses (Pepper, 1942. p. 146).

3.2 The Philosophy of Pragmatism: Peirce's Architectonic.

A Common Confusion: Being Pragmatic and the Philosophy of Pragmatism

Pragmatist philosophy, at least at the "popular" level is dogged by confusion between the colloquial use of the word "pragmatist" and its technical meaning in philosophy. This is not without some justification in the sense that William James's promotion of the term fuelled this confusion. To distinguish between James's "pragmatism" and Peirce's understanding, Peirce introduced the word "pragmaticism"; Dewey avoided this terminology all together by referring to "instrumentalism" and "experimentalism", the terminology adopted by Singer and Churchman.

Hook elaborates:

> Peirce repudiated the term "pragmatism" after William James made it popular. Dewey often deplored its debasement in common usage. In recent years it has been made synonymous in some quarters with chicanery, unprincipled behavior, and self-serving expediency.

(Hook, 1974, p. ix).

This popularised version was made even stronger with its association with an emerging characterization of American culture:

> Since the chief practice of Americans seemed to be, in the eyes of their poorer neighbors, the making of money, pragmatism was cried down as the typical philosophy of a parvenu people, insensitive to tradition and culture, and devoted only to the invention of machines to make more machines by human beings who acted as if they were themselves only complicated machines.
>
> This European conception of pragmatism reached American shores and infected some of the more tender-minded intellectuals who attributed their ineffectuality not to their own failings but to the addiction of the American

> people to the philosophy of pragmatism. It is now an almost unchallenged commonplace that pragmatism is a superficial philosophy of optimism, of uncritical adjustment and conformity, of worship of the goddess success.

(Hook, 1974, p. 4).

But as Hook reminds us:

> Such an interpretation of pragmatism not only runs counter to what we know of the personalities of Peirce, James and Dewey, but is based upon a tendentious reading of their work.

(Hook, 1974, p. 4).

Many versions of pragmatism exist (Haack, 2006), and consequently it is understandable that some confusion continues to exist. For example, discussing the need for a "moral stance" Midgley (2000) notes that:

> This moral stance is certainly not new to philosophy: for example, it was a cornerstone of the Pragmatist movement at the tum of the 20th Century. Authors like James (e.g., 1904), Pierce (e.g., 1934), Dewey (e.g., 1946) and Singer (1959) argued for a morally committed philosophy which, instead of pursuing a Grand Truth, viewed 'truth' as 'what works in practice'.

(Midgley, 2000, p. 108).

Although Midgley qualifies this statement with the observation that:

> … theirs was not a naïve notion of 'working in practice', but one which required a significant effort of inquiry to tease out the assumptions underlying what it means to say that something 'works'.

(Midgley, 2000, p. 108).

In attempting to capture the essence of pragmatic thought Midgley is emphasising James's "pragmatism" more than Peirce's "pragmaticism".

Midgley's later quotation of Jackson's *colloquial* usage compounds this situation:

> Jackson …. criticises atheoretical pragmatists for this kind of fragmentary thinking': while pragmatists welcome the idea of a pluralistic use of methods, they turn their back on theory, and thereby lose coherence.

(Midgley, 2000, p. 256).

Similarly, Ulrich (1983) further adds to the confusion by inferring that Peirce's system of categories of itself defines pragmatism:

> The term should be associated here not with the common understanding of American *pragmatism* (Peirce, Dewey, James) according to which "true is what works", but rather with the theory of signs, for which Charles W. Morris … has introduced the name semiotics.

(Ulrich, 1983, p. 240)

In an associated explanatory note, Ulrich acknowledges Peirce's work as the "cornerstone of the later theory of signs" and incorrectly cites Habermas as the originator of the term "pragmaticism" although acknowledging that "Habermas regards Peirce as the pioneer of historical-hermeneutic science and of his "pragmaticism"!

The Evolution of Pragmatism.

Pragmatism is a branch of philosophy conceived and developed by Charles Sanders Peirce (1839-1914), but significantly articulated by William James, John Dewey, George Mead and others. In his 1898 California Union address, James referred to Peirce's use of the term "Pragmatism" to describe his ideas being expounded within the "Metaphysical Club", a small group of intellectuals who met for a short time in the 1870s in Cambridge, Massachusetts (Menand, 2001; Wiener, 1946).

Singer (1925), referring to a statement by William James in 1907 in which he expressed the idea that pragmatism would “run through the classic stages of a theory’s career” starting with being attacked as being “absurd”, then being admitted to be “true, but obvious and insignificant”, and finally where “its adversaries claim they themselves discovered it”, recalls what is presumably an earlier occasion when James introduced pragmatism:

> Looking back over the years that have lapsed since this was written (i.e., James’s 1907 statement), I cannot say that James's prophecy as to the future of pragmatism has been fulfilled; but that the world, at least the world in which I have lived, has lost its first sense of the absurdity of pragmatism is undoubtedly true. No one was more bitten than I with this first feeling of the absurd, unless it was some other of my kind among those who gathered of an evening in 1896 to listen to a reading of James’s now famous little essay on The Will to Believe- the essay which, so far as James was concerned, opened the campaign for pragmatism. James had written the paper that winter as a lecture to be delivered before the Philosophical Clubs of Yale and Brown Universities, and I cannot recall what the occasion was that brought a small number of us graduate students at Harvard together to hear it reread; but I do recall that we were very much bewildered and not a little shocked by the reading.

(Singer, 1925, p. 169).

Later, Singer (1925, p.188) described pragmatism as a “moment in the swing of thought from realism to idealism, and how for it the most vital, that is to say, the moral and religious, aspects of our world are things to work and fight for, to make and to mould, not just to find and come across” but, significantly, nowhere references Peirce[7].

[7] This is quite strange given the level of common interest between Peirce and Singer in the study of measurement, and their close friendships with James- Singer was a student of James, and almost certainly reflects the level of feeling against Peirce by most contemporaries including Dewey, but not James.

Dewey (1925, p. 3) explains that the term "pragmatism" was suggested to Peirce by his study of Kant and the distinction Kant made between the terms *pragmatic* and *practical.* "The latter term applies to moral laws which Kant regards as *a priori*, whereas the former term applies to the rules of art and technique which are based on experience and are applicable to experience". James emphasised that while there was nothing new in the pragmatic method, the "forerunners of pragmatism used it in fragments: they were preluders only" (James, 1907/1995, p 29). James, however, went on to provide an interpretation of the concept which misinterpreted Peirce and, as explained above, in order to differentiate his concept from that popularised by James, Peirce introduced the term "pragmaticism" as a "term ugly enough that no one would want to use it"[8].

The fundamental ideas of pragmatism were set out by Peirce in two key articles: "The Fixation of Belief", (Peirce, 1877), and "How to Make our Ideas Clear", (Peirce, 1878). Peirce emphasised that he wrote these articles for popular consumption and therefore they understated the significance and depth of the concepts involved. Nevertheless, they remain the most quoted sources of Peirce's early ideas. Translations of these papers appeared in Paris one year after their publication in America, and, when combined with James's contributions, had a major impact in Europe. For example, in a course of lectures delivered in 1913-14, Durkheim argued that pragmatism attacked "traditional rationalism", and the "Cartesian basis to French culture...it would overthrow our whole national culture", and necessitate having to "embark upon a complete reversal of this whole tradition". (Durkheim, 1914/1983, p. 1).

There are now many excellent accounts of the history of pragmatic thought from Peirce and his antecedents, to the present day. One of the most accessible is De Waal (2005). This broad account is supported by many detailed accounts of individual aspects and themes. Bernstein (2006) calls the 20th Century the "Pragmatic Century" despite an apparent loss of significance of pragmatism in the United States to analytic philosophy after the 1950s.

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[8] Despite the ambiguity, this paper will adopt the current convention of using the term "pragmatism" to describe both Peirce and James's versions.

In contemporary terms, Mounce (1997) argues that that there are two key branches of pragmatism- “classical” pragmatism associated with Peirce, James and Dewey, and “neo-pragmatism” associated principally with Rorty. Susan Haack sees the situation as being more complex than this:

> In short, the history of pragmatism is both confusing and disturbing. Confusing: as the substantive philosophical views and views of philosophy offered under the rubric "pragmatism" proliferate in bewildering variety, you begin to wonder whether the label serves any real purpose. Disturbing: as the reformist aspirations of the classical pragmatist tradition have been transformed by contemporary neo-pragmatists into one or another form of revolutionary anti-intellectualism, you begin to worry that Russell was right to predict that pragmatism would lead to "cosmic impiety," or at any rate to fascism.
>
> Long ago, A. O. Lovejoy complained that there were thirteen pragmatisms; Ralph Barton Perry suggested that pragmatism was the result of James's misunderstanding of Peirce; and British pragmatist F. C. S. Schiller cheerfully acknowledged that there are as many pragmatisms as pragmatists. More recently, Rorty writes (1982, p. 160; this volume, p. 636) that "'Pragmatism is a vague, ambiguous and overworked word," while H. O. Mounce and Nicholas Rescher argue that there are two pragmatisms: the honorable, descending from Peirce, and the dishonorable, descending from James and Dewey to Rorty and his admirers. Each of them has a point; but it's really more complicated, and more interesting, than any of them allows- more like the old joke about soldiers passing a message down the line: first man to second, "Send reinforcements, we're going to advance"; next-to-last man to last, "Send three and four pence, we're going to a dance".

(Haack, 2006, p. 18).

Haack is particularly scathing when it comes to “neo-pragmatists”:

> Somehow, however, classical, reformist pragmatism was gradually transmuted into the revolutionary neo-pragmatism fashionable today, and Peirce's aspiration to reform philosophy by making it more scientific gradually diverted into an aggressive scientism, on the one hand, and an airy literary dilettantism, on the other. These two apparently contrasting styles of neo-pragmatism have this much in common: Each in its own way, repudiating traditional philosophical projects, is closer to the most aggressively anti-philosophical style of positivism than to classical pragmatism. Both are more revolutionary than reformist; both are more or less overtly anti-intellectual in tendency.
>
> Richard Rorty, most influential of contemporary neo-pragmatists, proposes in the name of pragmatism that the metaphysical and epistemological territory at the traditional center of philosophy be abandoned and not re-occupied; that the old preoccupation with method and argument be given up as we acknowledge that "to know your desires is to know the criterion of truth" (1991a, p. 31); and that to call a statement true is just to give it "a rhetorical pat on the back" (1982, p. xvii); and that philosophy should disassociate itself from science and remake itself as a genre of literature, "in the service of democratic politics" (1989, p. 196). And philosophers of the boldest scientistic stripe also aver allegiance to pragmatism: for example, Paul Churchland, who tells us that, since the ceaseless cognitive activity of the ganglia of the sea slug doesn’t involve representations, we should abandon the idea that truth is the goal of inquiry (1989, pp. 150-51), and Stephen Stich, who assures us that "once we have a clear view of the matter," we will see that there is no value in having true beliefs (1990, p. 101).

(Haack, 2006, p. 17).

Given the importance of Paul and Patricia Churchland’s contribution to the consciousness debates (see Chapter 2), Haack’s reference to Paul Churchland as representing a further articulation of pragmatism (a neo-neo-pragmatist!) is particularly interesting:

> ..an enthusiast of the most scientistic, most revolutionary, and least Peircean style of Quinean naturalism. He is an eliminative materialist who believes that, since no smooth reduction is likely to be forthcoming of beliefs, desires, etc., to neurophysiological states of the brain or central nervous system, "folk psychology"-i.e., our ordinary explanations of people's behavior by reference to their beliefs, desires, etc.- is false, and its ontology mythical. Human cognitive activity doesn't involve beliefs, desires, or representations, but differs only in degrees of complexity from that of humbler creatures like the sea slug.

(Haack, 2006, p.51).

Other pragmatist scholars are not as negative about these developments. Nathan Houser, the General Editor of the chronological edition of the Peirce papers, sees the contributions of the neo-pragmatists as “expanding common ground between contemporary American philosophy and early pragmatism”. He suggests these developments possibly explain : “… why Peirce’s stock appears to be rising”:

> More than any other of the first-generation pragmatists, Peirce seems almost to belong to the family of analytic philosophers- though only, I would say, a rather distant relative, a great uncle perhaps and one best not mentioned in polite conversation. But close enough that parts of his work have always been considered to be at least relevant to mainstream interests.

(Houser, 2005, p. 730).

Similarly, Bernstein (2006) is not quite as critical of Rorty, arguing that despite Rorty’s apparent aversion to Peirce (Rorty, 1982), instead, favouring Dewey and Mead, many of his arguments are based on the work of Wilfred Sellars (1912-1985) which, Bernstein claims, were anticipated by Peirce’s earlier writings. In fact, Bernstein argues that pragmatism was ahead of its time and philosophy is only just catching up with it. He illustrates this view with a description of the manner in which Hilary Putman, despite his analytical origins “integrates Peircian, Jamesian, and Deweyian motifs” (Bernstein, 2006, pp. 6-7). Similarly, there has been speculation as to the extent that the dominant American analytical philosopher Willard Quine embraced pragmatist concepts (Koskinen and Pihlstrom, 2006; Quine, 1953).

Specifically, Houser (2005) sees the future of pragmatism being largely driven by the relationship between Peirce's contributions to logic and mathematics within the context of his pragmatist system, and developments in artificial intelligence, computer science and the philosophy of the mind. The importance of Peirce's contributions to mathematics and science was emphasized by Ernest Nagel as far back as 1933 in his review of the first two volumes of Hartshorne and Weiss's Collected Works of C.S. Peirce, (Hartschorne and Weiss, 1931-34). Nagel was critical of the thematic structure of these volumes with their apparent neglect of Peirce's contributions to science and mathematics: "….. his scientific interests seem to have been subordinate to a far flung metaphysics" (Nagel, 1933, p. 366). Nagel continued to emphasise this aspect of Peirce's work (Nagel, 1940, 1982)[9].

In an example of the current relevance of Peirce's work in mathematics to computer science, Sun-Joo Shin (2002) presents a reconstruction of Peirce's theory of representation and system of "existential graphs". In this context, Peirce raised the question of the comparative reasoning power of diagrams compared to symbols as demonstrated in the use of "Venn" diagrams in Boolean algebra.

Greater access to Peirce's unpublished works over the past 20 years has supported this renewed interest in pragmatism, and Peirce in particular. It is something of a scandal that Peirce's library which included some 1,200 books (many likely to be heavily annotated), 12,000 printed pages, and 80,000 handwritten pages-it is estimated that it will require 104 volumes to publish these works- has ended up being in disarray while being in the custody of the Department of Philosophy at Harvard University since 1914 (Houser, 1989; Moore, 1984). As a consequence, Peirce biographer, Joseph Brent, reports that after completing a doctoral dissertation on Peirce in 1960, he was forced to wait until late 1991 to publish a biography because of an embargo on

[9] This discussion has direct, contemporary relevance to cognitive mapping when used for data collection and logic in systems thinking, and invites the exploration of more "intelligent" mapping techniques.

quoting “letters and other material essential for a Peirce biography” (Brent, 1998, p. xvii).

Despite these differences concerning the direction of pragmatism and the importance of Peirce, the influence of pragmatism, particularly its emphasis on linking theory and practice, is widespread. Haack describes it this way:

> Papini's nice analogy comes to mind, of pragmatism as a great hotel where in every room a philosopher is at work, each in a different way and on a different question, but all arriving through the same main corridor: Richard Bernstein looking to the classical pragmatist tradition for a reconciliation of now-warring "analytic" versus "continental" parties; Hilary Putnam marrying Jamesian and Wittgensteinian themes; Nicholas Rescher developing his conceptual idealism, Joseph Margolis his anti-foundationalist philosophies of science and history; James Gouinlock in ethics; and my own Critical Common-sensism epistemology and philosophy of science and synechistic conception of the place of the sciences within inquiry generally. ….The influence of classical pragmatism is also still widely felt outside the United States, in the work of Jurgen Habermas, Karl-Otto Apel, Hans Joas, Umberto Eco, Gerard Deledalle, and others.

(Haack, 2006, pp. 50-51).

Charles Sanders Peirce (1839-1914).

It is clear from the above that Charles Sanders Peirce is central to any discussion of pragmatism and its possible relationship with fields such as systems thinking.

Peirce’s standing is now undoubted, and he has been referred to as a “polymath” and openly compared with Leibniz (Fisch, 1972). Nagel concurs:

> It has become commonplace to say that Charles Peirce continues to be the most original philosophical mind that the United States has yet produced, that he was more nearly like Leibniz than any other American philosopher with

> respect to the range, variety, and ingenuity of his intellectual contributions, and that he was the founder of what is still this country's most distinctive philosophical movement.

(Nagel, 1982, p. 303).

This conclusion continues to be supported:

> Charles Sanders Peirce is the most profound philosophical thinker produced in America.

(West, 1989, p. 43).

> Charles S. Peirce was without doubt the greatest American philosopher.

(De Waal, 2001, p. 1).

Consequently, while others, for example, Matthews (2005), have explored the possible relationships between the neo-pragmatists and systems thinkers, particularly related to Churchman, and Singer's influence on Churchman and Ackoff is better known (Britton and McCallion, 1994), the intent of this Chapter is to follow Fred and Merrelyn Emery's lead and concentrate on the relevance of Peirce (Emery and Emery, 1997; Emery, 1993).

This direction is motivated by the search for a better way to situate systems thinking within the mainstream of science; the logic basis of pragmatism looks promising: "Pragmatism is a doctrine of logic". Potter (1997, p. 39).

Hausman (1993, p. 20) observes that Peirce's seminal 1877-78 articles reflect Peirce's concern to "incorporate the logic of experimental science into philosophy". On the surface, this observation suggests that Peirce was simply trying to "scientize" philosophy in a positivist tradition. But, Peirce was strongly anti-Cartesian (see Delaney, 1993, pp. 81-118) and, "(I)n Peirce's view, the modern age reached a low point in metaphysics when it embraced the mechanistic conception of the world" and effectively returned to "nominalism" (Parker, 1998, p. xiii).

What we need to remember is that Peirce's version of science was not in the positivist tradition but one that placed science within a social and behavioural context[10]. Some, like Goudge (1950), have been unable to reconcile the apparent disparity of the scientific and social positions adopted by Peirce, and, as a consequence, thought that Peirce held two separate philosophical orientations: "a tough-minded empiricism and a speculatively developed metaphysics" (Hausman, 1993, p. xiii). Paul Weiss (1940, p. 253) remarks that "it was Peirce's and his contemporaries' tragedy that he had friends and well wishers, but none who both sympathized and understood".

Hausman (1993) and others recognize that there is a much more systemic framework hidden in Peirce's many works. It is an architectonic that Peirce frequently referred to but never expressed in a single form. While this is sometimes attributed to Peirce's often disorderly conduct, one suspects that it is more a symptom of Peirce's philosophy not being static, but an evolving system representing a form of scientific pluralism not appreciated or easily recognized. It is in this sense that Rosenthal (1994) positions Peirce as pre-empting the "Kuhnsian interpretations of the scientific enterprise" and describes Peirce's architectonic as a commitment to pluralism. She describes *her* work as "an attempt to jump off the deep end, so to speak, and elicit the inherent strand of pragmatic pluralism that is embedded in the very core of Peirce's thought and that weaves his various doctrines into systematic pattern of pluralism that gives a new design to his understanding of convergence." (Rosenthal, 1994: ix).

Anderson (1995, p. 26) adopts the same metaphor:

> There are at least two reasons why the notion of strands of system is appropriate to Peirce's life's work. The first is his claim that philosophy proceeds not from a single premise or set of premises along a single thread of reasoning but inductively, gathering from experience what it can and braiding it into a cable of belief. He first stated this in "Some Consequences of Four

[10] This supports the interpretation of "engineering systems" thinking advocated by Cook and Ferris (2007).

> Incapacities" in 1868 when responding to Descartes's method: "Its [philosophy's] reasoning should not form a chain which is no stronger than its weakest link, but a cable whose fibers may be ever so slender, provided they are sufficiently numerous and intimately connected"….. The second reason lies in the fragmentary nature of Peirce's philosophical writing….. In a very direct way, then, readers of Peirce's work are forced to take up the variety of strands he produced to reconstruct the architectonic he offered. The strands present a variety of avenues into Peirce's system.

Feibleman's conclusion that Peirce's pragmatism is itself an open system supports Anderson's view:

> He (Peirce) has managed to combine the best features of his two Greek models in that he has designed a system but managed to keep it open. The English tradition followed Plato in being merely inquisitive, the Germans followed Aristotle in being merely systematic. Peirce followed the scientific method in being inquisitively systematic. For, although he had a system, he did not regard it as in any sense the final word, and assumed that it would be modified and expanded by later investigators.

(Feibleman , 1970, p. 487).

Consequently, one view of Peirce is that he was the first *constructivist* post-modernist (Griffin, Cobb, Ford, Gunter, and Ochs, 1993).

Peirce's Architectonic[11].

There is no doubt that Peirce's work more than adequately addresses the four aspects of a philosophy identified by Johanssen and Olaisen (2005a; b) cited earlier. Of course, any particular philosophy needs to provide an integrated view of these aspects; each must reinforce the others. Such is the contemporary view of Peirce.

[11] Given the above comments about the dynamic inherent in Peirce's philosophy, and the consequent reference to "strands of system", using the term "architectonic" to describe Peirce's pragmatism may appear too static, but it is the better known convention.

Hausman (1993) provides a useful starting point in understanding Peirce's archetectonic. Like Haack (2006), Hausman (1993, pp.1-2) describes Peirce's work as "something like entering a labyrinth with almost as many entrances as passages". But, Hausman identifies four strongly inter-dependent themes that can act as "building blocks" for the architectonic:

- The pragmatic criterion for meaning- the "pragmatic maxim" and the rationale for terming his philosophy "pragmatism", and modes of inference as tools for conducting inquiry including abduction, deduction, and induction.
- A theory of signs- a semiotic.
- A theory of "categories", providing the minimal bases for describing all phenomena; a phenomenology, or, as Peirce described it, "phaneroscopy".
- A theory of continuity- "synechism". This is central to Peirce's metaphysics and the basis of what Hausman describes as Peirce's "evolutionary realism".

By comparison, in editing the *Cambridge Companion to Peirce*, Misak (2004) identifies seven technical themes for discussion:

- The pragmatic maxim.
- Truth and reality.
- Semiotics.
- Theory of inquiry.
- Logic: Deduction, induction, and abduction.
- The categories.
- Metaphysics.

Of course, scholars differ in their descriptions of Peirce's architectonic, depending on what aspect of pragmatism they start with. This starting point then acts as an organising principle for interpreting the rest of the system. It is testimony to the systemic nature of Peirce's thought that you can enter from different directions and cover the whole territory. For example, Weiss (1940) described Peirce's categories as the "essence" of his system; Parker (1998) reviews Peirce's critique of Kant's logic and also uses categories as a starting point; Potter (1996, 1997) starts with Peirce's conception of "normative science" and then discusses inquiry, the pragmatic maxim, realism, continuity and synechism and tychism, chance, and Peirce's theism; Misak's (1999) starting point is truth and reality, leading to a later discussion of Peirce's epistemology and its underlying morality (Misak, 2000), and, as mentioned previously, Rosenthal (1994) starts from a position of Peirce's pluralism in science.

In considering the application of pragmatism to systems thinking, it will be useful to choose the most appropriate "strands" and to "re-braid" them to form a strongly integrated philosophical core to systems thinking.

Based on the discussion in Chapter 2, the following "strands" seem appropriate:

- Peirce's theory of continuity (synechism and tychism): providing a worldview that underpins systemic thought. Note that this also includes characteristics associated with modern theory in chaos and complexity.
- The pragmatic maxim: guiding us to defining systems by their intended outcomes- the "system principle".
- Peirce's phenomenology: providing a cognitive basis to systems thinking and logic for making definitions and defining symbols.
- A theory of inquiry that helps to "fix belief", is action orientated, celebrates pluralism and community, and takes into account human fallibilism.
- An ethical and aesthetical basis.

These are discussed in turn:

1. Peirce's Theory of Continuity: Synechism and Tychism.

Synechism is a theory of continuity which emphasises connectedness and flux, and allows for novelty and surprises[12]. Hausman (1993) describes it as "evolutionary realism". Tychism refers to the idea that chance is a fact of life, and that natural laws are probabilistic and inexact.

[12] Consequently, right from the start, pragmatism shares a world view with systems theory.

West (1989) argues that Emerson, who adopted Goethe's naturalistic worldview, which in turn was developed from Spinoza and Greek philosophy, inspired Peirce's synechism.

This worldview provides a logical basis to the strands discussed below: for example, the category of thirdness provides the essence of continuity between firstness and secondness. A consequence of this is the relationship between a system and its context: it is logically impossible to define a system without simultaneously defining its context. Similarly, combined with Peirce's semiotic, synechism provides the basis for linking signs to meaning.

2. The Pragmatic Maxim.

Peirce's pragmatic maxim starts with the simple proposition that our beliefs "guide our desires and shape our actions…belief does not make us act at once, but puts us into such a condition that we shall behave in a certain way, when the occasion arises" (Hausman, 1993, p.37). In this way, Peirce distinguishes belief from "doubt". "Doubt stimulates us to action until it is destroyed…..the irritation of doubt causes a struggle to attain a state of belief". He calls this struggle "inquiry". Hausman describes the pragmatic maxim as a belief that is either "self-conscience or non-conscious preparedness to act in a certain way".

Peirce's original definition is complex, illustrating something of the obscurity of reading Peirce and the need to build up wider understandings: the pragmatic maxim is the "doctrine concerning the meaning, conception, or rational purport of objects, namely, that these consist in the effects, which might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of these effects is the whole of our conception of the object" (Peirce, 1878).

Consequently, the pragmatic maxim relates beliefs, or perceptions, to action, either actual or intended. It is consistent with current cognitive theories of the embodiment of mind (Lakoff and Johnson, 1999).

Murphy (1990, p. 25) emphasises a further articulation by Peirce that notes that the nature of belief has three properties:

- It is something that we are aware of.
- It appeases the irritation of doubt.
- It involves the establishment in our nature of a rule of action, a habit.

The third of these properties emphasises that Peirce's pragmatism is a theory of action, or in James's terms- "beliefs are rules of action" and the pragmatic method is "primarily a method of settling metaphysical disputes that are otherwise might be interminable". (James uses a debate about whether a person chasing a squirrel, which remains positioned on the other side of a tree truck, ever goes around the squirrel or not, to demonstrate this point. The argument is resolved by clarifying what is actually meant by "goes around"). (James, 1907/ 1995, p.17).

3. Peirce's Phenomenology.

The basis to Peirce's phenomenology is a system of three categories which is capable of describing the most fundamental features of all experience. Each category is "inextricably interwoven and present to consciousness, no matter what the particular phenomenon. They cannot be isolated from one another in any given instance" Hausman (1993, p.10).

The three categories are: *firstness*- the category of "quality" which is monadic and is embodied in the object, *secondness*- the "reaction" we encounter to firstness and can only exist with reference to firstness, and *thirdness*, that aspect that "mediates" between firstness and secondness.

Consequently, we can contemplate something like the colour "red" which, in its state of firstness, has no meaning, just its intrinsic "redness". Our reaction to this (secondness) may be to interpretation of this "redness" as a sign to stop, which leads to us contemplating or actually stopping. Thirdness is the interpretation we have used to connect the property of "redness" to the meaning of "stopping", which, incorporating the pragmatic maxim, earns it meaning from the actual or intended action that results, that is, the contemplated or actual action of stopping.

Peirce's *semiotics* is a theory of signs and a major example of the application of his categories. The sign or symbol corresponds to firstness; its corresponding object is secondness, and the interpretant linking sign and object is thirdness[13]. When a number of signs and objects are linked, a web of meaning forms that provides a basis to "an integrative, social-semiotic theory of mass communication" (Jensen, 1995, p. 3).

Peirce's phenomenology is consistent with his theory of continuity, and provides the basis of Peirce's critique of atomism:

> Peirce's phenomenology "is opposed to atomism of the sort found in British empiricism. The analysis is not undertaken as if there were discrete bits of sense data that serve as building blocks of analysis. Sense data are products of analysis. Instead, Peirce's phenomenology begins in the midst of things, within a total experiential situation in which phenomena are given as complex wholes.

(Hausman, 1993, p. 10).

In comparing and clarifying the cognitive assumptions that define differences between Peirce's phenomenology and the Cartesian view, Gentry (1946, p. 635), emphasises the importance of logic and the role of symbols:

> Peirce's theory of cognition proper is presented as an alternative to the Cartesian view, and its first principles are formulated with specific reference to four presuppositions he finds fundamental to Cartesianism: (a) that we have the power of intuition, (b) that we have the power of introspection, (c) that we have the power to think without signs, (d) that we have the capacity to conceive the incognizable. The focal principles of Peirce's theory are three in number: (a) that mental action is describable in terms of the formulae for valid inference, (b) that

[13] This provides a theoretical basis to brand management.

mental action is intrinsically symbolic in character, (c) that the reality of mental action is a social reality, i.e., it is the reality that attaches to "a sign developing according to the laws of inference" in an ideal community of cognitions.

On this basis, we can again see the appeal of Peirce's phenomenology to contemporary cognitive science as represented by Churchland (1995).

4. Modes of Inquiry and Rules of Inference.

Peirce describes inquiry as the "process of struggle to pass from a state of doubting to a state of belief" (Hausman, 1993, p. 20). He describes this as a process involving a "community of inquiry", and in this sense, pre-empts Kuhn. It is Dewey's articulation of this process that gives rise to what we know variously as "action learning", and "action science" (Argyris, Putman and McLain Smith, 1985). Peirce's strict application of logic to this process gives rise to an evolutionary epistemology which anticipates Popper.

Peirce's notion of inquiry provides the basis for his case for the rejection of Cartesianism, which Murphy (1990) summarises as:

- The denial that philosophy must begin with *universal* doubt- we always enter a situation with some knowledge.
- Because of experimentalism, the denial that that the ultimate test of certainty is to be found in the individual consciousness.
- Consequent to this, the denial that philosophical theory should be a single thread of inference, in the manner of Descartes.

While meaning is revealed by outcomes and intentions, truth is an outcome of inquiry:

> Technically, pragmatism was developed as a theory of meaning and then as a theory of truth. In its broadest sense as a philosophy of life, it holds that the logic and ethics of scientific method can and should be applied to human affairs. This implies that one can make warranted assertions about values as

> well as facts. It recognizes that the differences in the subject matter of values require the use of different methods of inquiry, discovery, and tests in ascertaining objective knowledge about them. Most daring and controversial of all pragmatism holds that: it is possible to gain objective knowledge not only about the best means available to achieve given ends- something freely granted, but also about the best ends in the problematic situations in which the ends are disputed or become objects of conflict.

(Hook, 1974, p. xi).

Peirce (1878) identified three inadequate methods of fixing belief:

- The method of *tenacity*- in this case, belief is formed as a matter of habit, even to the extent of excluding the possibility of exposing oneself to views that are contrary. Indeed Peirce's use of the example of the supposed merits of free trade to demonstrate his case has a resonance that is all to close to the many examples of "tenacity" in current public policy debates.
- The method of *authority*- "this method has, from the earliest times been one of the chief means of upholding correct theological and political doctrines, and of preserving their universal or catholic character". Identified as being much more powerful than the method of tenacity (as witnessed by monumental construction efforts applied in building edifices such the Egyptian pyramids etc, that are "hardly more than rivaled by the greatest works of Nature".
- The method of *a-priori*- where belief is based on the acceptance of "fundamental propositions (that) seemed 'agreeable to reason'". Peirce identifies such an approach to inquiry in metaphysics and observes that, while it is "far more intellectual and respectable from the point of view of reason than either of the others which we have noticed" but nevertheless "a true induction" and, in the end, not much different from the method of authority.

In each case, Peirce demonstrates the manner in which each of the above methods raises doubt and leads to the necessity for finding a method in which "the ultimate conclusion of every man shall be the same". Peirce identifies this method as the "method of science".

In a significant departure from Kant's dichotomous treatment of deduction and induction, and their links to analysis and synthesis, Peirce returns to Greek dialectic involving three modes of inference- deduction, induction, and abduction, or retroduction.

> There are in science three fundamentally different kinds of reasoning, Deduction (called by Aristotle {synagögé} or {anagögé}), Induction (Aristotle's and Plato's {epagögé}) and Retroduction (Aristotle's {apagögé}, but misunderstood because of corrupt text, and as misunderstood usually translated abduction). Besides these three, Analogy (Aristotle's {paradeigma}) combines the characters of Induction and Retroduction.

(CP 1: 65).

Indeed, Peirce later identified abduction as being at the heart of pragmatism and reflected on his fascination with the (cognitive) process by which we are capable of isolating a relatively small number of plausible hypotheses to account for observable facts.

While in his earlier writings, Peirce used abduction and retroduction as synonyms, he later articulated abduction as "hypothesis formulation and selection" and retroduction as "hypothesis testing and elimination" (Rescher, 1978: 41). Rescher describes the taxonomy of Peirce's overall inductive conception of science as shown in Figure 3.2 and identifies it with Popper's (later) refutationist model of scientific inquiry.

Abductive inference is most concisely described along with deductive inference and inductive inference as one of three possible variations to the "modus ponens" argument.

Deductive Inference:

Statement A is true. (data)
If statement A is true, then statement B must be true (rule).
Therefore, statement B must be true (result).

Alternatively,

$$P \rightarrow Q$$
$$\underline{P \text{ is true}}$$
$$\therefore \; Q \text{ is true}$$

This is the most familiar form of inference and is accepted as the most rigorous form of argument. For example, if we assume the premise that: "contracting reduces costs", and we contract, then costs will be subsequently reduced. In practice, such an argument will raise an immediate objection from the observer who will note that this premise is overly simplistic and that, in particular, several enabling conditions are necessary before the hypothesis could be deemed true. That is, P is a conditional (Bayesian) statement. Furthermore, both P and Q are likely to be conjunctions of several statements (vectors).

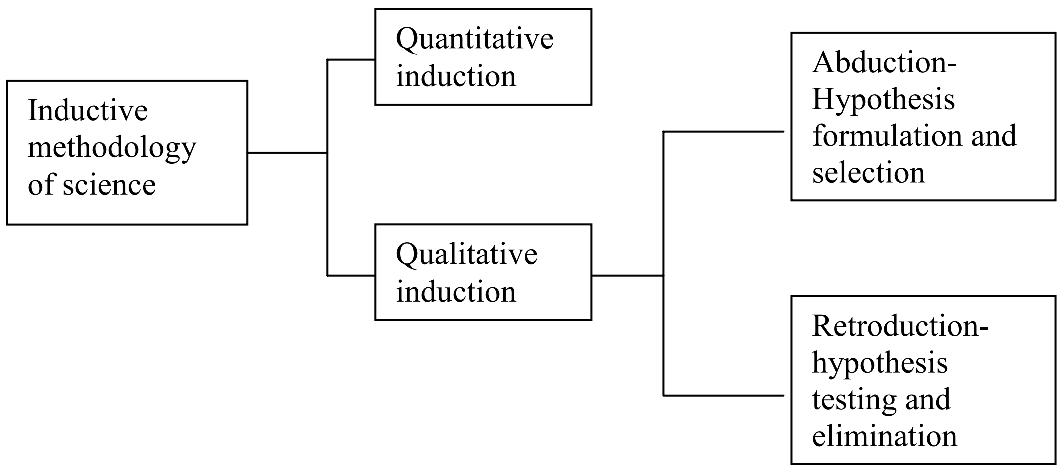

Figure 3.2: Peirce's Taxonomy of Inductive Methodologies (Rescher, 1978b, p.41).

Inductive Inference:

Induction is defined as:

Statement A is true. (data)
Statement B must be true (result).
Therefore, A must cause B (rule)

Alternatively:

$$\frac{\begin{array}{c}P \text{ is true} \\ Q \text{ is true}\end{array}}{\therefore\ P \rightarrow Q}$$

In this case, we are asserting a conclusion based on a pattern of data relating to P and Q. For example, if we observe that cost reductions appear to follow contracting, we might conclude that contracting *causes* the cost reduction. In fact, the cost reduction might have more to do with increased productivity of computers, than the advent of contracting. Nevertheless, induction is a vital process for attempting to empirically support hypotheses.

Abduction:

Abduction is defined as:

Statement B is true (result)
On the basis of my experience, my best guess is that A causes B (hypothesis/ rule)
Therefore, I will assume A to be true.

Alternatively:

$$\frac{\begin{array}{c}P \rightarrow Q \\ Q \text{ is true}\end{array}}{\therefore\ P \text{ is true}}$$

While this is the least rigorous form of inference, it is the only form that can generate new knowledge.

The following abstracts detail how Peirce uses the three modes of inference to constitute "logic of inquiry". It is this logic that forms the basis of Dewey's experiential learning model (Dewey, 1910) and its extant versions including, for example, Kolb (1984), Shewhart (1939) and Deming (1950), and Argyris, Putman, and McLain Smith (1985).

Peirce starts by describing abduction as:

> ..the provisional adoption of a hypothesis, because every possible consequence of it is capable of experimental verification, so that the persevering application of the same method may be expected to reveal its disagreement with facts, if it does so disagree. For example, all the operations of chemistry fail to decompose hydrogen, lithium, glucinum, boron, carbon, nitrogen, oxygen, fluorine, sodium, … gold, mercury, thallium, lead, bismuth, thorium, and uranium. We provisionally suppose these bodies to be simple; for if not, similar experimentation will detect their compound nature, if it can be detected at all. That I term retroduction[14].

(CP 1: 68).

But Peirce warns:

> Retroduction does not afford security. The hypothesis must be tested. This testing, to be logically valid, must honestly start, not as Retroduction starts, with scrutiny of the phenomena, but with examination of the hypothesis, and a muster of all sorts of conditional experiential consequences which would follow from its truth. This constitutes the Second Stage of Inquiry. For its characteristic form of reasoning our language has, for two centuries, been happily provided with the name Deduction.

(CP 2: 470).

[14] At this point Peirce was still using abduction and retroduction as synonyms.

In turn, Peirce describes the purpose of deduction:

> The purpose of Deduction, that of collecting consequents of the hypothesis, having been sufficiently carried out, the inquiry enters upon its Third Stage, that of ascertaining how far those consequents accord with Experience, and of judging accordingly whether the hypothesis is sensibly correct, or requires some inessential modification, or must be entirely rejected. Its characteristic way of reasoning is Induction. This stage has three parts. For it must begin with Classification, which is an Inductive Non-argumentational kind of Argument, by which general Ideas are attached to objects of Experience; or rather by which the latter are subordinated to the former. *Following this will come the testing-argumentations, the Probations; and the whole inquiry will be wound up with the Sentential part of the Third Stage, which, by Inductive reasonings, appraises the different Probations singly, then their combinations, then makes self-appraisal of these very appraisals themselves, and passes final judgment on the whole result.*

(CP 6: 472).

The final sentence has been emphasised to note the importance of "appraisals" using what we can now identify as practices of single and double-loop learning (Argyris and Schön, 1974). This can be enhanced to include Flood and Romm's (1996 a,b,c,d) "triple loop" learning which adds consideration of "power relationships", and to include ethical and aesthetical considerations (for example, unintended consequences).

In summary, Figure 3.3 describes Peirce's model of inquiry as conducted by a "community of inquiry".

These modes of inference and their application within a social context are central to understanding Peirce's concept of inquiry and truth. Indeed, Peirce later identified abduction as being at the heart of pragmatism reflecting Peirce's fascination with the (cognitive) process by which we are capable of isolating a relatively small number of plausible hypotheses to account for observable facts.

Note that framing of Peirce's modes of inference in terms of modus ponens invites its extension to "modus tollens" where the antecedent is determined to be logically false when the consequence is shown to be false.

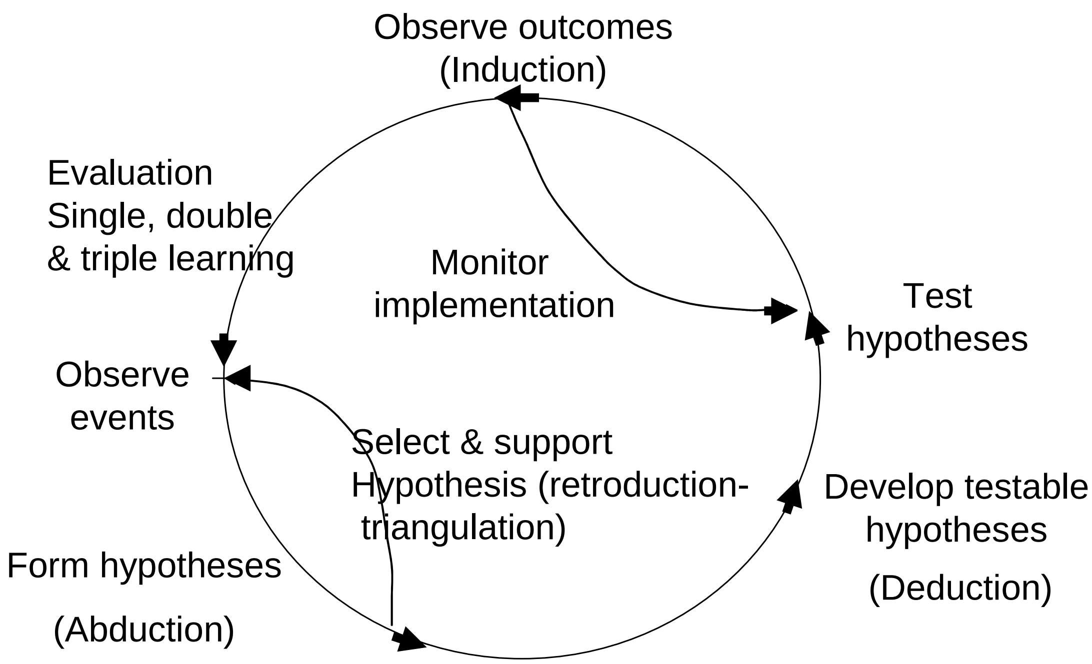

Figure 3.3. Peirce's System of Inquiry.

That is:

$$P \rightarrow Q$$
$$\underline{Q \text{ is false}\quad\quad}$$
$$\therefore\ P \text{ is false}$$

Hence, we can define the logic supporting the formation of hypotheses and their statistical testing used in positivist science. Similarly, by considering the logical implications of assuming the antecedent to be false, even though we know it to be true, we establish the basis for exploring "counterfactuals"; for example, what would have been the future of the British monarchy, if Princess Diana had not died?[15]

While abduction is clearly wrong in deductive logic, Peirce argued that abduction was the only form of inference that extends knowledge- deduction simply develops logical results from hypotheses, and induction uses data to quantify arguments. Abduction is now recognised as an essential part of the scientific method (Houser, 2005) and has a particular significance for management decision-making (Powell, 2002) and the field of artificial intelligence (Josephson and Josephson, 1994).

Haack summarises the importance of abduction:

> The method of science requires abduction. Scientific inquiry is creative; it requires imagination to come up with abductive hypotheses, or with the neologisms and shifts of meaning that stretch the limits of the linguistic resources a scientist inherits. But there are "trillions and trillions of hypotheses" that might be made, of which only one is true; we succeed as well as we do, Peirce suggests, because evolution has given human beings an instinct for guessing which "though it goes wrong oftener than right, yet the relative frequency with which it is right is ... the most wonderful thing in our constitution" (CP 5:172-73).

(Haack, 2006, p. 25).

Abduction, deduction, and induction provide a cycle of inference in which experience is used to develop a small set of hypotheses from what may arguably be an infinite set of possibilities; deduction can be used to reformulate hypotheses into forms suitable for testing using inductive inference. This gives rise to Peirce's experimentalism as the pragmatic basis for inquiry.

Despite the emphasis on rigour, Peirce was aware that this process was subject to error (fallibilism) and, as a result of his assumptions of synechism and tychism, that

[15] The study of counterfactuals is important in studying causation and has direct implications for the design of simulation experiments as used in System Dynamics (Collins, Hall, & Paul, 2004).

all inferences were conditional. On this basis, we can differentiate between the logics of laboratory sciences and social science methods like “action research”. In a laboratory science, and within reasonable limits, the conditionals (such as room temperature) can be identified, measured, and controlled. In systems terms, a “closed” system is created. In the social sciences, this is rarely possible: we are dealing with “open systems”. In this sense, laboratory science is a “special case” of social science! (The significance of this argument is further developed in Chapter 6).

Finally, it is worth observing that while deduction is the form of inference most strongly identified with Cartesian logic, inductive logic identifies with British empiricism, and abduction with pragmatism.

5. Fallible Behaviour.

Peirce’s recognition of the fallible nature of human cognition and its translation into error and maladaptive behaviour, appears in stark contrast to his emphasis on rigorous logic and a scientific approach. More than anything else, this sets Peirce apart from modernism and the Lamarkian view. It is essential to understanding his anti-Cartesian stance.

Haack (2006) provides an excellent description:

> In Peirce's philosophy, the individual appears as the locus of ignorance and error, and as becoming self-aware only as he interacts with others. So, as you might expect, Peirce's conception of scientific inquiry is not only thoroughly fallibilist but also thoroughly social. Each genuine, good-faith inquirer contributes to a vast enterprise within and across generations, making his work freely available to others; so, even if he fails, his will be one of the carcasses over which future generations of inquirers climb as they storm the fortress of knowledge.
>
> Fallible and imperfect as scientific inquiry is, if it were to continue long enough- Peirce is aware that there is no guarantee that it will- eventually a final, indefeasibly settled opinion would be agreed. Why so? The key elements are the combination of the direct and the interpretive in Peirce's theory of perception, the

> metaphysical doctrine he calls "scholastic realism," and his conception of the reasoning involved in scientific inquiry. Peirce's conception of experience is broad, including both sensory perception and, in mathematics, observation of imagined diagrams. Sensory perception, according to Peirce, is both direct and interpretive. The percipuum- to use the term he coined in 1902- consists of the percept, the perceptual event or presentation, and the perceptual judgment, the belief prompted by the experience; the two are conceptually distinct, though usually inseparable in practice.

(Haack, 2006, p. 23).

6. Peirce’s Aesthetic/Esthetic and Ethics.

For Peirce, logic was rooted in ethics and eventually aesthetics. All three constituted “normative science”, which in turn is the result of interpreting phenomena through the lens of metaphysics. For Peirce, metaphysics was not something vague, but, as Kant argued, something systemic and “put together with exact logical care” (Potter, 1996. p. 68). “(L)ogic, in classifying arguments, recognizes different *kinds* of truth; ethics admits of *qualities* of good; and esthetics is so concerned with qualitative differences ‘that abstracted from, it is impossible to say there is any appearance that which is not esthetically good’ (CP: 5.127)” Aesthetics draws from a continuum of goodness (Potter, 1996, p. 42). That is, Peirce saw the normative sciences as “those which distinguish good and bad as the representations of truth” (Potter, 1997, p 39).

So, Peirce’s philosophical framework was based in ethics and aesthetics which explains his criticism of James’s version of pragmatism as a shallow reflection of his pragmaticism:

> It is a logical method helping us to know just what we think, just what we believe. Our thought’s meaning is to be interpreted in terms of our willingness to act upon that thought- it is to be interpreted in terms of its conceived consequences. Peirce, then, sees a connection between thinking and doing, and so a connection between good thinking and good doing. What we are prepared to accept as proper conduct, good conduct, approvable conduct, as the

interpretant of our thinking, must be the measure of proper, good, acceptable, logical thinking. Thus logic depends upon ethics. But in its turn ethics must depend upon something else. Conduct is approved or disapproved to the degree that it conforms or fails to conform to some purpose, but the question remains as to what purposes are to be adopted in the first place. But we cannot get any clue to the secret of Ethics ... until we have first made up our formula for what it is that we are prepared to admire. I do not care what doctrine of ethics be embraced, it will always be so. (CP. 5.36) To determine what we are prepared to admire, what is admirable per se, is the task of esthetics.

Esthetics, then, attempts to analyze the summum bonum, the absolutely ideal state of things which is desirable in and for itself regardless of any other consideration whatsoever. Esthetics studies the ideal in itself, ethics the relation of conduct to the ideal, and logic the relation of thinking to approved conduct.

(Potter, 1997, pp. 39-40).

3.3 Peirce and Systems Thinking.

There are many references to Peirce in the systems literature and his influence both directly and indirectly is profound but largely unrecognised. Figure 3.4, based on evidence of direct interactions and referenced papers, provides some indication on the extent of this web of influence. Some of these linkages are discussed below.

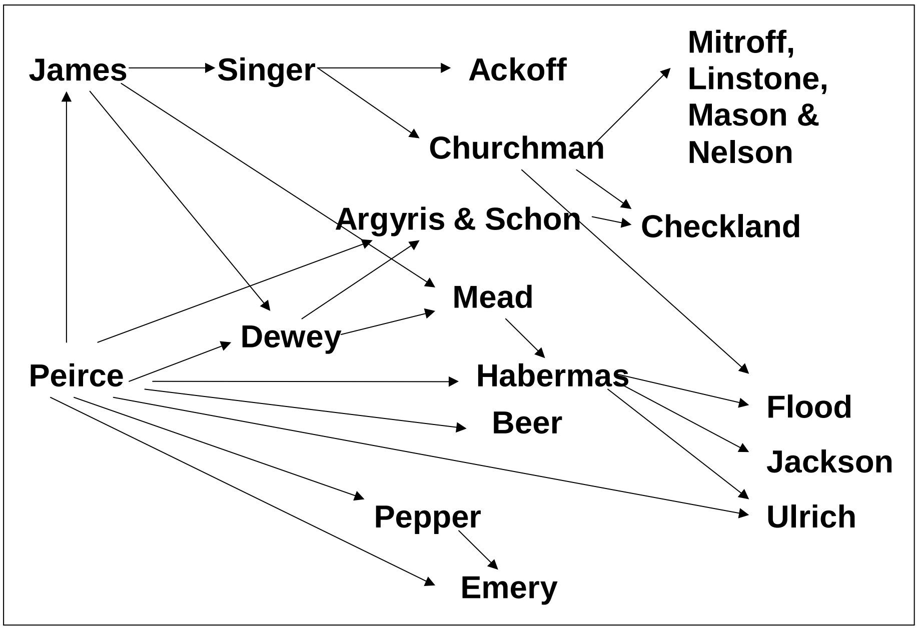

Figure 3.4. Peirce's Web of Influence.

Early Recognition of Linkages.

The earliest evidence of the links between systems thinking and pragmatism were made by Churchman and Ackoff and has been described in some detail by Britton and McCallion (1994). However, this linkage was essentially to Singer and Dewey, not directly to Peirce (see below).

Lilienfeld (1978) noted the relevance of this linkage when he identified Pepper's "contextualist" hypothesis as an "anticipation" of systems thinking (Lilienfeld, 1978, p. 8). In this context, contextualism represents the classical pragmatist philosophy associated with Peirce, James, Bergson, Dewey, and Mead (Pepper, 1942, p. 141), and not just Singer. In particular, Lilienfeld demonstrated how Peirce's synechism and tychism link to the Gestalt view of systems:

> "The world is seen as an unlimited complex of change and disorder. Out of this total flux we select certain contexts as organising Gestalt's or patterns that give meaning and scope to a vast array of details that, without the organising patterns, would be meaningless or invisible".

(Lilienfeld, 1978, p. 9).

Herbenick (1968; 1970) was possibly the first to establish the direct relationship between Peirce and systems thinking, at least as it was defined by Churchman in the 1960s with strong links to engineering systems and operations research (Churchman, 1968).

Herbenick emphasised Peirce's advocacy to determine plans that are "unitary" in purpose and involving "community" and illustrates this with a discussion of Peirce's taxonomy of science and his hierarchy of theoretical sciences. Herbenick notes that Peirce's discussion of the "economy of research" pre-empts operations research (Herbenick, 1970, p. 86).

Most significant, however, is Herbenick's argument that Peirce clearly differentiated between the "systems concept" and the "systems approach" and his conclusion that Peirce was the "silent pre-cursor" to this "systems era" (Herbenick, 1970, p. 93).

Churchman and Ackoff.

Pragmatist philosophy is the basis of the contributions of Churchman and Ackoff, although it is through the work of Churchman's professor at Pennsylvania- Edgar Arthur Singer, rather than through Peirce directly. (This influence is documented by Britten and McCallion , 1994).

As referenced earlier, Singer's earliest encounter with pragmatism is recorded in his account of a reading of William James' essay *The Will to Believe* Singer (1925). Furthermore, the lack of Singer's attribution to Peirce has been noted.

Consequently, it is not surprising that this same lack of reference to Peirce was continued by Churchman and Ackoff. In fact, Churchman and Ackoff (1950, p., 194) did write explicitly about early pragmatism, but not in very positive terms: in recognising "the synthetic character of pragmatism", they described it as borrowing "from practically every development in science and philosophy" and saw the early exponents of pragmatism such as Peirce and James, as being "at the same time profuse and unsystematic". Consequently, they concentrated their attention on Dewey and Singer.

One can only speculate as to where Churchman and Ackoff would have taken systems thinking if they were more completely aware of the work of Peirce (and James).

Emery Open Systems Approach.

Peirce became increasingly important to the development of Fred and Merrelyn Emery's socio-ecological open systems theory. In fact, Fred Emery moved from a position of apologising for not having the room in his readings for a contribution from Pepper (Emery, 1981, 1971), to this reference being a cornerstone to later writings (Emery and Emery, 1997; Emery, 1993).

The secret to Fred Emery's interest in pragmatism is included in his apology for not being able to include Pepper in his readings. Emery wrote: "This is of particular importance because the 'root metaphors' he (Pepper) identifies and rigorously defines are all clearly operating in different systems theorists and account for much of the mutual incomprehension that exists among them. 'Contextualism' is the root metaphor which comes closest to our bias in selecting this volume" (Emery, 1971, p. 15).

Emery argued that it was only contextualism that facilitated the proper consideration of organisations as *open* systems. While the notion of open systems in the thermodynamic sense is applied to mechanistic systems, and in the biological sense (ie, in the sense of von Bertalanffy), to organic systems, neither of these is particularly appropriate for human organisations. Consequently, Fred and Merrelyn Emery refer to systems relating to formism, mechanism, and organicism, as being *closed* because none of these systems describe a relationship between the environment and an organisation in which their interrelations are mutually determining and governed by laws which are able to be known. Specifically, these laws relate to the intra-relations which exist within the organisation and within the environment, and the planning and learning relations which define the interaction between the system and the environment. Contextualism is the only world view which adequately accommodates human activity as purposeful behaviour. It is this argument which explains Emery's doubt, raised in his review of Checkland (1981), that the classical operations research/ management science/ hard systems approaches can really be made "soft" by simply imbedding them in a learning framework, and his criticism that making the distinction between hard and soft systems focuses on the wrong agenda- the real issue is between open and closed systems (Emery, 1982). In contrast, the Emery OST approach is all about establishing dialectic between the system and its environment.

Checkland's Soft Systems Methodology (SSM).

Checkland makes strong reference to the influence of Churchman and Singer in the design of his system of inquiry, but makes no reference to Peirce.

Nevertheless, it would appear that Checkland is very much closer to the views of Peirce, than is initially evident. In this respect, Emery's (1982) criticism of SSM mentioned above appears to misinterpret Checkland- Checkland recognises the "open socio-technical systems" approach's "core paradigm is one of *learning* rather than *optimisation* and that is where lies the resemblance to soft systems methodology" (Checkland, 1981, p258). In another sense, Emery's view may be better understood by recognising that the process of obtaining root definitions and rich picture diagrams as a means of establishing a mode of inquiry in the sense of Singer and Churchman, is heavily dependent on machine metaphors to describe the system as an input-output transformation. One then has to switch to what Emery would describe as an open systems framework to incorporate Checkland's learning process as a way of establishing an "appreciative system".

The CATWOE process and the construction of "rich picture" diagrams (Checkland, 1981) are devices for establishing hypotheses about the nature of systems and consequently, are part of the abductive process. Similarly, Checkland's action learning process, involving a Framework of ideas, a Methodology, and an Area of application (FMA), corresponds to both Peirce's phenomenology and the application of his modes of inference. (The framework of ideas is used to interpret an area of application to provide a systemic outcome and hence action).

Beer's Viable Systems Diagnosis (VSD).

In *Decision and Control*, Beer (1966) sets out to show how science can be used to solve problems of decision and control. His words ring with a certain resonance in today's world where we need to replace the hierarchical approach to decision and control with one that uses communication technology in the non-hierarchical structures of the new organisational forms. Within this context, the principles of requisite variety and the ideas of attenuation and amplification take on a renewed importance.

Similarly, Beer recognises that management is not about deduction and proof, nor the "application of facts": "When we speak of management and its decisions we are really speaking of the settling of opinion or belief" (p16). He goes on to argue that "it is not true that belief is settled either by rigorously scientific method on the one hand, or by erratic and emotional caprice on the other". Beer then proposes reference to Peirce's paper, *On Fixing Belief,* and enters into a discussion of Peirce's four approaches- tenacity based on conditioning stakeholders, authority, apriority or reliance on axiomatic belief of "self-evident" proposition, often couched in the latest language describing a new (short-term) fix for our businesses and economic systems, and finally, the method of science. Importantly, Beer reminds us that scientists are also prone to "fixing belief" through the application of the first three non-scientific approaches. Nevertheless, like Peirce in relation to philosophy, Beer is concerned to introduce into management some of the rigour which scientists bring with them.

The Critical Theorists- Flood, Jackson and Ulrich.

Despite their different emphases on critical theory- Flood and Jackson on complementarism, and Ulrich on emancipation, all acknowledge their debt to Habermas's communicative action, and in the case of Ulrich, to Peirce directly. For example, see Flood and Romm (1996 (a, b) and Ulrich (1983).

However, Habermas in turn acknowledges his debt to Peirce and to Mead in particular. (Habermas 1968, 1989).

System Dynamics (SD).

Other than a possible correlation of SD's "pragmatic", engineering approach to problem solving (as noted by Cavaleri 2005), there does not appear to be any formal interaction between the development of SD and pragmatist philosophy.

Richardson's (1991) history of feedback thought provides the principal account of the deeper historical background to SD, but no formal links to pragmatism are apparent. Nevertheless, as pointed out by Ryan (1996), with respect to abduction, consideration of the characteristics of SD and the characteristics of pragmatism reveal a number of synergies:

- SD adopts a continuous view of events, corresponding to synechism. Feedback structures are an integral part of this worldview. Furthermore, surprises are contemplated through the operation of feedback loops.
- SD uses reference modes to define a system of interest in the context of a problem focus. This corresponds to the pragmatic maxim of meaning.
- SD places a heavy reliance on the use of symbols to describe systems- the stock-flow diagram provides a very simple language (a semiotic).

- More contemporary approaches to SD emphasise group model building- representing a “community of inquiry”.

It will be shown in Chapter 7, that the use of the “events- pattern of events- structure” heuristic that largely defines the SD approach is an abductive process and that the rigour of SD methodology can be significantly enhanced by applying Peirce’s modes of inference.

Conclusion.

This Chapter supports the need to make the philosophical underpinnings of systems approaches transparent and advocates the use of Pepper’s world hypotheses as an important entry to this discussion. While acknowledging the importance of Pepper’s other three world hypotheses to systems approaches, the Chapter identifies a special interest in Pepper’s contextualist hypothesis. This mainly relates to the pragmatist philosophy of Charles Sanders Peirce. It is shown that Peirce has had a significant influence, either directly or indirectly, on many prominent contemporary systems theorists.

Peirce’s pragmatism constitutes strongly connected and comprehensive strands of thought based on a continuous world view, and including a theory of meaning, a phenomenology, a rigorous system for inquiry to establish truth, a logical basis in ethics and aesthetics, and the acceptance of pluralism in science. These strands can be used in a flexible, innovative manner to strengthen the logic and practice of systems thinking. Used individually or collectively, you can always be assured that remaining pieces of logic are sitting in the background, ready to be brought forward as the case may require.

Chapter 4 applies these principles to develop a rigorous definition of the systems concept and methodology, within the wider scientific method.

Chapters 5, 6, and 7 apply these concepts to the development of a systemic approach to knowledge management, and to the development of a rigorous foundation to action research, particularly as it applies in System Dynamics methodology.

Chapter 4. Systems Thinking and the Scientific Method.

4.1 Introduction.

Some 25 years ago Checkland observed:

> 'Systems thinking' is not yet a phrase in general use. Eventually, I believe, systems thinking and analytical thinking will come to be thought of as the twin components of scientific thinking, but this stage of our intellectual history has not been reached. It is necessary to establish, if we can, the phrase's credentials.

(Checkland, 1981, pp. 74-75).

As argued in previous Chapters, despite significant advances in system thinking, particularly in areas such as systems inquiry (Checkland, 1981; Flood and Jackson, 1991); systems intervention (Midgley, 2000; Flood and Romm, 1996 a,b,c,d); the learning organization (Senge, 1990); and group model building (Vennix, 1996), nothing much seems to have changed in the widespread acceptance of systems thinking over the past 25 years (Atwater, Kannan, and Stephens, 2005; Bawden, 2005; Hammond, 2002). And, as Checkland (2000) observed, the hope that General Systems Theory (GST) would "provide a meta level language and theory in which problems in many disciplines could be expressed and solved" and so "help to promote the unity of science" has not materialized- "looking back from 1999 we can see that the (GST) project has not succeeded" (Checkland, 2000, p. S 11). Systems thinking remains marginalized from mainstream science.

To change this situation, systems thinking needs to better understand its longer term historical importance in science and reconsider its (relatively recent) association with organicism. As explained in Chapter 1, this association promotes systems thinking as the opponent of mainstream "reductionist" science, and, rather than winning some assumed "battle", systems thinking has become trapped in the rhetoric of the 19th

Century arguments in biology between “reductionism” and “holism” (Koestler and Smythies, 1969; Weiss, 1969).

As a contribution to this change, this Chapter argues that we must return to some basics of the scientific method and accept Checkland’s challenge to clarify the relationship between “systems thinking and analytic thinking”. To achieve this outcome, it is argued that the scientific method is best understood as dialectic between analysis and synthesis supported by Peirce’s triadic logic, where a “system” is understood as a cognitive construct that frames this debate. In this context, as Johanssen and Olaisen (2005 a) observe, the system plays a central role in the scientific method and lays the foundation for framing ethical debate. (Also see Lakoff (2004; Lakoff, 2006)). This argument leads to the conclusion that the open systems concept, in the sense of socio-ecological systems, provides our most useful systems frame for addressing contemporary *human* issues.

4.2. Analysis, Synthesis, and the Scientific Method.

The problem with Checkland’s reference to systems thinking, analytical thinking and the scientific method is that, given the history of science primarily links analytical thinking to synthesis (Gross and Jones, 2004; Holton, 1998 b), it is implied that systems thinking is the same as synthesis. This interpretation is reinforced by references such as the title of Hammond’s book: “*The Science of Synthesis*” (Hammond, 2003) and Culliton’s article “*Age of Synthesis*” (Culliton, 1962). This situation contrasts with Ackoff’s recognition of the complementary nature of analysis and synthesis, but with analysis more closely identified with “machine-age thinking” and “synthesis with systems thinking”. (Ackoff, 1981, p. 16).

In the following sections it will be argued that systems thinking involves both analysis and synthesis, and that systems thinking provides a distinctive approach to the manner in which *both* analysis *and* synthesis operate within the scientific method. But before discussing the role of systems thinking, the relationship between analysis and synthesis and the scientific method needs to be defined more clearly. In particular, the scientific method will be defined as constituting a dialectic between analysis and synthesis.

Analysis and Synthesis.

Ritchey (1996) records that:

> (T)he terms analysis and synthesis come from (classical) Greek and mean literally "to loosen up" and "to put together" respectively”…. In general, analysis is defined as the procedure by which we break down an intellectual or substantial whole into parts or components. Synthesis is defined as the opposite procedure: to combine separate elements or components in order to form a coherent whole.

(Ritchey, 1996, p. 1).

Significantly, Ritchey also makes a comment with which this author is in agreement:

> Careless interpretation of these definitions has sometimes led to quite misleading statements- for instance, that synthesis is "good" because it creates wholes, whereas analysis is "bad" because it reduces wholes to alienated parts. According to this view, the analytic method is regarded as belonging to an outdated, reductionist tradition in science, while synthesis is seen as leading the "new way" to a holistic perspective

(Ritchey, 1996, p. 1).

In the history of science, two issues have dominated the discussion of analysis and synthesis. Firstly, whether or not it makes sense to think of them as separates or couples (Gross and Jones, 2004), and secondly, the order in which analysis and synthesis are applied. We will consider the second issue as part of a broader discussion of the dynamics associated with analysis and synthesis. Note that each of these issues assumes that some process has occurred that identifies an entity to which analysis and synthesis may be applied for which Holton, (1998 b) identifies a number of relevant assumptions.

Identifying "hypothesis" as the "entity" constituting a starting point for Analysis and Synthesis.

C.S Peirce provides the starting point for inquiry as"(T)he surprising fact, C, is observed". (CP 5: 187)

That is, a phenomenon exists that sufficiently attracts our attention and motivates our further inquiry. The challenge is then to make sense of this "surprising fact" by interpreting the event within some contextual frame. This frame then becomes the focus of our attention. Such frames have been variously described as a "system" (Crick, 1994), a "statement of purpose" (Riemann as described by Ritchey (1996), a "model" (Nersessian, 2002), and a "hypothesis" (Plato as described by Holton (1998 b)). To help facilitate our discussion of the scientific method, the more traditional path will be adopted and this entity will be referred to as a "hypothesis"[16].

Holton notes that while Descartes and Newton agreed with Plato that analysis needs to precede synthesis, there were differences in their descriptions of how the initial hypothesis is obtained. Plato described this stage as being an inductive process, while Descartes "gave a large role to clear and undisbelievable ideas and the role of intuition", and, Newton "relied on observation and experiment to anchor the first principles in experience" (Holton, 1998 b, p. 117). In this stage, a new knowledge frame is perceived upon which further hypotheses can be based using deductive reasoning and tested empirically.

Einstein described the jump from the observed facts to the set of "Axioms of Fundamental Principle"- the fundamental hypothesis, as a:

> Speculative leap based on hunch, conjecture, inspiration, and guesswork….We are dealing, after all, with the private process of theory construction or

[16] In fact, to provide meaning and to define conditionals, all hypotheses must be formulated within the context of a system of meaning.

innovation, the phase not open to inspection by others and indeed perhaps little understood by the originator himself. But the leap to the top of the schema symbolizes precisely the precious moment of great energy, the response to the motivation of "wonder" and the "passion of comprehension".

(Holton, 1998a, p. 31)[17].

It is this type of "speculative leap that sets abduction apart from induction. Einstein's model is described in Figure 4.1.

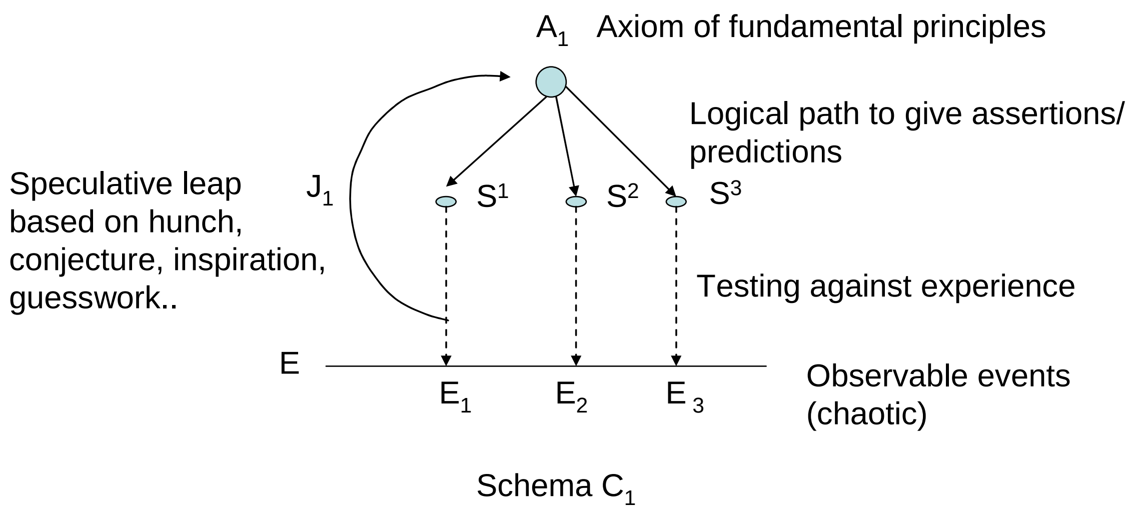

Figure 4.1. Einstein's Model for Constructing a Scientific Theory (Holton, 1998a, p. 31).

In addition to Einstein's theory of relativity, this "speculative jump" is what characterizes the great developments in science such as Euclid's elements, Galileo's re-conception of the planetary system, the Newtonian model, and Descartes' framework of thought.

Peirce provided the most explicit description of the logic of forming a hypothesis. Rather than leave the creation of hypothesis to a purely intuitive process, Peirce advocated that hypotheses result from a form of inquiry that, as noted previously, is

[17] Consequently, abduction is associated with the process of synthesis, a foundation stone of systemic thought.

called abduction and sits beside deduction and induction as an important part of the logic of inquiry. This contrasts with the approach of the positivists who rely only on deduction and induction and argue that while hypotheses can only be verified using sense experience, they are not derived from sense experience. Such an approach leaves hypothesis formation unexplained. (Fairbanks, 1970).

As previously discussed, Peirce described the logic of abduction as follows:

> The surprising fact, C, is observed.
> But, if A were true, C would be a matter of course.
> Hence, there is reason to suppose that A is true.

(CP 5: 187)

While Peirce identified abduction as the only form of inquiry that generates new knowledge, he acknowledged that compared to deduction and induction, it was the least rigorous form of inquiry.

The Dynamics Associated with Analysis and Synthesis- Analysis and Synthesis as Dialectic.

Holton (1998 b, p. 111) argues that analysis and synthesis and are best discussed as "couples" and observes that, "at the base of these two related terms there lies one of the most pervasive and fundamental "themata in science and outside". Holton describes a number of different ways in which analysis and synthesis have been used and describes the differing emphases with which they are used. Holton notes that from a cultural point of view, synthesis plays the more prominent role, but, from the point of view of praxis (as in professional, scientific, and scholarly work), "the positions of analysis and synthesis are entirely reversed, and the former is more prominent". So, Holton argues that analysis and synthesis cannot be realistically separated as ideas and recommends that:

> …it is the more important for us to seek out the relations within the Analysis and Synthesis couple in order to understand the full power of each of the components rather than be misled by the asymmetrical valuations of them in

contemporary theory and practice – possibly the result of the preponderance (and success) of reductionistic thought in our time."

(Holton, 1998 b, p. 113).

With respect to the question concerning the order of application of analysis and synthesis, there is a degree of confusion. Holton (1998 b), paraphrasing Plato indicates that, for a given initial hypothesis, analysis must precede synthesis: "..attempting synthesis without a previous analysis does not lead to truths".

In contrast, when describing the analytic process, Lewin (1942/1997, p. 214) advises that:

> What is important in field theory is the way analysis precedes. …field theory finds it advantageous, as a rule, to start with a characterisation of the situation as a whole. After the first approximation, the various aspects and parts of the situation undergo a more and more specific and detailed analysis.

This confusion is resolved by Ritchey's emphasis on the circularity of the interaction:

> Every synthesis is built upon the results of a preceding analysis, and every analysis requires a subsequent synthesis in order to verify and correct its results. In this context, to regard one method as being inherently better than the other is meaningless.

(Ritchey, 1996, p. 2)

It is now advocated that this feedback process be identified as dialectic. Dialectic has a rich history in thought going back to Greek times. It "refers to some sort of polarity or binary opposition, either a debate between two perspectives or a conflict between two realities" (Dunning, 1997, p. 11). Consequently, dialectic is usually expressed as involving a "thesis", an "antithesis", and a "synthesis". But when combined with theories of action, this "synthesis" becomes the basis for action and hence forms the new "thesis". Hence knowledge advances[18].

Arthur (1998, p. 451) calls this process a "systematic dialectic" in which knowledge develops in stages which he calls "categories" that express "the forms and relations embedded within the totality, its "moments." The task of systematic dialectic is to organize such a system of categories in a definite sequence, deriving one from another logically".

Arthur, citing Hegel, describes the transition from one category to the next as a "progression" in which "successive categories are always richer and more concrete" and where "it is important that the transition involves a "leap" to a qualitatively new categorical level" (Arthur, 1998, p. 451).

In this way, the scientific method can start to be understood as a dialectic process involving cycles of analysis and synthesis in which each cycle results in a new and/or more complete framing of knowledge (category) (Bochner, 1969; Wheeler, 1935).

Following the development of each hypothesis, further analysis may take place (informed by deductive and inductive logics) and/or appropriate tests of the hypotheses undertaken and consequential action taken. New data allow us to question the viability of the initial hypothesis and the dialectic continues.

This process is consistent with Quine's "naturalised epistemology" as is the systemic framing of a hypothesis with Quine's "meaning holism" (Gibson, 2004). A consequence is the applicability of the Quine-Duhem Thesis that "(N)o part of a scientific theory can be confirmed or disconfirmed; only the theory as a whole can be confirmed or disconfirmed" (Lakoff and Johnson, 1999, p. 456). This theorem summarises Quine's case against "radical reductionism" one of "two dogmas of empiricism" (Quine, 1953). It has obvious significance to systems thinkers!

[18] In Chapter 6 it is noted that Takeuchi and Nonaka (2004, p. 6) describe their knowledge creating process in these terms.

Despite some possible confusion in which the word “synthesis” is being used in two places- for example, if “analysis” is the thesis, and “synthesis” is being seen as the antithesis, their synthesis is the new “synthesis”- there are three reasons why dialectic provides a sound basis for describing the dynamic interaction between analysis and synthesis:

Firstly, the proven technical capability and practicality of dialectic to progress knowledge by facilitating the interplay between seemingly opposite ideas such as analysis and synthesis (Hampden-Turner, 1990, 1994; Sternberg, 1999b; Trompenaars and Hampden-Turner, 2001). Secondly, the need for a process that recognizes the strengths and limitations of human cognition (Crombie, 1997; Emery and Emery, 1997; Kahneman and Tversky, 2000; Simon, 1981; Sloman, 1999) and provides checks and balances to avoid the excesses of extreme reductionism and extreme holism. Thirdly, the necessity to recognize the assumptions made in applying analysis and synthesis (Holton, 1998 b).

At this point, it must be recognised that a clear distinction needs to be made between taking action in a social system compared to taking action in a laboratory context (such as attempting to replicate an experiment). This distinction clarifies the difference between “scientific research” and “action research”. In the first case, the research aims to establish universal truths governed by covering laws, while in the latter case the research aims to *evaluate* the process of hypothesis formation and implementation *within a social context*.

Consequently, the basics of action research identified with Lewin and described by Blum (1955, p. 1) involves two stages-

> (1) A diagnostic stage in which the problem is being analysed and hypotheses are being developed.
> (2) A therapeutic stage in which the hypotheses are tested by a consciously directed change experiment, preferably in a social "life" situation”,

In this sense, scientific research and action research are not competing approaches to science, but complementary, albeit as Blum points out, where the design of the scientific method ideally needs to be influenced by the social objectives of the research[19].

In summary, each cycle of dialectic can be described as a learning process starting with the "surprising fact" which leads to the formation of an explanatory hypothesis, followed by analysis and consequential action generating new data and further surprising facts. (Figure 4.2).

There is a close similarity between this description of the scientific process with that identified by Peirce as being analogous to Cuvier's evolutionary process. This process emphasizes that science advances in leaps, compared to the more stable evolutionary processes identified with Darwin and Lamarck (Sharpe, 1970; Tuomi, 1992). Similarly, the process can be related to Dewey's "Spiral of Learning" (Kolb, 1984, p. 23). This latter similarity is made explicit by recognizing that Dewey's experiential logic is drawn from Peirce's notion of the continuity of inquiry supported by his triadic logic (Dewey, 1938).

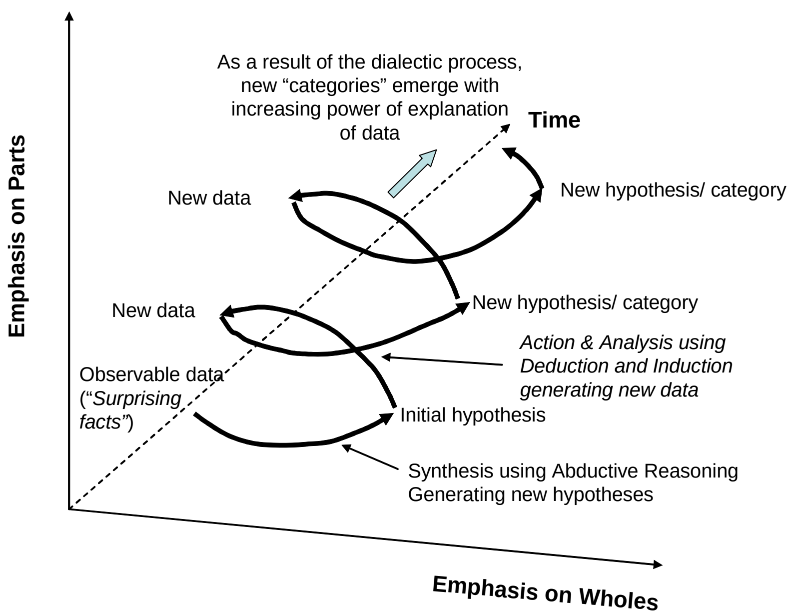

Figure 4.2: The Scientific Method as Dialectic Between Analysis and Synthesis.

[19] These issues are considered in greater detail in Chapter 6.

This process operates at both the macro level in the sense of the “grand syntheses” of Newton and others, but also at the micro level with individual experience. For example, Bawden et al (2007, p. 132), describing the “Hawkesbury” approach to systemic development and praxis describe their approach:

> From a systems perspective, the whole approach takes on the vibrant dynamic of the dialectic between the differentiation of the parts and their integration into the whole- between the different sub-systems of the learning system and the whole system, between the different levels within the system and between the learning system and the environment in which it operates, and so on.

4.3 Systems Thinking and the Scientific Method.

Having developed a description of the scientific method as a dialectic involving analysis and synthesis supported by the logics of abduction, deduction, and induction, Checkland’s question concerning the relationship between systems thinking, synthesis and the scientific method can finally be addressed.

It will be argued that systems thinking provides a distinctive way of framing the dialectic described above and that this results in specific implications for the way in which analysis and synthesis occur. This argument will be developed in three parts: the manner in which a “surprising fact” is recognized, the nature of the systems frame chosen to interpret that data, and the consequential manner in which this frame determines the structuring of the first synthesis (the initial abduction) and the following analysis.

“The Surprising Fact”

The fact that attracts the interest of the system thinker comes in many forms. Systems thinkers are often characterized by their interest in complexity, often described as an “Ackoff mess” (Checkland, 1981). In System Dynamics, interest is established by the recognition that an individual event is part of a pattern of events. In Emery Open Systems Theory the starting point is the desire to develop an improved future. For von

Bertalanffy it was to find a better explanation of biological phenomena than was accorded by vitalism. For Critical Systems Thinking, it is stimulated by a desire to adopt a pluralist approach to inquiry. In each case, however, a holistic frame is sought as a basis for developing any hypothesis.

Framing the Systems Hypothesis.

The most outstanding characteristic of systems thinking is the way it frames the dialectic using holistic structures compared to, for example, the use of probabilistic and Bayesian inferential frames to describe hypotheses and shape action (Griffiths & Tenenbaum, 2006). As indicated in Chapter 1, the history of systems thinking suggests that different disciplines have evolved different conceptual frames for describing hypotheses. Some obvious examples include the Newtonian synthesis that is used to describe the physical world, quantum physics that describes the sub-atomic world, and Darwin's theory of evolution, which is used to describe the biological world.

At least three generic systemic frameworks can be identified in contemporary systems approaches:

1. The closed system which is associated with attempts to describe the physical world including systems of classifications, and simple and complex, feedback machines;
2. The input-output open systems which are associated with von Bertalanffy's attempts to describe the biological world; and
3. The open socio-ecological systems which are associated with early attempts by psychologists such as Tolman (1932) to describe human, purposeful behaviour.

In the case of the first two, there have been significant attempts to expand the domain of application from their particular fields to encompass other disciplines. For example, von Bertalanffy (1950) demonstrates the extension of his biologically inspired systems framework to physics where "the theory of open systems leads to fundamentally new principles" (p23). The socio-ecological frame appears to be the least recognized- for example, Midgley (2003) omits any significant reference to developments in this area.

It must be emphasized that some developments in systems thinking bridge two or more of these primary frameworks. For example, developments in feedback thought and cybernetics arguably span each of the frames, servomechanisms are part of the closed systems frame, cybernetics is most prominently associated with the input-output biological frame, and Beer's Viable Systems Model (VSM) can be easily associated with the data structures required for the viability of open, purposeful systems.

It may be argued that autopoietic systems constitute a fourth systems genus. Alternatively, they may be considered to have hybrid qualities. Maturana and Varela (1980, p. 81) describe autopoietic systems as "autopoietic machines", which do not have inputs or outputs, but are homeostatic machines with all feedback being endogenous. Consequently, feedback that goes into the environment of the machine is endogenised. The machine adjusts internally to counter the effects of external perturbations adopt a similar structure as a self-referential structure but retain the environment as a "domain of understanding".

Pepper's Classification of World Hypotheses and the Explanatory Power of Different System Constructs.

Significant attempts have been made to show how these different "world views" can relate to each other. For example, Singer's (1954) extensive work on the "dialectic between the schools" argues that while Locke's empiricism and Spinoza's pure reason constitute the thesis and anti-thesis, Kant provided the synthesis[20] (Churchman, 1981, p. 10). Consequently, Singer argued that it is perfectly sensible to think of a biological entity living in a physical world. Churchman (1948, pp. 44-60) classifies dialectics associated with "modern" philosophies including experimentalist, empiricist, and rationalist philosophies based on sixteen possible combinations of affirmation and negation to four propositions in logic:

[20] In these terms, Peirce's pragmatism can be interpreted as a clarification and extension of Kant's synthesis.

- The answering of any question of law presupposes the answering of at least some questions of fact.
- There exist answers to at least some questions of law.
- The answering of any question of fact presupposes the answering of at least some questions of law.
- There exist answers to at least some questions of fact.

(Churchman, 1948, p. 51).

Pepper's "World Hypotheses" (Pepper, 1942) provides a useful way to better understand the relationships between generic frames by interpreting them as "root metaphors". As discussed in Chapter 3, Pepper proposed four "world hypotheses and associated "root metaphors" that sit between the extremes of dogmatism and utter scepticism. Pepper also identified the schools of philosophy that underpin each hypothesis. These are realism or Platonic idealism, naturalism or materialism, absolute idealism, and American pragmatism (Pepper, 1942, p. 141). Pepper's classification of hypotheses associates each world hypothesis with an underlying logic demonstrating differences in analytic power and in synthetic power.

Kolb (1984, pp. 109-120) identifies isomorphism between Pepper's structure of knowledge and the structure of the learning process, identifying the synthetic-analysis dialectic with "grasping via apprehension" versus "grasping via comprehension", and the dispersive inquiry-integrative inquiry dialectic with "transformation via extension" versus "transformation via intention".

From a systems thinking perspective, there are clear and acceptable roles for system constructs associated with each of the metaphors associated with Pepper's world hypotheses. Some have greater explanatory power than others. For example, in management classification systems (formism) associated with financial accounts, market segmentation, and organizational structure play a significant role in business communication and analysis. One can expect greater explanatory power as business models move from a base in formist and mechanistic terms (e.g., the dynamic strategy models described by Warren (2002) and Sterman (2000), to the highly non-linear (organicist) models associated with chaos theory (Guastello, 1995). Contextualist models emphasizing the co-evolution of the business with its environment can be expected to offer the greatest explanatory power. Note that contextualism is the only hypothesis that admits of human, purposeful behaviour and consequent novelty; formism and mechanism are the *results* of such behaviour.

The Relationship between Systems Framing and Analytic and Synthetic Processes.

The choice of metaphor not only determines the manner in which hypotheses are framed but the way in which analysis and synthesis proceed. For example, under the world hypothesis of Formism, synthesis relates to the accumulation of categories while analysis is expressed in terms of the way categories are broken down into sub categories. Similarly, Mechanism results in synthesis being the description of a machine (for example, the universe as a clock), while analysis considers the properties of parts of the machine.

Pepper (1934) provides an early and detailed explanation of the way in which analysis and synthesis are affected by the systems frame. In this paper, Pepper articulates Tolman's description of purposive behaviourism in terms of a shift from the description of psychological phenomena from a mechanistic to a contextualist frame. Pepper describes such a shift as "revolutionary" requiring a comprehensive change of language- "they are terms for new concepts" (p.109). He argues that it is not the parts of the system that are so important, but the relationships between them, and between them and their contexts in a continuously changing flux.

We can now see that the analytic-synthetic dichotomy is associated with contrasts between the first two "analytic" worldviews and the second two "synthetic" worldviews. Importantly, Pepper argues that all are important and have a useful role in reasoning forming a "sort of bedrock of cognition" (Pepper, 1942, p. 84). Synthesis (and the "process" philosophies) provides *understanding* of purpose by putting things into context while analysis (and the analytic philosophies) provides *explanations* of how things work.

The Abductive Phase and the Process of "Sweeping-In".

Again, a variety of approaches have evolved in systems thinking that assist the abductive phase of forming a hypothesis. In Checkland's SSM there is an explicit reference to the input-output transformational frame in both the CATWOE mnemonic and the construction of Rich Pictures (Checkland, 1981). System Dynamics methodology adopts a closed systems perspective and concentrates on defining a system in stock-flow, feedback form that is sufficient to replicate observed behaviour over time as well as possible behaviours into the future. Consequently, questions of logical consistency can be addressed.

The most general approach is what Churchman describes as Singer's process of "sweeping-in" and which Churchman adopts as the main guard against committing an "environmental fallacy" (Churchman, 1979, p. 4). Consequently, it is most associated with the socio-ecological frame:

> According to Singer, if a person sets out to answer any question of fact, he finds that he must learn more and more about the world, i.e., he discovers that his original question becomes more and more complicated, not simpler and simpler, and investigation will reveal even more complexity, not simplicity. Consequently, the framing of issues becomes extremely critical.

(Churchman, 1981, p. 1).

Churchman (1981, p. 22) sees that the implication of Singer's sweeping-in process is that "there is no such thing as the philosophy of science, per se, that all issues we try to investigate are based on a systems approach in which we have to ask, "is the investigation warranted ethically?".

In contemporary systems thinking terms, the sweeping-in process may start by classifying data according to some criteria or other (seeing what you have), and include the use of diagrams such as Checkland's "rich picture diagrams", causal maps and stock-flow diagrams in System Dynamics, and engineering systems diagrams, and structured processes such as search conferences and dialogue sessions. In each case, there is an attempt to capture and codify the insights and perspectives of stakeholders.

Consequently, the most common sweeping in process is to develop multiple perspectives of a situation and to attempt their synthesis. While the idea of taking multiple perspectives dates back to at least Jain Indian philosophy of about 3 AD (De Bary, 1958), (see Chapter 1), it was significantly embraced in systems thinking by the development of socio-technical systems thinking (Trist and Murray, 1993) and, following more directly in the footsteps of Singer, extended by Linstone (1984), and Mitroff and Linstone (1993). Viewing perspectives from "four windows" is central to Flood's Critical Systems Thinking (Flood, 1999), and integrating stakeholder perspectives is central to System Dynamics method (Sterman, 2000).

Open Systems.

Understanding systems thinking is confounded by a number of dichotomies each drawing attention to particular aspects of systems thinking. These include: wholes versus parts; soft versus hard systems; open versus closed systems, synthesis versus analysis, holism versus reductionism, and organismic versus mechanistic.

Each of these dichotomies relate to long traditions of debate in the history of science. For example, Wheeler (1935) describes the history of thought- scientific and otherwise- as "consisting in a struggle between the mechanical and the organismic points of view", which he relates to the "part-whole" problem, and traces this history from medieval times. He identifies a cyclic pattern and courageously predicts that "permanent harmony will be attained some time before 2000 AD" (Wheeler, 1935)!

But the most important development in systems thinking from the perspective of the scientific method is gleaned from the open versus closed system dichotomy. These developments have occurred in two disciplinary areas. The first starts in biology with von Bertalanffy breaking the back of vitalism. As previously described, von Bertalanffy was concerned with the way an organism (system) transformed inputs into outputs. He was not concerned with any structural characteristics of the environment and as a consequence was not able to describe any process of adaptation let alone active adaptation (Emery and Emery, 1997).

The second area of development of the open systems perspective is associated with Gestalt psychology and came with Heider's (1930) demonstration that "the environment had an informational structure at the level of objects and their causal interactions, and that the human perceptual systems were evolved to detect and extract that information" (Emery and Emery, 1997, pp. 130-131).

To some extent, Heider was preempted by 19th century mathematician Bernhard Riemann's demonstration in 1866 that "systems" are best understood by first asking questions about their purpose, which can only be determined by making observations in the system's environment. Consequently, in his study of the "The Mechanism of the Ear" he advocated first asking questions about the purpose of the ear, gleaned from contextual information, and was critical of the immediate adoption of Helmholtz's anatomical approach (Ritchey, 1996).

Gibson's (1979) ecological explanation of perception built on Heider's result (Emery and Emery, 1997) and set itself in contrast with the "inferential" theory of perception which asserts that "the visual system infers the perceptual world on the basis of both sensory information and assumptions, biases, and knowledge inherent to the perceiver" (Proffitt, 1999, pp. 448-449). For Gibson "no inferences are required to account for perception because the purpose of perception is not to achieve a mental representation of distal objects" but to "control purposive actions…perceptions can be based entirely on optical information if, and only if, the observer is allowed to move and explore the environment" (Proffitt, 1999, p. 449).

The relationship between open and closed systems can be further understood by appealing to Peirce's logic of categories (Chapter3). If we describe a closed system as "firstness" then the reaction to this closed system ("secondness") corresponds to the understanding we gain from this closed systems. This is achieved by placing the closed system within a knowledge context (as in Maturana's autopoiedic system)- the open system ("thirdness") (See Figure 4.3). This description is also consistent with the argument presented by (Cook and Ferris, 2007) in their interpretation of systems engineering.

Significantly, and returning to the theme that analytic processes attempt to explain how something works, while synthesis attempts to establish understanding of purpose, Proffitt reconciles the two approaches to perception by pointing out that the inferential approach addresses the question of how optical information is transferred into representations of the world, while the ecological approach addresses the question of understanding what we perceive. (Proffitt, 1999, p. 471).

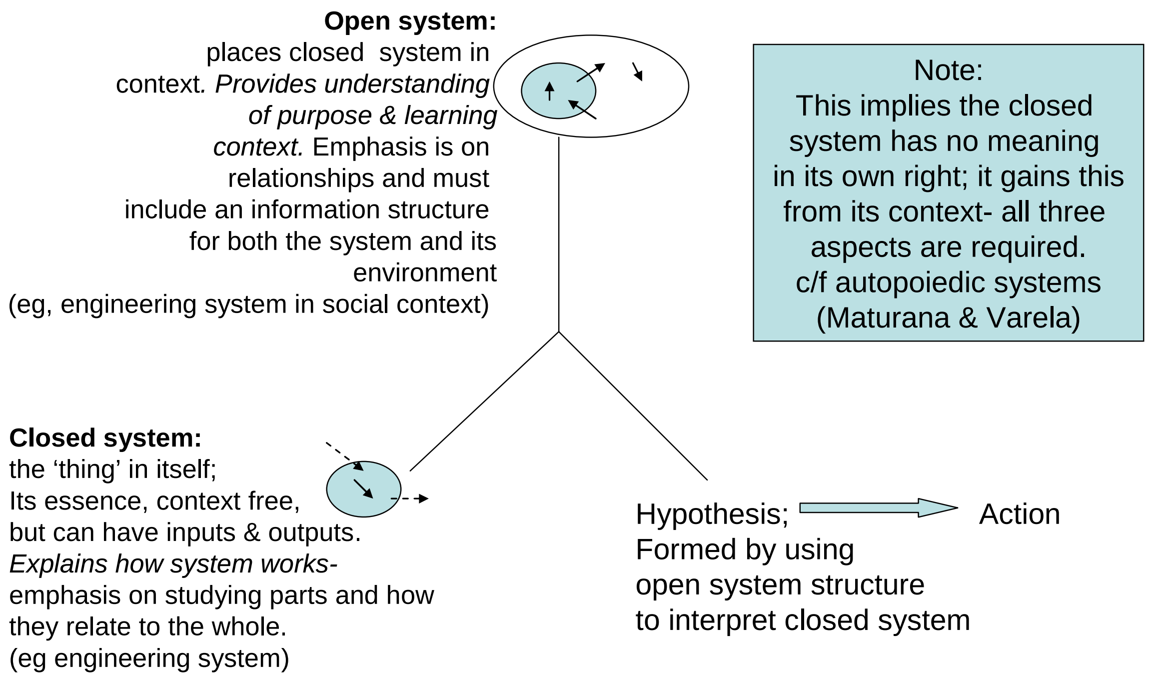

Figure 4.3. The Relationship Between Open and Closed Systems

The strands of socio-ecological systems- the idea of environments having "causal textures" (Emery and Trist, 1965; Emery and Trist, 1973; Trist, Emery, and Murray, 1997) and associated information fields (Johnson, 1996), the nature of purposeful systems (Ackoff and Emery, 1972), and their synthesis within the frame of Pepper's contextualist world view and more explicitly Peirce's pragmatist architectonic (Hausman, 1993; Parker, 1998) constitute a major advance in contemporary systems thinking. Key elements are summarised in Emery and Emery (1997) and Emery (1999; 2000).

Finally, the socio ecological frame and its associated co-evolutionary epistemology of ecological learning can be identified with the fundamentals of action research. Indeed, of the three basic systems frames identified previously, the socio-ecological frame and its cognitive origins, is the only one that is entirely consistent with action research (Kolb. 1984, p. 119). It uses context to establish purpose and hence social worth, it recognizes purposeful behaviour and hence the importance of participation in processes, and it applies abductive thought as a basis for hypothesis formation upon which action is taken or is at least proposed.

Nevertheless, in the spirit of Checkland's SSM roadmap (Checkland, 1981; Tsouvalis and Checkland, 1996), it is recognized that the closed system and the input-output frames provide ways of developing hypotheses that have been used within the socio-ecological/ action research constructs. Indeed, these constructs only have meaning once they are embedded in such learning processes.

Defining Systems and Systems Thinking.

It is now a relatively straightforward matter to define what is meant by a "system" and what "systems thinking" means.

A system is a cognitive construct for making sense of "surprising facts". Although attacking systems thinking as perceived at that time, Lilienfeld's 1978 definition, cited earlier does provide us with a more complete definition (Lilienfeld, 1978, p. 9).

Systems thinking occurs when we use this cognitive construct to frame the scientific process which can be defined as a dialectic between analysis and synthesis. In this sense the importance of the systems approach is summarized by Johanssen and Olaisen:

> Understanding, explanation and predication (wherever possible) will, as far as systemic thinking is concerned, always be oriented towards deeper contexts and therefore, the construction of new patterns. It is the pattern which combines systemic thinkers dealing with scientific problems/phenomena (Bateson, 1972). It is the construction and synthesis that constitute the search

> object. The analysis is purely a tool in order to reach it. If the analysis is given precedence, the construction and synthesis will lag behind. Science is for systemic thinking a moral project (Bunge, 1989). If science is not constructed as a moral project, it will not only lose its legitimacy but also its direction, which is the search for truth, and can thus be a means to achieve unethical goals.

(Johanssen and Olaisen, 2005 a, pp. 1261-1262).

Conclusion.

In addressing Checkland's (1981) statement, it has been established that scientific method can be interpreted as dialectic between analysis and synthesis and that systems approaches are not just concerned with synthesis but are characterized by the manner in which various system constructs frame this debate. In this respect, systems thinking plays a central, and ethical role in the application of the scientific method.

Noting Odum's (1977) call for the acceptance of a "new ecology" that emphasizes both holism and reductionism as an essential way forward in addressing the difficult global situation we now find ourselves in, there is a special need for systems thinkers to fully incorporate the importance of purposeful behaviour and turn their attention to the importance of the open systems/ socio-ecological model in systems science.

Part 2. Applications to Knowledge Management.

Knowledge has become the key economic resource and the dominant- and perhaps even the only- source of competitive advantage.

Peter Drucker, *Managing in a Time of Great Change*, 1995.

Chapter 5. Knowledge Management.

5.1 Introduction: Knowledge Management and the Emergence of "New Economy" Businesses.

Stewart (2001, p. ix) identifies Knowledge Management (KM) as one of "three big ideas that have fundamentally changed how organizations run". (Stewart nominates Total Quality Management and Re-engineering as the other two- perhaps a somewhat contentious selection, depending on how you interpret these terms).

But Boisot (2002 b, p. 65) quite correctly reminds us that: "(M)ost of the challenges posed by the effective management of knowledge resources are not particularly new. They have, in effect, been with us since the scientific revolution of the seventeenth century".

The current interest in knowledge management has roots that spread back to at least the 1930s. Gehani (2002) stresses the importance of the contribution of Chester I. Barnard (1886-1961) to knowledge management and Nonaka and Takeuchi (1995, pp. 36-37) note Barnard's attempt to synthesize scientific management theories with human factors, and to emphasise the importance of "behavioral knowledge". Similarly, Levitt, March & Chester (1990, p. 11) discuss Barnard's anticipation of "contemporary treatments of organizations in information economics and agency theory".

In the 1960s Forrester (1961) argued that we rely too heavily on the use of numeric data, and tend to ignore the much greater quantities of data that exist in written form and as data in peoples' heads (mental data). He proposed the use of the "industrial dynamics" approach for mapping and capturing data, and, because of human cognitive limitations in dealing with feedback and delays, the use of simulation modelling as a learning framework.

Drucker (1969) discussed the concept of the knowledge society and implications for management while Nonaka and Takeuchi (1995) argued that the success of Japanese companies over their US competitors during the 1970s and 80s was due to their superior knowledge creation capabilities. On the basis of a Shell Corporation study of the survival of firms, De Geuss (1988, p. 74) declared: "We understand that the only competitive advantage the company of the future will have is its managers' ability to learn faster than their competitors".

More recently, Arthur (1994; 1996) and Teece (2000), identified the relationship between knowledge management and strategies based on innovation as the basis for capturing the benefits of increasing returns, often, but not always through first mover strategies as demonstrated by recent corporate successes. Kaplan and Norton's (1996) "Balanced Scorecard" (BSC) approach to performance measurement and strategy implementation emphasizes the importance of intangibles associated with "Learning and Growth".

Boisot offers three reasons for the most recent heightened interest in knowledge management:

- The cheap availability of data in both "richness and reach" (Evans and Wurster, 2000) resulting from the information technology revolution has allowed organisations to focus on "knowledge resources" which "often reside deep in people's heads" and which in general terms has not been observable or measurable.
- The "rapid evolution of information and communication technologies has led to the 'dematerialization' of economic activity- the substitution of data and information for physical resources".
- The realisation that knowledge cannot be managed in the same way as a physical resource and that this is reflected by a "certain schizophrenia" by economists- some treating it as a normal tradeable factor of production, while others treat it as something like a public good.

Boisot (2002 b, p. 66).

A fourth reason can be added to Boisot's list- recognition that a dramatic shift has taken place in the relative importance of "tangible" versus "intangible" assets as drivers of business value (Burgman, Roos, Ballow, & Thomas, 2005).

Burgman et al (2005, p.,589) observe that during the late 1990s, "new economy" companies like Microsoft, Cisco Systems, and Lucent Technologies were emerging that were "knowledge based" as distinct from the traditional manufacturing type companies that were "natural resource-based". Furthermore, these companies were "asset-lite" in the sense that their balance sheets recorded a relatively small asset base for the market value of the business, and substantial proportions of this market value were based on "expectations" for future earnings. Burgman et al report that in 1999, the 22 companies categorised as "new economy" companies in the S&P (Standard & Poor's) 500 had a combined MVA (Market Value Added = enterprise value less capital employed) of $2,275.6 billion, accounting for some 31.8% of the Top 100 companies and 24.2 % of the Russell 3000 companies (p., 590). (Microsoft was the most successful shareholder value creating company, with a MVA of $629.5 billion).

Data cited by Daum (2003) supports these observations: in 1982, 38% of the total market value of firms in the S&P 500 was determined by intangible assets. By 1999, this percentage had increased to 84%. Ballow, Burgman, Roos and Molnar (2004) estimate that during the 2000 peak of the US share market, 85% of market value of the S&P 500 was "unexplained", and that this came back to 25% in the "post crash" year, 2002.

The role of information technology and the increasing importance of intangibles have led to the recognition of "new economy" forms of business organisation. Stabel and Fjeldstad (1998) identify three generic value creation business organisations:

- The value chain: representing the traditional form of "supply chain" business.
- The value shop: where problems are solved or opportunities exploited (for example, consultancies; assessment and placement agencies).
- Value network: where the firm provides a network within which buyers and sellers can trade (for example, Amazon; eBay).

Value shops and value networks constitute the core of new economy companies. A key differentiator is that while value chains largely operate under *diminishing* returns to “tangible” inputs such as land (or environment), labour and capital, value shops and value chains, enjoy *increasing* returns from “intangible” factors such as reputation, brand, and customer lists. This implies that there is a fundamental difference in the economic models underpinning these businesses with profound implications for the structure of accounting systems; for example, does it make sense to amortize brand value?

Harris and Burgman (2005) show that 50% of S&P 500 companies could be considered to be value chains, while value shops and value networks each represent 13.6 %; and the remaining 16.8% have more than one dominant form of value creation. However, it must be observed that some traditional value chain business like retailing have shifted more towards value network businesses, with a heavy dependence on stakeholder networks along their supply chains to achieve competitive advantage. Tapscott, Ticoll and Lowy (2000 p. 17) describe the “B-Web” as the new platform for the 21st Century that supports these networked organisations. Pioneered by companies such as Schwab, eBay, MP3, and Linux, Tapscott et al describe B-Webs as: “partner networks of producers, service providers, suppliers, infrastructure companies, and customer linked via digital channels- are destroying the firm as we know it and generating wealth in entirely different ways”. For traditional supply chain businesses such as the automotive industry, these changes are expressed as the transformation of “supply chains” to “value constellations” (p. 17).

Consequently, Harris and Burgman’s estimates possibly understate the proportion of “new economy” businesses.

Normann (2001) identifies another characteristic of new economy companies: the emergence of a new business paradigm where the business is “an organizer of value creation”:

> Out of these (technological) opportunities emerges a new archetype of the organization: The business company as an organizer of value creation. The crucial competence of business companies today is exactly this: the

> competence to organize value creation. This does not mean that production competence or relational competence are unimportant, but that such competences are now increasingly being 'framed' by the overriding competence of organizing value creation far beyond their formal boundaries.

(Normann, 2001, p. 24).

While there is strong evidence of the growth in importance of new economy businesses and an increasing recognition of the importance of intangibles and knowledge management, questions remain as to how well traditional industrial era businesses are making the transition to knowledge companies.

Ruggles (1998) examined the results of a study of 431 U.S. and European organisations conducted by Ernst and Young in 1997 describing "what firms are *doing* to manage knowledge, what else they think or think they could be doing, and what they feel are the greatest barriers they face in their efforts" (Ruggles, 1998, p. 80). Adopting a process-based view of the firm, Ruggles identified eight major categories of "knowledge-focused activities":

- Generating new knowledge.
- Accessing valuable knowledge from outside sources.
- Using accessible knowledge in decision making.
- Embedding knowledge in processes, products and services.
- Representing knowledge in documents, databases and software.
- Facilitating knowledge growth through culture and incentives.
- Transferring existing knowledge into other parts of the organization.
- Measuring the value of knowledge assets and/or impact of knowledge management.

(Ruggles, 1998, p. 81).

Ruggles concludes:

> The executives who responded to our study did not hold high opinions of their organizations' performance in any of these areas… For example, only 13% thought they were adept at transferring knowledge held in one part of the organization to other parts….However, 94% of the executives agreed that it would be "possible, through more deliberate management, to leverage the knowledge existing in my organization to a higher degree".

(Ruggles, 1998, p. 81).

Unfortunately, not much seems to have changed over the past decade. Despite the increasing availability of the new technologies, the spectacular success of the hyper growth networked businesses like eBay and Cisco, and the transformation of some traditional supply chain businesses such as Wal-Mart, attempts by most traditional businesses to transform to new economy businesses by implementing improved knowledge management have not been successful. Spender (2006) provides a sober assessment:

> The knowledge management (KM) and intellectual capital (IC) fields are clearly of many parts, and are frequently marked, as the wags have it, by much heat but little light. We still find little empirical support for their promoters' enthusiasms. Yet we see information technologists confidently explaining how the Internet changes everything, and human resource specialists telling us that managing knowledge work and intellectual capital is our future. Economists talk of knowledge-based competitive advantage whilst jostling with sense-making cognitive philosophers. In the background bicycle riders plead they cannot explain what they are doing. All the while CEOs pronounce knowledge their company's crucial asset while failing to measure IC or explain how success or failure might arise from such stardust. Nonetheless KM projects are now widespread throughout the public and private sectors, much trumpeted across a broad range of endeavours. So broad, in fact, it is difficult to tell whether there is much agreement about the objectives, methods and measures that properly belong within the scope of KM. Against this academic whining many managers will argue it does not matter what we call these projects so long as they happen. Their objective is better use of the organization's

knowledge and IC, and that while philosophers might puzzle about what this is - precisely – participating managers have little difficulty differentiating useful knowledge from the useless. The organization's knowledge needs to be revealed, gathered up, organized, capitalized and made fully available. Wasteful re-discovery of what we already know is eliminated. Others in the organization can then use the common pool of knowledge or the sum of the employees' intellectual capital to achieve the overall objectives more economically.

This seems straightforward, yet KM projects have an alarmingly high failure rate. Many organizational projects fail, of course, but KM failures often resonate more widely than most. First, they have novelty appeal KM is the new buzz and its projects are often sold as more strategically significant than yet another product-market revision. They generally portend new business models in the business process re-engineering (BPR) sense. Second, KM projects are often seriously expensive, both in direct costs for their software and hardware and in changes in the way organizations function. People get invested in the projects, and against them, power patterns change, there are winners and losers. Third, KM projects often open up new market images. A retail bank switching to customer relationship management (CRM) is going to change its appearance quite radically as far as its customers are concerned. For all of these reasons KM failures can be very damaging. We know all this, yet there seems little understanding of why KM projects fail or evidence of learning from such failure.

(Spender, 2006, pp. 12-13).

While Spender (2006) provides a quite dismal picture, significant improvements in some aspects of the development of knowledge management tools, such as in the identification, codification and reporting rules of intellectual capital, are occurring (Burgman and Roos, 2007). Perhaps wider adoption of knowledge management principles will only occur when the results of this type of research are implemented and matters such as the definition of concepts and terms are resolved, reporting systems for intellectual capital become standardised and widely implemented, and when knowledge management tools can be more easily codified and understood within a systemic framework.

In this Chapter, four challenges will be defined and solutions proposed that demonstrate the application of the systems thinking frameworks and associated pragmatist philosophical strands discussed in Chapters 1 to 4. A fifth challenge, relating the knowledge creation process to action research, will be discussed in Chapters 6 and 7.

The challenges are:

1. Clarify terminology: distinguishing between knowledge, information and data.
2. Develop tools for the identification of knowledge using knowledge maps.
3. Demonstrate how intangibles can be measured and modelled.
4. Develop systematic *and* systemic knowledge management implementation frameworks.

5.2. Definitions and Knowledge Maps: Measuring and Modelling Intangibles.

In starting to address the issue of distinguishing the terms, data, information, and knowledge, Tuomi (1999, p. 1) cites Sveiby's (1997) observation that:

> Some of the present confusion concerning how to do business in the knowledge era would probably be eliminated if we had a better understanding of the ways in which information and knowledge are both similar and different. The widespread but largely unconscious assumption that information is equal to knowledge and that the relationship between a computer and information is equivalent to the relationship between a human brain and human knowledge can lead to dangerous and costly mistakes.

(Sveiby, 1997, p. 24).

Leaving aside the cognitive issues for the moment, it is observed that in colloquial terms, “data” and “information” often mean the same thing. Similarly, “information” and “knowledge” are used interchangeably. Clearly, this situation causes ambiguity in knowledge management at even the most basic level.

Attempting to clarify the meaning of these terms by appealing to their use in science raises many difficulties when one realises that these terms have evolved from fields of thought that are distinct in application but where fundamental links only become explicit when the depths of theory are plumbed:

- Data- from statistical analysis.
- Information- from communication theory.
- Knowledge (and wisdom) - from philosophy and the philosophy of science.

***Data*:** usually defined as known facts, or quantities amenable to calculation.

The statistician distinguishes between different forms of data: qualitative/quantitative data; ordinal/ cardinal; numerical/ categorical; discrete/ continuous. The concern for the statistician is to align appropriate mathematical functions with data types so that appropriate statistical measures can be derived. For the social scientist qualitative and quantitative data from a wide variety of sources including both longitudinal and cross-section surveys of social phenomena are used. Triangulation of data becomes an essential skill.

The quantitative scientist data comes from experimentation and observation where moderating variables can be controlled.

Whatever the source, type, or potential use, by itself, data has no utility; it “remains one of our most abundant yet underutilized resources” (Davenport, Harris, DeLong, and Jacobsen, 2001).

***Information*:** The technical meaning of information comes from information theory with origins in statistical thermodynamics. Consequently, it is not surprising that

Shannon's definition of information is expressed in terms of a measure of entropy (uncertainty) in a message. It is not concerned with the *content* or *meaning* of the message (Shannon, 1948; Weaver and Shannon, 1949).

***Knowledge*:** is "justified true belief" (Plato). This begs the question: What is "true belief", and how is it "justified"? Attempting to answer this question constitutes the theory of knowledge (epistemology) and many philosophers believe that this is the core issue of philosophy: "for if philosophy is the quest for truth and wisdom, then we need to know how we are to obtain the truth and justify our beliefs" (Pojman, 1999, p. 1).

The history of science reveals that, despite the spectacular breakthroughs in creating new knowledge frames (paradigms) by individuals such as Newton and Darwin, the creation of "knowledge" is an intensely social activity that crosses cultures and spans time. Collins (1998), in discussing the role of philosophy in early developments in Western knowledge, describes the process:

> …philosophical networks represent the central attention space of the community of intellectuals, where arguments of widest consequence are carried out. Philosophy drives up the level of abstraction and reflexivity, promotes periodic movements of synthesis, consciously argues over methods, and thereby lays down epistemological principles. Transferred to topics of naturalistic observation and mathematics, the philosophical networks turn empirical compilations into theories, lay methods of commercial arithmetic or practical geometry into puzzle-solving contests carried out under increasingly stringent rules. The philosophical networks import not only consciousness of abstraction but also a social impetus to innovation. This appears to have happened in early period of ancient Greece, for a time in the Islamic networks, and again in Europe after 1500.

(Collins, 1998, p. 551).

Wisdom: at the social level, wisdom is knowledge that has become imbedded in culture and is able to perceive and evaluate the long-run consequences of behaviour (eg, Sun Tzu. *The Art of War,* is considered to be a book of wisdom). For the individual, wisdom has more to do with being able to see a situation from multiple perspectives and to be able to resolve the resulting dilemmas. Goldberg (2005) presents neuro-physiological evidence that we gain wisdom as we grow older because of a cognitive shift towards the increased use of multiple frameworks as an aid to memory, compensating for a decline in short term memory with ageing.

The most popular translation of these technical definitions into an integrated form is known as the "Data, Information, Knowledge, Wisdom (DIKW) Hierarchy"; also known as the "Knowledge Hierarchy", or the "Knowledge Pyramid" (Sharma, 2005). Sharma notes that Ackoff (1989b) is often cited as the initiator of the DIKW hierarchy but traces the concept to the poet, T.S. Eliot and his poem "The Rock":

> *Where is Life we have lost in living?*
> *Where is the wisdom we have lost in knowledge?*
> *Where is the knowledge we have lost in information?*

In discussing the knowledge hierarchy where "data is a prerequisite for information and information is a prerequisite for knowledge", (Tuomi, 1999, p. 1) describes data as "simple facts that become information as data is combined into meaningful structures, which subsequently become knowledge as meaningful information is put into context and when it can be used to make predictions". Tuomi argues that such a framework is fundamental to the design of information systems and that different systems result when this hierarchy is reversed. Such is the strength of episodic thinking that viewing the relationship between data, information and knowledge in feedback terms is apparently ignored.

In fact, Tuomi identifies a number of alternate conceptions:

- Data understood as symbols which have not yet been interpreted; information data with meaning, and knowledge is what enables people to assign meaning and thereby generate information

- Data are simple observations of states of the world, information is data endowed with relevance and purpose, and knowledge is valuable information.
- Information is meaningless, but becomes meaningful knowledge when it is interpreted.
- Information consists of facts and data that are organized to describe a particular situation or condition whereas knowledge consists of truths and beliefs, perspectives and concepts, judgments and expectations, methodologies and know-how .
- Information is a flow of meaningful messages to start with, but becomes knowledge when commitment and belief is created as a result of these messages.

(Tuomi, 1999, p. 2).

And, observes that:

> Underlying all these models of knowledge as a "higher form of information" is the idea that knowledge has to be extracted from its raw materials, and in the process, meaning has to be added to them. Although, for example Nonaka and Takeuchi, Wiig, and Sveiby point out that knowledge is about action, most of the time knowledge is conceptualized as meaningful, accurate, and usable representation of facts in context. The underlying conception also assumes sequentiality; a process model where something simple is converted into something more complex and valuable.

(Tuomi, 1999, p. 2).

Note that the first of Tuomi's conceptions is not consistent with his observation that *all* these models view knowledge as a higher form of information. It will be shown below that this conception is based on Peirce's triadic categories, and not the hierarchical view of knowledge. But first, let us consider the hierarchical view in more detail.

Earl's (1997) discussion of the hierarchical approach to defining data, information and knowledge starts by identifying three levels of knowledge:

> ….science (which can include accepted law, theory and procedure); judgment (which can include policy rules, probabilistic parameters and heuristics); and experience (which is no more than transactional, historical and observational data to be subjected to scientific analysis or judgmental preference and also to be a base for building new science and judgments).

(Earl, 1997, pp. 5-6).

On this basis, Earl postulates two models: the first is a hierarchy where each of the levels of science listed above represents an "increasing amount of structure, certainty and validation" and defines three "knowledge states": accepted, workable, and potential. The second model "attempts to differentiate between data, information and knowledge, in which events generate data, which are manipulated, presented, and interpreted to form information, which then can be tested, validated, and codified to form knowledge" (Figure 5.1).

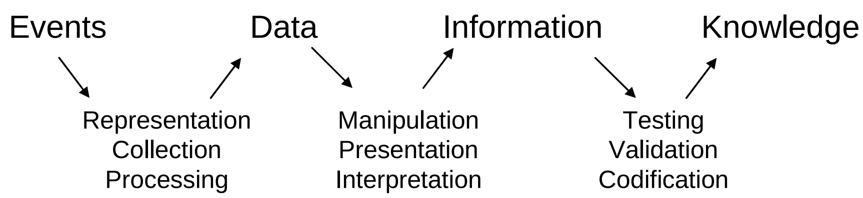

Figure 5.1. An Episodic View of the Knowledge Hierarchy (Earl, 1997, p.7).

Clearly, the episodic/hierarchical view of the knowledge process does not directly address questions such as:

- What data should be collected?
- What framework is used to interpret data?

That is, this representation does not adequately address the importance of perceptions and the way perceptions influence information and knowledge formation. For example, if knowledge leads to action then new data will be created which influences information etc. But what new data is observed and recognised? While the model can be improved by introducing feedback structures such as those shown in Figure 5.2, the additional relationships introduced raise further questions about the role of sense making (Weick, 1995, 2001) and its juxtaposition with "rational" processes.

The differences between the episodic view of knowledge creation and the feedback view relates to the objectivist and constructivist views of knowledge mentioned before. The episodic view derives from seeing knowledge as a tangible object about which truths can be arrived by simple observation. The feedback view acknowledges that knowledge is constructed by our experience and is essentially self-referential.

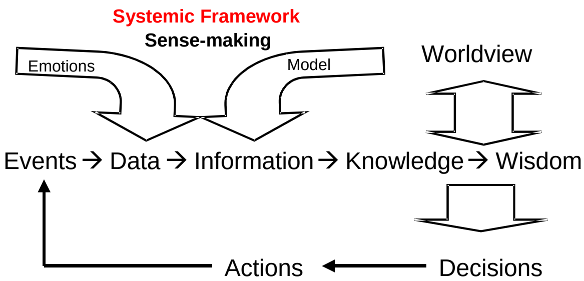

Figure 5.2. The Knowledge Creation Process- the Feedback View

Snowden (2002) rejects the episodic, hierarchical approach to knowledge and proposes a very flexible framework that admits of chaotic behaviour. He identifies three ages in recent developments of knowledge management describing his "Cynefin" model as the third age:

- Information for decision support.
- The popularisation with Nonaka's knowledge management model (Nonaka, 1994) with its emphasis on tacit-explicit knowledge conversion.
- The development of the "Cynefin" model; Snowden's creation of four domains of knowledge- social networks; communities of practice; temporary

communities with disruptive space; and coherent, bureaucratic structures- each have validity within different contexts.

It will now be shown that framing the definitions of data, information, and knowledge, using Peirce's triadic system of categories addresses the issues raised above, even to the extent of making links with Snowden's "Cynefin" model.

A Pragmatist Response.

Peirce's categories (Chapter 3) facilitate the development of rigorous definitions for data, information, and knowledge that are consistent with the technical backgrounds of the terms. Data is identified with firstness, information with secondness, and knowledge relates to thirdness, the interpretant that allows us to make sense of data and construct information. This results in a "semiotic tripod" (Figure 5.3) (Merrell, 1997). [21]

Using the dialectic process described in Chapter 4, knowledge is codified, and systemically arranged in terms of a metaphor at each level or category in the dialectic process. It is what is accepted by the community of inquiry as the "hypothesis to the best explanation" and provides the basis for shaping action. Because information informs action (the pragmatic maxim) the diagram may be extended to show action and the generation of new data- Figure 5.4.

Action gives rise to further data which may result in the creation of a new explanatory hypothesis and hence new information. The repetition of this process, which correlates with the dialectic, produces an "information field" (Figure 5.5), and an "epistemology of communication" (Jenson, 1995). These concepts are further developed by Liu et. al. (2002) for the design of information systems under the title of "organizational semiotics".

Significantly, because we are only explicitly using two of the "strands" of Peirce's system (categories and pragmatic maxim), other strands are implied. Consequently,

[21] Boisot (2002, p. 8) arrives at a similar definition: "Information is what a knowing individual is able to extract from data, given the state of his/her knowledge".

we can hypothesise that Peirce's worldview defined by synechism and tychism is consistent with Snowden's chaotic model of knowledge development. This connection is illustrated by Merrel's cusp catastrophe model of knowledge model which incorporates dynamics resulting from the interactive use of abductive inference, community learning, and systemic framing of knowledge- Figure 5.6 (Merrell, 1992, pp. 212-224).

There are two important applications that derive from using Peirce's semiotic framework for defining the relationship between data, information and knowledge. These applications are to logics for mapping knowledge and for measuring intangibles (our next two knowledge management challenges).

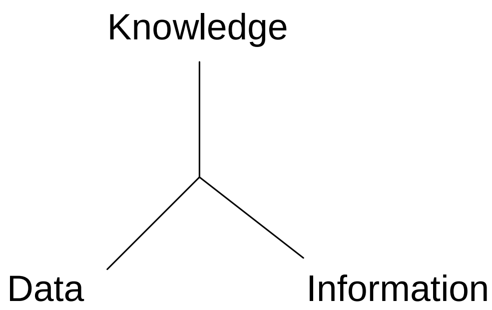

Figure 5.3. The Semiotic Tripod. (Based on Merrell, 1997)

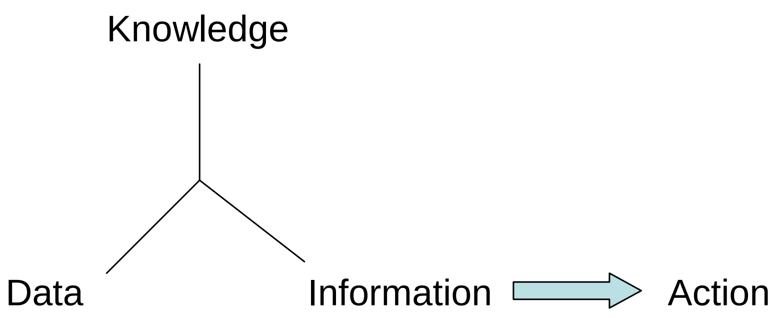

Figure 5.4. Defining Data, Information, and Knowledge Using Peirce's Categories

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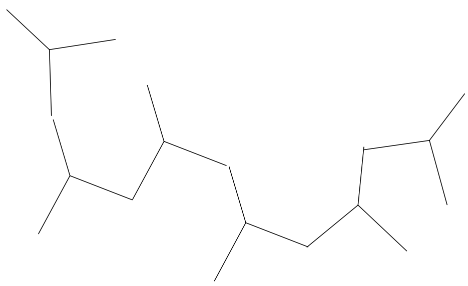

Figure 5.5. A Semiotic Information Field.

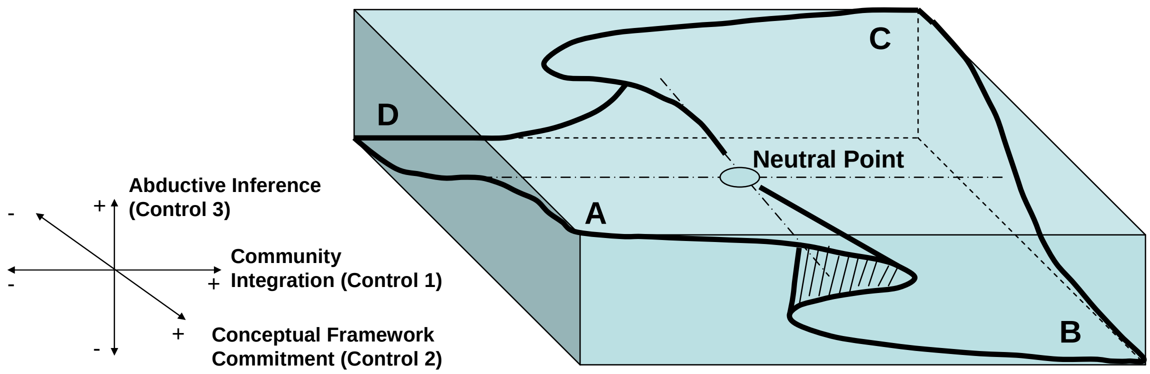

Figure 5.6. Merrell's Catastrophe Model of Knowledge Creation Model Based on Three Control Factors: Abduction; Community; Conceptual Framework (Merrell, 1992, p. 216).

Knowledge Maps.

Evans and Wurster (2000) recently declared that technological advances have overcome the need to make the traditional trade-off between "richness "and "reach" of data; we can have both in a cost effective manner. But how do we decide what information is going to be important to our decision-making? In other words, how do we prioritise our information needs to avoid being swamped with data?

Anecdotally, the problem arises when organizations undertake knowledge audits and use survey instruments that include questions about knowledge sharing and the like.

How is a respondent to answer this question in other than the most general way? Such responses are not particularly helpful. Knowledge maps have been suggested as at least a part-solution.

Surveying the field of knowledge maps, Wexler (2001) observes:

> …analysts from various fields are pointing to knowledge maps or K-maps… as one feasible method of coordinating, simplifying, highlighting and navigating through complex silos of information….. knowledge maps are being experimented within education, business, and healthcare….In these fields managers/administrators are compelled to grasp their competitive advantage rests in the ability to mobilize, diffuse and evaluate intellectual capital. This is not surprising. The model of accomplishment in making sense of complex, vital information in society today is the human genome project, In this high profile use, mapping is held out not only as a way of making sense and organizing known spatial relations but also of exploring new territory.

(Wexler, 2001, p. 249).

Clark & Mirabile (2004) also recognise the importance of these issues and pose a fundamental question facing knowledge managers:

> Is it possible to efficiently organize and categorize knowledge that is available to us in order to facilitate decision making regarding its use? Asked another way: Can we develop methods to help people determine both if a particular piece of knowledge is useful to them and, if so, where in their respective organizational systems it would have the most application and impact?

(Clark and Mirabile, 2004, p. 115).

They suggest that it is possible to develop such a method and propose a three-part approach:

- "…devise a framework of categories into which knowledge streams could be logically placed"
- Determine "some method of determining how to "map" the knowledge, that is, how to determine in which category the knowledge logically belongs",
- "…to create a system of metrics to determine impact or relevance to the organization and to seek revisions and upgrades on some periodic basis".

(Clark and Mirabile, 2004, p. 116).

The following approach adopts Clark and Mirabile's three-parts as criteria for a mapping process. The first two parts are provided by the mapping conventions used in the field of System Dynamics- an even more complete system of mapping is provided by Forrester's (1961) original "Industrial Dynamics"- combined with the logic of Peirce's triadic categories; the third criteria is achieved using Peirce's semiotics framework and will be discussed in the next section.

As indicated previously, the major obstacle to developing knowledge maps is the confusion in the use of the terms data, information, and knowledge. Forrester's (1961) method of describing management decision making, described in Figure 5.7, overcomes this confusion and this diagram corresponds with the method of defining data, information and knowledge using Peirce's triadic semiotics: data corresponds to firstness, information to secondness, and the knowledge that underpins the decision, corresponds to thirdness, the interpretant.

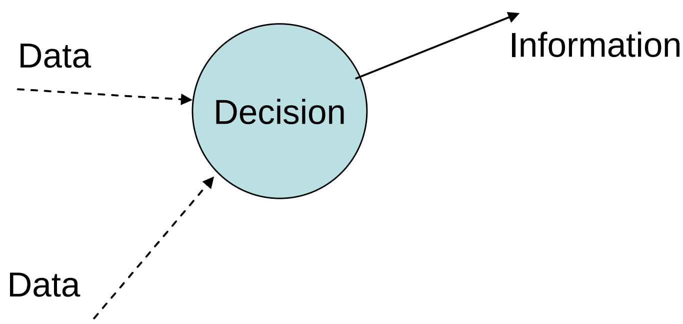

Figure 5.7. Describing Decisions in System Dynamics Mapping.

By mapping a system using the stock-flow structure defined in System Dynamics (Sterman, 2000), it is possible to identify key data and information flows and decision points. Consequently, it is possible to focus on individual decision points and ask the question whether this decision is based on either explicit or tacit knowledge, or a combination of both (Polanyi, 1958). Explicit knowledge can be modelled either as a mathematical formula, or, if it relates to a behavioural response, in terms of a graphical relationship between variables, using the convexity properties of the function to describe behavioural responses. If the decision is based on intuition, or tacit knowledge, processes can be put in place to identify the basis of the decision–making.

In general, data will flow from "stock variables" and information will drive rates of change, that is, affect action. Hence a knowledge map based on the format shown in Figure 5.8 can be constructed and used as basis for undertaking knowledge audits of systems. In this diagram, data on the value of fixed assets is combined with data on employee experience using a non-linear function that shows an increasing returns effect to experience to provide information that drives the rates of increase and decrease of long-term customers.

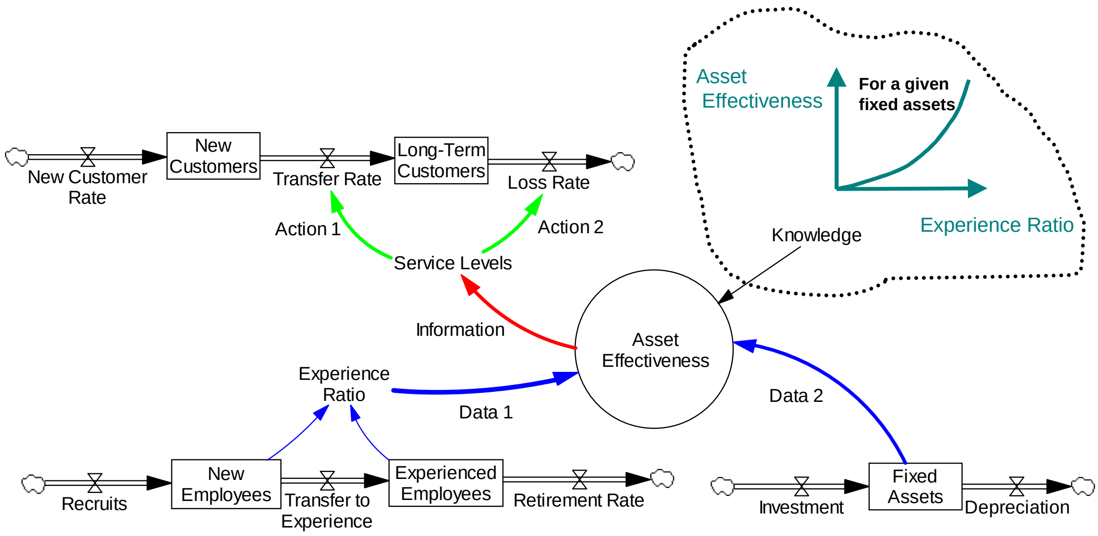

Figure 5.8. A Knowledge Map Using System Dynamics Notation and Peirce's Semiotics.

A map such as this allows the system of interest to be defined by a "community of inquiry" and provides a common language concerning, for example a supply chain, or a business network, and allows stakeholders to discuss issues such as sharing data, information, and knowledge in a more focussed and defined manner.

While this mapping system sits comfortably with value chains, an outstanding question remains to explore the extent to which it can be applied to value shops and value nets. Intuition and experience suggests that this is feasible, for example, in the case of value nets by modelling each of the component companies in stock-flow terms and then linking their operations through information flows, and in the case of value shops, modelling the dynamics of variables such as "reputation" (to be discussed in the next section). Such extensions seem reasonable but suffer the same problem as Porter in his quest to apply his competitive model framework to new economy issues (Porter, 2001; Porter and Kramer, 2006): the basic metaphor of a supply-chain/ stock-flow, feedback structure is strongly rooted in the industrial age. In contrast, Roos, Pike, and Fernstrom (2005) propose a framework where the transformations of key resources are mapped using a "bubble diagram" in which resources are represented by circles with diameters proportional to the size of the resource. They see the key processes of new economy businesses as transforming resources from one state to another, albeit with quite complex systems of interactions. Roos et al's evidence is that different types of value creating businesses have different transformation patterns. For example, service networks will have smaller "bubbles" corresponding to natural resources.

Measuring and Modelling Intangibles.

Reference has previously been made to the importance of intangibles as drivers of market value and the need to develop appropriate metrics to complement knowledge maps . Zadrozny (2006, p. 85) observes that "(D)espite its potential, few managers have begun to even scratch the surface of information about intangibles and the opportunity it offers". (Zadrozny defines intangibles as any non-physical asset that can produce economic benefits. "They cover broad concepts such as intellectual capital, knowledge assets, human capital and organizational capital as well as more specific attributes like quality of corporate governance and customer loyalty" (p., 89).)

One of the first attempts to report on intangibles was the Swedish insurance and finance company Skandia. In 1991, the company appointed a director of intellectual capital in one of its global operating units, Skandia AFS. (Edvinsson, 1998, 2002).

The reporting framework developed at Skandia is shown in Figure 5.9.
In a sense, this structure was seminal because it provided accounting definitions to a variety of terms such as Intellectual Capital, Human Capital, Intellectual Property etc. Note that, following the usual accounting convention, Intangible Assets are shown as a residual.

Nevertheless, in general terms there is still no accepted set of definitions for such classifications: Kauffman and Schneider (2004, p. 385) conclude that the literature on intangibles shows that "few examples of empirical work exists, and the literature also generally lacks a theoretical framework that could be used and tested" and that "the field lacks a standard definition for intangibles or IC".

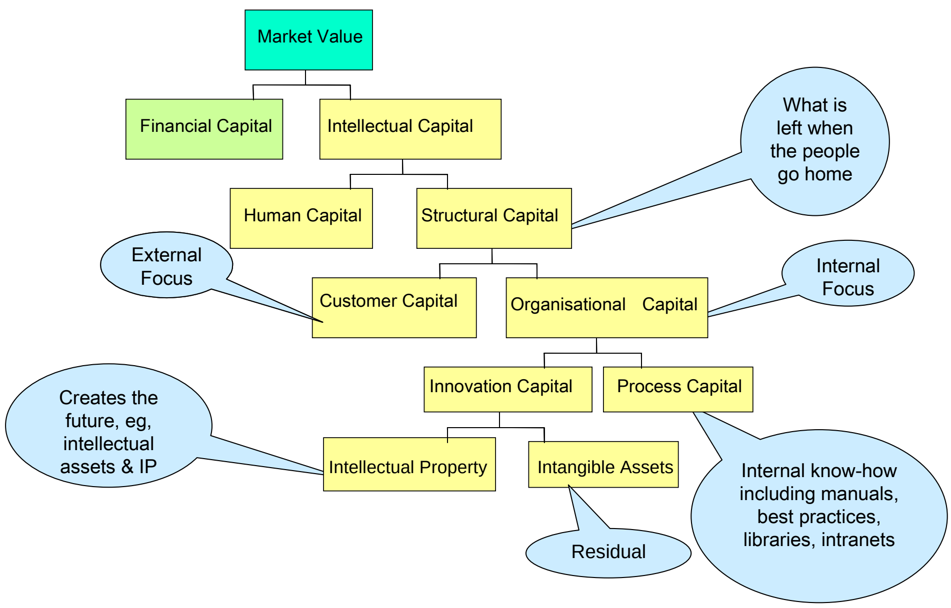

Figure 5.9. The Skandia Value Reporting Scheme (Edvinsson, 1998, p. 281).

Part of the difficulty is the confusion that exists because the literature does not adequately distinguish between *financial* and *management* accounting interests in reporting intangibles. Financial accountants are constrained to report on the historical performance of businesses for various legal and taxation reasons so as to minimise the opportunity for fraud and deception. Consequently, there is little solid basis upon which to report on intangibles, except as a balance item, or where a market value has been possible because of the sale of an intangible such as a brand, or the purchase of "goodwill" when one firm buys another.

Barton (1984, p. 105) distinguishes between tangibles and intangibles from a financial accounting perspective:

- Tangible assets-
  - Physical long-term assets such as buildings, plant & equipment
  - Legal rights such as leases and securities
- Intangible assets-
  - Purchased goodwill of another firm taken over
  - Preliminary expenses incurred in the formation of the company or on a new share issue
  - Debenture discounts where debentures are sold below their par value
  - Patents and trade marks
  - Capitalized expenditure on R&D

Barton explains that it is necessary to classify these intangibles separately because of the "arbitrary methods used for the valuation of intangibles; while price paid for goodwill, or R&D expenditure may be objective, amortization is usually arbitrary".

Hand and Lev (2003, p. 305) offer a similar description:

- An intangible is any non-physical item that has the ability or potential to provide a future economic benefit to the firm.
- The economic definition goes beyond GAAP (Generally Accepted Accounting Practice) to include the on-balance sheet recognition of a variety of costs that GAAP mandates be immediately expensed as soon as they are incurred.

- Examples include R&D, advertising, personnel capabilities, patents, customer service, and strategic alliances.

These definitions and examples describe the nature of intangibles and emphasise the problem of defining appropriate measures for financial accounting purposes. Wyatt (2002, p. 72) cites the current accounting rules in Australia:

> SAC 4 *Definition and Recognition of the Elements of Financial Statements* advocates capitalization of an asset on the balance sheet only when the future economic benefits are expected and there is a reliable cost or other value to record the accounts. In addition, goodwill, R&D and exploration and evaluation cost classes of intangibles are specifically regulated under mandatory accounting standards.

Wyatt (2002, p. 75) notes that "(C)oncerns about the availability, and abuses, of reliable measures in relation to revalued assets and capitalization of intangible assets prompted the USA to proscribe these practices generally".

Australia GAAP is following in this direction.

This conservative approach to accounting for intangibles is necessary in *financial* accounting, but inadequate for *management* accounting purposes, where the concern is estimating the future value of the firm. Unfortunately, studies such as Rodov & Leliaert (2002) which provide useful surveys of attempts to develop an accounting system for intangibles are wrong in criticising what they perceive as inadequacies in financial accounting systems. What they are really talking about is systems for managerial accounting where the aim is to provide data for investors who want to understand what constitutes the tangible and intangible drivers of future value, and their multiplier effects. Within this context there is a need to provide some standardisation in the definitions of terms and methods of reporting. Rodov and Leliaert (2002, p. 335) report that "on both sides of the Atlantic moves are under way to improve (off-balance-sheet) disclosure on intangibles in annual reports (IASC; FASB, 2002). It means that at least publicly quoted companies must have an alternative (and complementary) way to measure and manage their intangibles, since financial reports may in future be totally void of such measures". But the point must be repeated, and it will be demonstrated in technical terms below, that such reports will always be by definition, highly subjective, and incapable of meeting financial reporting requirements.

A Pragmatist Response:

Peirce's pragmatic maxim makes us realise that an "intangible" can only have meaning if it influences our behaviour and it is this behaviour, intended or actual that defines the meaning. Furthermore, intangibles result from sense data which can be traced back to a number of tangibles. For example, the "ambience" in a room will depend on such measurable factors as size, temperature, the amount of furniture, and the level of noise in the room etc. Intuitively, the individual "weights" these factors and arrives at a "feeling" of how "comfortable" they find the room, and demonstrate this outcome by their decision to stay in the room, or leave.

Consequently, from a measurement perspective, we can get an estimate of the value of an intangible using an index number which identifies the factors that an individual identifies as important, gets an estimate of the weightings of these factors from the individual, and constructs a corresponding index (the simplest formats being additive and multiplicative forms normalised to produce values ranging from 0 to 1). Values of this index must then be calibrated against behaviour. Note the importance of stressing that any such measure is entirely subjective and therefore is inappropriate as a basis for measuring *financial* accounting performance.

We can use Peirce's triadic semiotics to explain the logic of what is going on here. The index formed correlates with a piece of data, or a symbol, and constitutes firstness; the reaction of the individual is secondness, and the framework of tangible factors and weightings represents the interpretant, that is, thirdness- see Figure 5.10.

For example, in the case of Skandia mentioned above, the "quality" of alliances that Skandia entered into was a major intangible driving its growth performance. This "quality" can be measured by an index based on the factors Skandia believe were important to the future success of a possible alliance such as the years of experience of the potential partner (a surrogate for reputation), the size of their client base, and their record of defaults. All these factors are quantifiable. This translates into measurable outcomes in terms of new clients- see Figure 5.11.

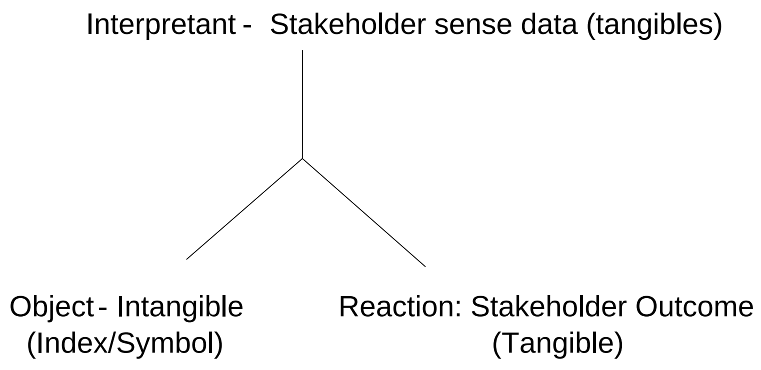

Figure 5.10. A Semiotic Framework for Measuring Intangibles

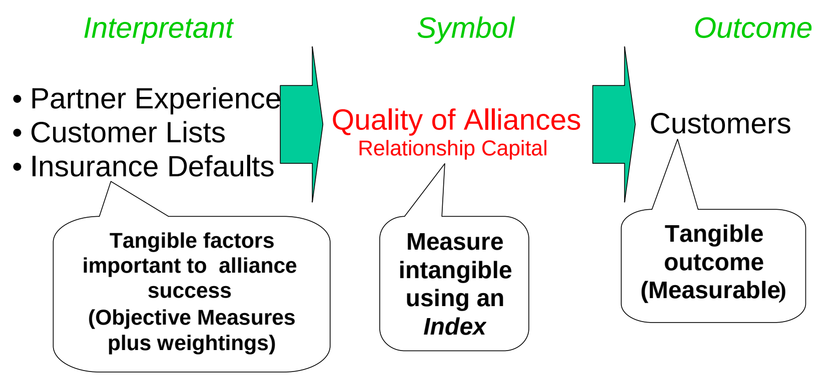

Figure 5.11: Skandia Alliances

These ideas can be used to improve the rigour with which intangibles are modelled in System Dynamics.

Sveiby, Linard and Dvorsky (2002) provide a useful account of the recent debates about modelling “qualitative” or “soft” variables in system dynamics models. Much of this discussion centres on the decision to include or exclude a qualitative variable. On the one hand you may be tempted to ignore the variable because it is not well defined and/or there may be large uncertainties regarding data and causal mechanisms. On the other hand, omitting the variable is equivalent to setting its value to zero.

However, the major issue in this instance is whether or not it is acceptable to model intangibles such as "reputation" as stock variables implying that it is possible to measure reputation, possibly in terms of some construed unit.

Consistent with the earlier discussion concerning measuring intangibles, modelling intangibles also raises questions concerning cognitive processes and how people form perceptions- when dealing with soft variables, we are dealing with a person's perception or reaction to a physical object or event. For example, "motivation" may be the reaction to a reward structure for an employee. In this case, if we assume that a reward structure is something that can be clearly defined and measured, it plays the role of the physical object. Motivation is the behavioural reaction to this reward structure. While we can define and measure the effects of motivation (for example, on absenteeism), "motivation" per se, cannot be measured except in the form of an index, which is dimensionless, and is defined in terms of the elements of the reward structure.

In System Dynamics, graph functions are used to define behavioural responses to such indexes (such as absenteeism). The convexity of the function represents the behavioural assumption we are making in relation to the interpreter- the employee in this example. So, for example, while we may assume that motivation increases with rewards, we need to indicate whether or not this occurs with increasing or decreasing returns, or possible some combination of the two. (The same type of convexity assumption is used in economics to describe things like isoquants, and consumer indifference curves).

This is precisely the model structure employed in Forrester's seminal growth model (Forrester, 1975, pp. 111-132). In this case, for example, "Sales Effectiveness" is modelled as an index with values ranging between 0 and 1 and dependent on Delivery Delays (measured in months). In this case the relationship is modelled as initially being convex to the origin, and then switching to concave. Consequently, Sales

Effectiveness is not severely affected by relatively small delivery delays, but at some point, it drops away rapidly, switching convexity to asymptote towards zero. In turn, Sales Effectiveness becomes a determinant of Orders Booked, and hence the Backlog of Orders.

This formulation makes complete sense, and avoids the rather fanciful idea of having a "Stock of Sales Effectiveness". For system dynamics models to maintain commercial integrity and relevance, it is important that the lead demonstrated by Forrester is followed, and that methods are made as logical and transparent as possible.

As a result of this situation, it is important at the outset to understand that the modelling of a particular intangible may vary from case to case. For example, if the intangible is included as an accounting factor with a view to interfacing with financial accounting statements, then its means of representation, and the way it is amortised need to comply with the appropriate accounting standards. On the other hand, if we are constructing different (management accounting) scenarios where trends in future market value are being considered, then less accounting exactness may be reasonable and greater subjectivity allowed. For example, Wyatt (2002) reports on studies that indicate that R&D expenditures in small start-ups are given greater weightings by investors than those for large, more established companies. It is also likely that the entrepreneurial processes followed by the small start-up will be significantly different from the processes followed in a large organisation.

Unfortunately, the modelling of intangibles in System Dynamics often does not follow Forrester's lead and stock variables are used to model intangibles. For example, Sveiby et al (2002) use stock variables to model intangibles such as "individual competence" and "tools and processes" as though these can be measured as homogeneous entities. Similarly, intangibles such as "quality", "image", "fraud short-term memory" are each modelled as stocks. This leads to forming questionable mathematical statements such as:

<Total competence for firm group = Number of consultants on each level*Average individual competence> (p.8).

When discussing the dynamic behaviours of intangibles, Warren (2002, p. 119) also treats intangibles as stocks: "Intangible resources take time to accumulate- reputation provides a good example". In fact, Warren models the index as a stock- for example, "Average Staff Skill Level" (p., 123); "Average Staff Morale Level" (p., 125); and "Perceived Reliability of Rail Services", and suggests using surrogate measures (p.128). But, in these examples, Warren doesn't include stock-flow structures to explain the dynamic behaviour of the components of the index. In a technical sense there is nothing wrong with representing an index as a stock, but it is unnecessary and introduces redundancy into the model. It is more important to understand the dynamics of the component factors that determine the value of the index.

Nevertheless, Warren (2002, p. 119) makes some important observations concerning the dynamics of intangibles:

- Value relating to intangibles can be destroyed very rapidly- one slip can cause a reputation to be sullied.
- Many intangibles are taken for granted until something goes wrong (eg, airline safety).
- Damage to intangibles such as reputation impacts directly on the performance of tangibles, say, in generating sales.

In summary, one of two approaches can be used to model intangibles: the approach used by Forrester described above, or the use of surrogates for intangibles. What is important is to avoid the situation of modelling entities such as "morale" as a stock as distinct from a behavioural outcome related to easily quantifiable factors.

DeCarolis and Deeds (1999) provide a useful example of using surrogates to model a range of intangibles in the study of "stocks and flows" of knowledge in the biotechnical industry- see Table 5.1. Note that the location index adopts the principles outlined above and results from the location index obtained using a factor analysis of several location measures including the number of biochemistry departments in a region, the number of bioengineering departments, and the number of medical schools.

Factor/Intangible	Surrogate
Geographic cluster effects	Location index
R&D intensity/ commitment	R&D spending
Access to industry knowledge	No of alliances
Research capability	No of citations of the firm's research team
Future cash flows	No of products in development
Level of innovation	No of patents
Firm performance	Total market value at end of the first day of trading

Table 5.1. Factors and Surrogates (DeCarolis and Deeds, 1999).

The important modelling challenge is to capture the way in which these surrogates provide sense data to investors and the way they influence their behaviour. In addition, it should be noted that it is only surrogates that can be sensibly amortized for accounting reporting. Note that surrogates work because it is assumed that they lead to the same behavioural outcome as the intangible. This is yet another example of the application of Peirce's pragmatic maxim.

Forrester's approach can be validated by reference to Peirce's semiotics. This can be demonstrated with reference to the Skandia example (Figure 5.12).
Stock-flow structures can be detailed for each of the interpretants identified and an index for "Alliance Suitability" described (firstness). This index relates to an alliance acceptance rate (secondness) and affects the number of alliances Skandia enters into. The relationship is shown in Figure 5.13.

All stocks identified relate to tangibles and can be measured without ambiguity. There is no need to model "Alliance Suitability" as a stock variable per se.

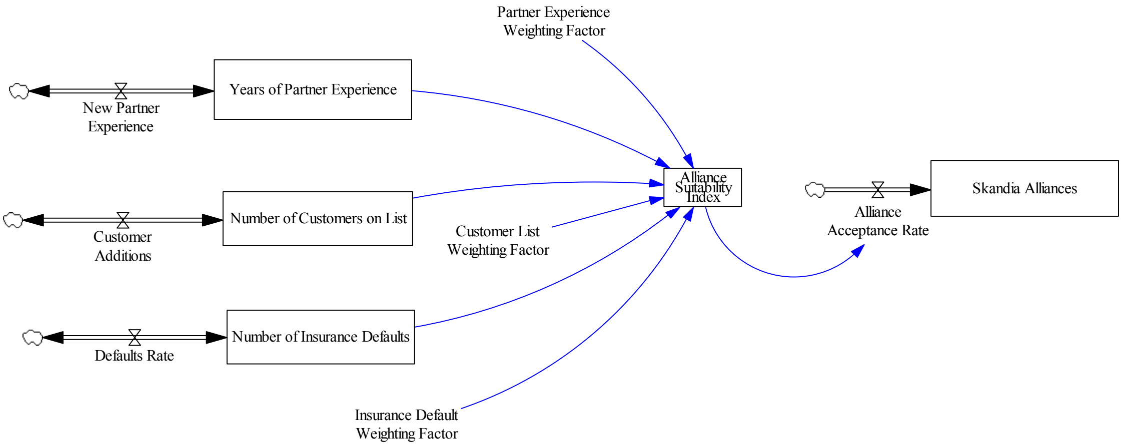

Figure 5.12. Modelling the Skandia Alliance Suitability Index.

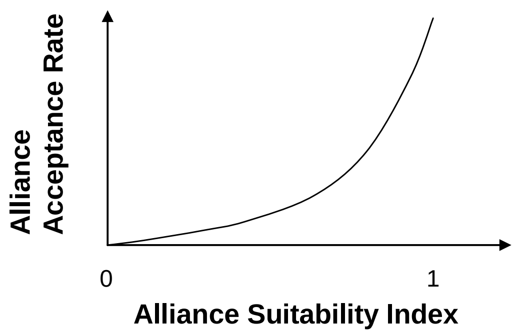

Figure 5.13. Determining the Acceptance Rate from the Suitability Index.

5.3. Developing a Systemic Approach to Knowledge Management.

Wong and Aspinwall (2004, p. 93) cite Drucker's 1993 assertion that "one of the most important challenges facing organizations in a contemporary society is to build systemic practices for managing knowledge". Wong and Aspinwall observe that the "KM frameworks that have been presented in the literature tend to focus on different aspects of KM and have different purposes" (p. 94). Others relate to what Wong and Aspinwall refer to as the "knowledge cycle process" and describe "the phases of knowledge flow (from creation to application) in an organization without providing guidance on how to implement KM" (p. 94-95). But eventually, Wong and Aspinwall conclude that knowledge management frameworks can be classified as being "system", "step" or "hybrid" (p. 96).

The system frameworks use "a graphical representation with the aim of providing a systemic and holistic perspective on KM implementation". The "step" frameworks are those that provide "a series of steps or procedures to be followed in the KM implementation process" (p. 96). As the name implies, hybrid approaches first establish a systems framework, and then complement it with a series of implementation steps. This Chapter is primarily concerned with systemic approaches, particularly those that provide the opportunity to use whatever detailed implementation tools that are deemed appropriate.

Finally, Wong and Aspinwall propose a set of guidelines for developing an implementation framework:

- Incorporate a clear structure to organize the tasks.
- Address the different knowledge resources or types.
- Include the KM processes or activities that manipulate the knowledge.
- Point out the influences that can affect the performance of KM.
- Provide a balanced view between a technical and social perspective.

(Wong and Aspinwall, 2004, pp. 102-103).

These guidelines are useful inasmuch as they articulate the challenge involved in developing a systemic approach to knowledge management. They help place us at the starting point for the dialectic process described in Figure 4.2; the point at which some “surprising facts” are observed.

How then, have these “surprising facts” been given meaning? A number of examples are provided and the nature of their systemic bases identified.

Example 1. Nonaka’s SECI Model.

Nonaka’s “Socialization, Externalization, Combination, Internalization” (SECI) model is arguably the best known approach to knowledge management and is defined by Nonaka (1991, 1994); Nonaka and Konno (1998); Nonaka and Takeuchi, (1995); and Takeuchi and Nonaka (2004). It received particular prominence when it was used to explain why US industry had fallen behind Japanese industry in the 1980s (Nonaka and Takeuchi, 1995).

From a systems framing point of view, Nonaka’s breakthrough was to recognise the importance of Polanyi’s classification of tacit and explicit knowledge.

Nonaka’s (1994) model starts with a definition of knowledge as “justified true belief” and applies Polanyi’s learning theory framework that differentiates knowledge as being either explicit or tacit (Polanyi, 1958, 1966). While explicit, or codified knowledge is knowledge that is transmitted in formal, systematic language, tacit knowledge is “personal knowledge embedded in individual experience and involves intangible factors such as personal belief, perspective, and value systems” (Nonaka and Takeuchi, 1995, p viii). On this basis Nonaka identifies four modes of knowledge creation. See Figure 5.14.

Nonaka’s (1994) model defines a spiral of organizational knowledge creation (Figure 5.15) based on a continuous dialogue between tacit and explicit knowledge as knowledge develops from the individual to successively higher levels of social aggregation and awareness. Takeuchi and Nonaka (2004, p. 5) identify this as a *dialectic* process. Nonaka (1994) identifies the involvement of five processes:

- Enlarging individual knowledge
- Sharing tacit knowledge
- Conceptualising and crystallization
- Justification, and
- Networking.

		To	
From		Tacit Knowledge	Explicit Knowledge
	Tacit Knowledge	Socialization	Externalization
	Explicit Knowledge	Internalization	Combination

Figure 5.14. Nonaka's Modes of Knowledge Creation (Nonaka, 1994, p. 19).

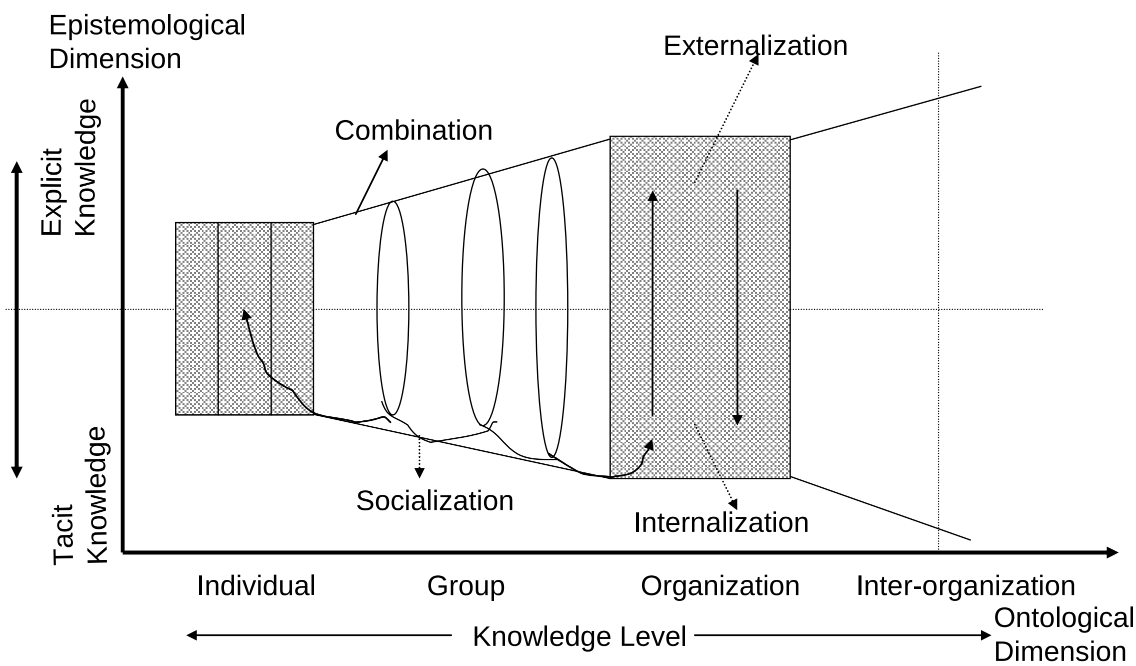

Figure 5.15. The Nonaka Model. (Nonaka, 1994, p.20).

Nonaka and Takeuchi have continued to influence thinking in current developments of knowledge management. Takeuchi argues that knowledge holds the key to generating continuing innovation and advocates that Western companies “need to ‘unlearn’ their existing view of knowledge and pay more attention to (1) tacit knowledge, (2) creating new knowledge, and (3) having everyone in the organization involved” (Takeuchi, 1998).

Nonaka and Konno (1998), Nonaka, Konno, and Toyama (2001), and von Krogh, Ichijo, and Nonaka (2000) have championed the idea of “ba”; a “platform where knowledge is created, shared, and exploited…ba is a context that *harbours meaning*”. (Nonaka, Konno and Toyama, p 13). Von Krogh, Ichijo and Nonaka (2000) discuss first-hand experience of implementing the Takeuchi and Nonaka model in companies such as Siemens, Unilever, Skandia and Sony.

Example 2. Boisot’s Information Space (I-Space) Model.

Boisot (1994, 1995, 1998, 2002a,b) addresses the problem that, while current mainstream economic theory is concerned with the production and exchange of tangible objects, it does not address the production and exchange of intangibles such as knowledge. Boisot’s model starts to address this issue by proposing that useful knowledge is produced through a process of codification and abstraction, which in turn facilitates its diffusion (Boisot, 1995, p. 5). Consequently, Boisot develops the concept of an “information space” defined by the three components- codification, abstraction, and diffusion (Figure 5.16).

Boisot describes knowledge that is *fully* codified using a *fully* articulated form of abstraction and *full* availability as “textbook” knowledge. Anecdotal evidence suggests that many managers rely on intuitive frames based on simple metaphors (for example, a game, a war, or an organic process) to codify their knowledge and diffuse it. But it is rare to find a manager who allows the essence of this codification to be surfaced and “benchmarked” against appropriate abstractions (theories).

Like the Nonaka model, we see that the systems frame that Boisot uses to make sense of knowledge management issues is based on formism.

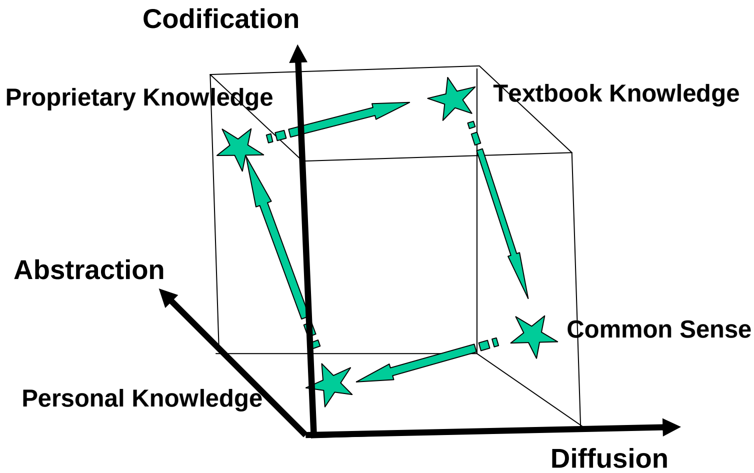

Figure 5.16. Boisot's Information Space (Boisot, 1998, p. 59).

Example 3. Earl's Strategic Approach.

Earl (2001, p. 215) adopts a strongly strategic but mechanistic approach and acknowledges from the outset the theoretical and technical difficulties involved in developing knowledge management strategies. Earl states something of the obvious when he writes: "Knowledge management, like knowledge itself, is difficult to define". In theoretical terms, Earl identifies knowledge management as being at least "consistent with resource-based theories of the firm…, namely building and competing on a capability that could be quite difficult for others to initiate". Studies of European and US firms by Kay (1993; 1995) suggest that successful firms develop a competitive advantage by consistently leveraging off four types of strategic assets: ability to innovate; reputation; monopolistic assets such as licences, patents and government contracts that restrict the market entry of competitors, and , most important of all, the "architecture" of stakeholder relationships. These assets are all strategic in the sense that they are very difficult, if not impossible, to copy, become imbedded in the culture of the organisation, and are the ultimate strength of the business. Significantly, all are "intangible" assets.

Earl (2001, p. 215) points out that because theoretical insights into knowledge management cut across traditional disciplines and professions, and draw on diverse disciplines including economics, philosophy, computer science, and sociology, organisations have difficulty in introducing knowledge management. A common approach is to appoint a “knowledge manager” with a broad brief acting across departments and divisions, but, based on case studies, Earl concludes that knowledge management in practice tends to fall into three schools:

- Technocratic, with an emphasis on engineering systems, IT, and knowledge directories.
- Economic, with a focus on commercial aspects.
- Behavioural, with an emphasis on knowledge generation and knowledge sharing.

On this basis, Earl defines a knowledge management strategy framework within which these schools can operate (Figure 5.17). An important aspect of this framework is that it ensures that knowledge management activities are closely related to strategy. This means that knowledge management initiatives are not as easily relegated to some lower priority within the organisation. The disadvantage of Earl’s model is that it adopts an episodic view of strategy compared to a feedback, learning approach such as that defined by Lyneis (1999).

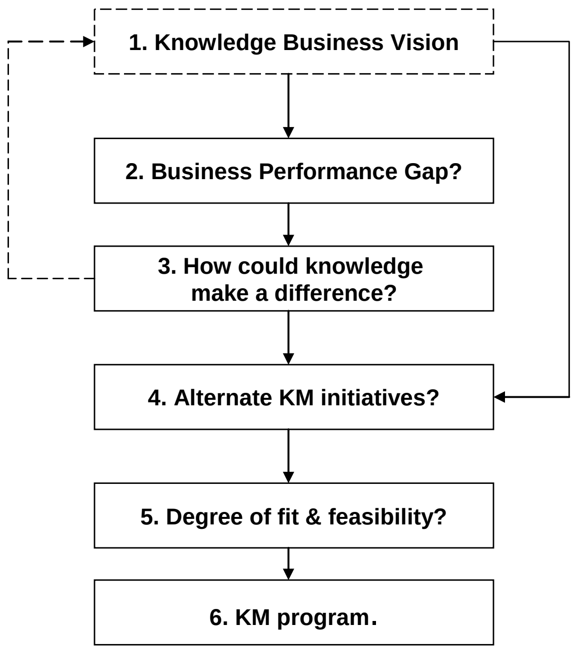

Figure 5.17. Earl’s Knowledge Management Strategy (Earl, 2001, p. 230).

Example 4. Sveiby's Model.

Although it has many characteristics of the social ecology, open systems approach, Sveiby's "Intangible Assets Monitor" (IAM) is described as an autopoietic systems approach (Sveiby, 1997, 2001; Sveiby, Linard, and Dvorsky, 2002).

Sveiby (2001, p.346-347) defines knowledge management as the "art of creating value from intangible assets" and defines three fields of intangible assets:

- The *External Structure* family- relationships with customers and suppliers and the reputation (image) of the firm. Some can be translated into legal property e.g., trademarks, brand names.
- The *Internal Structure*- created by employees and including patents, concepts, models, and computer and administrative systems.
- The *Individual Competence* family- employee competencies and R&D.

These are described in Figure 5.18.

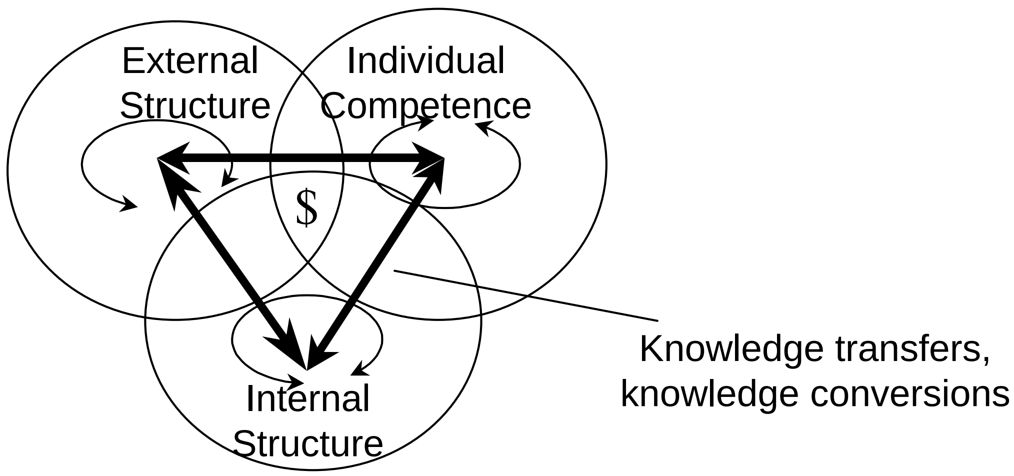

Figure 5.18. Sveiby's View of the Firm from a Knowledge-based Perspective (Sveiby, 2001, p. 347).

Note that this structure corresponds to what Ackoff and Churchman identified as the set of relationships that most characterise Jungian archetypes (Ackoff, 1989a). Sveiby indicates that his inspiration for identifying these relationships comes from Marshall McLuhan's concept of "media"; "people in organizations create external and internal structures in order to express themselves" (Sveiby, 2001, p. 345).

As in the case of Nonaka and Takeuchi (1991, 1995) and Nonaka (1994), value is created by the tacit/explicit transfer of knowledge between individuals, and the conversion of knowledge from one type to another.

Sveiby identifies eight knowledge strategy issues corresponding to the knowledge transfers associated with the various linkages shown in Figure 5.18:

- Between individuals–from individuals to external structure
- From external structure to individuals
- From individual competence into internal structure
- Internal structure to individual competence
- Within the external structure
- From external to internal structure
- From internal to external structure
- Within the internal structure.

Using this structure as a basis, Sveiby develops a system of knowledge management performance indicators (the IAM) which can be used as a knowledge management capability assessment tool. A knowledge management strategy can then be developed that addresses any capability gaps that become apparent.

Two important factors characterise Sveiby's model: his new economy model of the business firm which is rooted in the resource-based theory of the firm, and an autopoietic epistemology in which data is the only input into the system and where knowledge is endogenous and self-referential, this being most closely linked to Polany's "personal" knowledge (Sveiby, 2001, pp. 344-345).

Consequently:

> It is the individual that can use their competence to create value in two directions, by transferring and converting knowledge externally from or internally to their organisation. The external transfer involves intangible relationships with customers and suppliers and forms the basis for reputation (image of the firm….. The internal transfer relates to explicit administrative processes, internal networks, organisational culture and competencies of individuals.

(Sveiby, 2001, pp. 355-356).

Despite its originality, intellectual integrity, and the power of the IAM diagnostic, Sveiby's model poses a significant challenge for any traditional, functionally orientated business. To apply it demands a fundamental change in culture that crosses all functions. Experience with attempts to introduce quality management and other large scale initiatives that require fundamental cultural change emphasise the enormity of the task and the discipline required. And in areas like quality management, the outcomes are better defined (tangible) and relatively easily assessed in terms of business financial performance. In these terms, most organisations are likely to see Sveiby's model as normative.

Example 5. The Johanssen, Olaisen, and Olsen Model.

Johanssen et al (1999) propose a model that has a clear philosophical basis in systems thinking and adopts a learning cycle including planning, action, and reflection to individual motivation (Figure 5.19); that is, based on Peirce's triadic modes of inference (Chapter 3). It is strongly influenced by Ackoff's approach to systems thinking and organisational design (Ackoff, 1981, 1994, 1999; Ackoff and Emery, 1972).

Johanssen et al stress that, to change the way people think and act, each person must understand "how the partial system of which they are part influences the other partial systems, the system as a whole and the environment" (p, 36).

In this sense, Johanssen et al provide a model that has synergies with Senge's (1990) system of capabilities for a learning organisation. These have a particular characteristic that deserves emphasis. Apart from mandating the need for systemic thinking (the "fifth discipline"), Senge emphasises the duality between individual and organisational learning disciplines: personal mastery/ organisational vision, and dialogue skills/ team learning. In other words, the individual and the organisation must form a joint and informed aspiration, and learn together and reinforce each other.

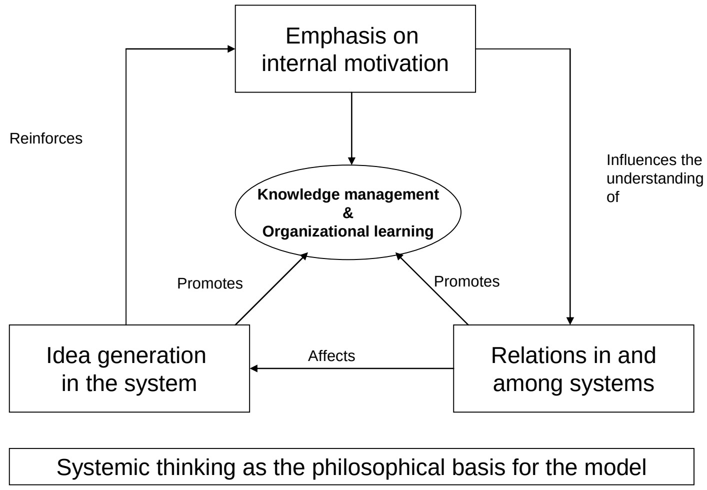

Figure 5.19. Johanssen, Olaisen, Olsen Model (Johanssen et al, 1999, p. 26).

Example 6. Cavaleri's KIST Model.

Cavaleri (2005) proposes a knowledge creating model that couples "systems modelling[22] with a pragmatic approach to knowledge-creation" (p. 378):

> On the surface, it appears that these two approaches are synergistic. Systems modelling techniques tend to discover answers to questions of related concern to those who are interested in the pragmatics of knowledge creation. How might they be integrated to work as a single process?

(Cavaleri, 2005, p. 393).

[22] Cavaleri is referring to System Dynamics modelling.

Drawing on Peirce's pragmatism, Cavaleri emphasises the need to ground knowledge in action and experience. Cavaleri notes the pragmatist leanings of System Dynamics:

System Dynamics is pragmatic in the following senses:

1. It links performance feedback to a reference mode of behaviour, which in pragmatism is the expected result;
2. Mismatches are traced to the actions and decisions of policy makers; and
3. The ineffective decisions and actions of policy makers are attributed to incomplete or incoherent mental models.

(Cavaleri, 2005, p. 283).

Finally, Cavaleri proposes a "Knowledge Intensive Systems Thinking" (KIST) model (p. 393) that attempts to integrate System Dynamics with pragmatist learning principles (Figure 5.20).

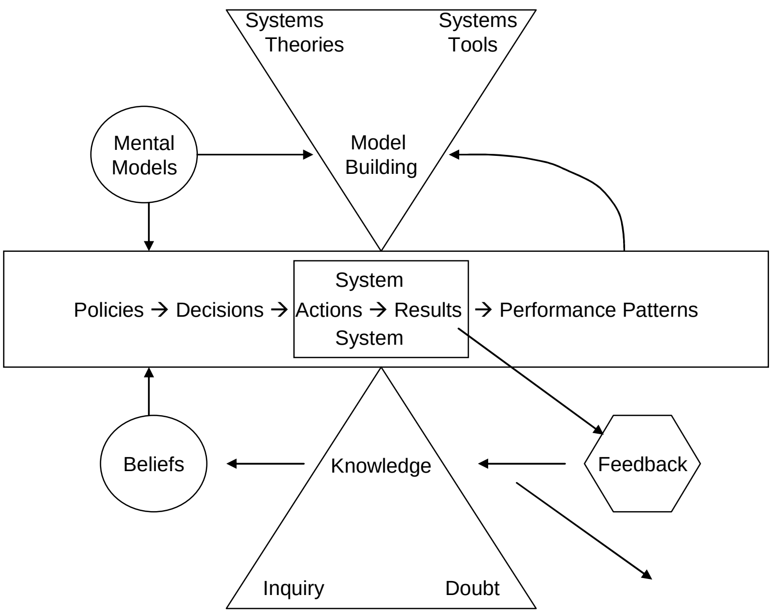

Figure 5.20. Cavaleri's KIST Model (Cavaleri, 2005, p. 393)

The proposed model is a first effort to make “systems thinking and attendant interventions more knowledge centric” (p. 393).

> KIST views systems modelling as being a top-down effort to capture the underlying structure of a system, and to envision the knowledge-creation process as being a bottom-up initiative designed to capture the perturbations of how a system responds to various knowledge-based actions that have previously been taken. Over time, and through iteration, a pragmatic knowledge-creation system records the results obtained by using specific acts….The central task of policymakers, then, is to use modelling-based insights to inform knowledge-creating processes in order to formulate better policies.

(Cavaleri, 2005, p. 394-395).

He concludes:

> It would appear that many of the great systems theorists were going in the right direction by trying to combine action learning with systems methodologies. However, the missing link, so to speak would appear to be the important role played by pragmatic knowledge- creating processes. I wish to call to the attention of systems theorists the emerging task of designing a next generation of pragmatic knowledge-intensive systems methodologies.

(Cavaleri, 2005, p. 395)[23].

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[23] This thesis attempts to extend Cavaleri’s model by providing a synthesis of systems theory and knowledge creation. By exploring the cognitive aspects associated with mental models and the philosophical basis of belief, it significantly *elaborates* aspects of Cavaleri’s model. Like Cavaleri, the pragmatist philosophy of C.S.Peirce is used as an integrative basis and a source of underlying logic.

Observations Leading to a New Synthesis.

The examples outlined above each demonstrate the framing of knowledge management using a variety of systems approaches. These frames range from simple classification systems- Example 1 (Nonaka) and Example 2 (Boisot); to mechanistic systems- Example 3 (Earl); to autopoietic systems- Example 4 (Sveiby); to ones with links to contextualism- Examples 5 and 6. In each case, a dynamic is defined to describe the knowledge development process. In many cases this process directly relates to working with dialectics such as tacit versus explicit (Nonaka)[24]; codified versus abstract (Boisot); actual versus desired performance (Earl); internal versus external phenomena (Sveiby, and Johanssen et al); and System Dynamics- pragmatist learning methodology (Cavaleri).
Some of these approaches have received considerable experimentation in practice, particularly the Nonaka, Boisot, and Sveiby models.

In the case of the Nonaka an extensive literature has emerged concerning the role of organisational design (the "hypertext" organisation, (Nonaka, 1994, p. 34)) and the importance of creating a knowledge and learning environment ("ba") within which to create knowledge and manage it (Nonaka and Nishgushi, 2001, p. 19). Boisot (1998) reports on applications of his I-Space model and concludes that it "appeared to offer three specific benefits:

1. It allowed a diagnosis- i.e., a mapping of technologies and linkages that organizational players could subscribe to and that would have been difficult to achieve without it. The diagnosis was, for many, counterintuitive.
2. It promoted constructive debate and generated numerous insights (and provided a common language).
3. It pointed to specific issues that need dealing with".

(Boisot, 1998, p. 253).

[24] Baumard (2002) provides some interesting studies of pathways followed by different companies moving between the tacit-explicit and individual- collective knowledge fields.

Significantly, Boisot points to how the I-Space, "as a conceptual framework could be further developed and applied" (Boisot, 1998, p. 253). In terms of the model of science described in Figure 4.2, Boisot is heading down the return path to creating more data that may lead to a re-conceptualisation of his model. Or, he may conclude his model is sufficiently robust to continue to work with.

Sveiby's model has also had extensive application in business, but anecdotal evidence would suggest that this has occurred with mixed success. Sveiby is critical of operational/ functional models such as the Kaplan and Norton's Balanced Scorecard (BSC) (Kaplan and Norton, 1996). He argues, for example, that despite some "superficial" similarities between the BSC and the IAM, "BSC takes an 'industrial era' theory of organisations for granted and simply adds non-financial measures to the traditional indicators in a non-systemic fashion. IAM, on the other hand, takes an information era perspective" (Sveiby, Linard, and Dvorsky, 2002, p. 2)[25].

While Sveiby's model has strong intellectual foundations, it may appear to be too sophisticated to the many organisations that are attempting to make the transition from functional management traditions into the knowledge era. (See earlier discussion in this Chapter).

Of the other three models outlined, Earl's model corresponds to a traditional strategy framework which has been found wanting (Lyneis, 1999); and the models by Johanssen et al and Cavaleri are purely conceptual.

Consideration of this variety of models and what appears to be their limited success suggests a need for a new, simpler synthesis that can both take advantage of existing models and themes, while helping create a bridge for the industrial- age organisation to move into the knowledge age. Such a model needs to have components that are identifiable with existing functional management roles, but encourage integration through a simple organising principle be integrative. The model needs to meet the criteria identified by Wong and Aspinall (2004) discussed previously.

[25] While this might apply to Kaplan and Norton's early work, their later work has shifted from the original goal of developing a "balanced" performance measurement system, to a framework for strategy development and learning (Kaplan and Norton, 2001, 2004, 2006). This progression is yet another demonstration of the process described in Chapter 4.

The following model attempts to do this. It is based on the theory relating open and closed systems depicted in Figure 4.3. It is driven by dialectic between normative approaches to knowledge management and one aiming for strong praxis[26].

In outline, this model starts with a description of knowledge management that links knowledge management challenges to exiting organisational functional areas. This creates a closed system, essentially mechanical view of knowledge management, which is then embedded within the context of an open system, contextualist environment defined by the organisation's strategic intent. Consequently, the ideal is to construct a knowledge management structure linked to specific strategic initiatives, rather that attempt, at least initially, a totally corporate approach where concepts become too general and unrelated to operations.

This model starts with Forrester's data hierarchy shown in Figure 5.21 (Forrester, 1961, p. 427). This diagram describes three primary forms of data- numerical, written and oral data, and mental data. The numerical and written and oral data constitute explicit data, the mental data is tacit (Polanyi, 1958, 1966). Forrester was particularly concerned that in modelling approaches such as operations research and econometrics, only a small percentage of data is held as numerical ("hard") data. More is held in documents and even more as perceptual data. (Christ (1975, p. 59) would appear to agree with this: when discussing the forecasting ability of econometric models, he concludes that "it appears that *subjectively adjusted* forecasts using *ex ante* exogenous values are better than the others").

Despite this, "rational" decision-making has tended to emphasise the use of hard data. Research in the cognitive sciences has provided concepts such as "mental models" to better understand how we construct knowledge and use all forms of data. As the previous discussion of the Nonaka and Boisot models confirms, their particular interest is how we create tacit knowledge and through socialization and dialogue processes and create explicit knowledge that is shared across "communities of inquiry".

[26] Other systematic approaches have been proposed by European scholars and international consulting companies including Probst, Raub and Romhardt (2000); Kluge, Stein, and Licht (2001), Davenport and Probst (2002), and Daum, (2003).

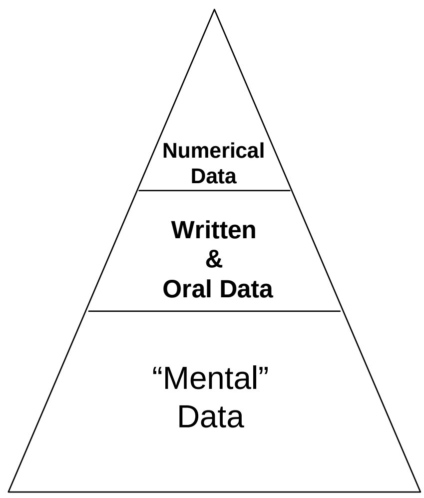

Figure 5.21. Forrester’s Data Hierarchy. (Forrester, 1961, p.427).

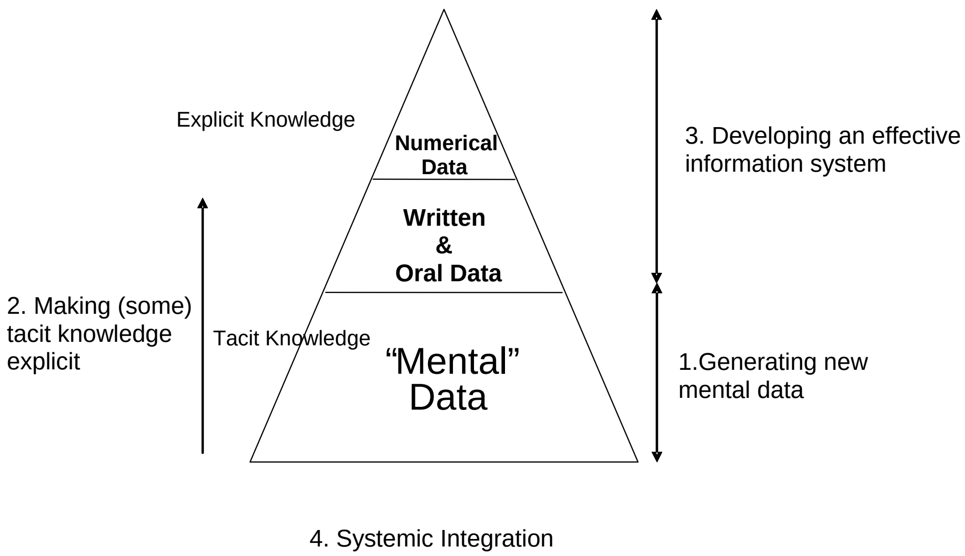

Figure 15.22. Four Knowledge Management Challenges

We can use Forrester’s data hierarchy to identify four knowledge management challenges (Figure 5. 22):

1. The problem of creating, maintaining an organizational climate in which new mental data is stimulated and in which worldviews and systemic frameworks are made explicit.

2. The problem of making mental data (tacit data) explicit and suitably codifying it so that it moves into the top two parts of the data triangle.
3. The problem of classifying numerical, written and oral data and making it accessible through data bases. A typical example is the collection and storage of transaction data for accounting purposes.
4. The systemic integration of these approaches around strategic intent including defining what data should be collected and what type of knowledge should be developed.

Unfortunately, many companies only emphasise the third of these challenges and so “knowledge management” becomes the province of the information systems department. Similarly, the first challenge is often seen as an isolated activity of the human resources department. It is rare to find companies that understand the need for an integrated approach to these challenges; they cannot be successfully managed in a piecemeal way. Nor do they easily recognise that the company’s strategic intent can help define what data and knowledge is important.

These four knowledge management challenges can be identified with typical functional roles:

1. Generating new tacit data- with human resource departments, but more properly across all functions, particularly operations.
2. Making tacit knowledge explicit- corporate modelling, operations and the development of systems maps, and the development of knowledge maps.
3. Developing an information system- the information systems function.
4. Systemic integration- with corporate and strategic planning.

Note that these functions correspond with the “knowledge focussed activities” described by Ruggles (1998, p. 80) and the three schools of knowledge management identified by Earl (2001, p. 215), cited previously.

The exercise is to now make these functions systematic *and* systemic.

To make these functions *systematic*, these functional processes can be described as a closed "mechanical" system as described in Figure 5.23.

This system can be made *systemic* by applying strategic intent as the organising principle for this system.

The functional elements of this model are briefly discussed below:

1. Creating Knowledge.

The principles developed by Nonaka (1994) and Boisot (1998) can be applied here. They involve the creation of knowledge, and the establishment an organisational climate and enabling conditions for knowledge creation.

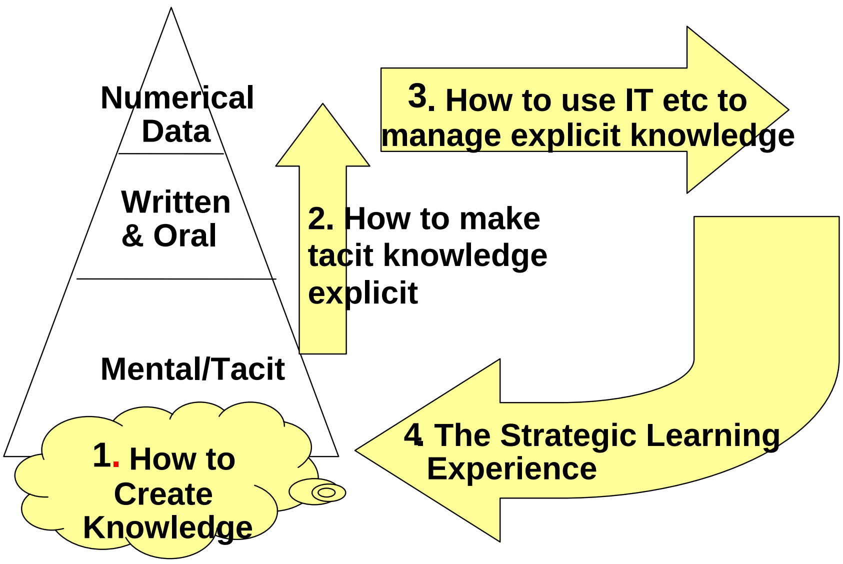

Figure 5.23. A *Systematic* Approach to Knowledge Management Based on Functions.

2. **Making Tacit Knowledge Explicit.**

The techniques of developing knowledge maps and measuring intangibles described previously, and the use of Boisot's I-Space maps are advocated as the major techniques for making tacit knowledge explicit. In general terms, this links with any business modelling process and techniques for capturing "deep smarts" (Leonard-Barton, 1995, Leonard, 2000).

3. **Information Management[27].**

The strategic importance of the "intelligence" provided by an integrated information system is described by Liautaud (2001), as the:

> …..fast emerging cross-departmental mandate for companies in virtually all industries. The new cross-departmental imperative for companies in virtually all industries to empower decision makers to obtain quick answers to their business questions by accessing immediately the information they need. The effective sharing, distillation, and analysis of information among such an array of departments- customer relationship, sales, product planning, marketing, and finance, for example- coalesces into an enterprise wide intelligence that is greater than the sum of its informational parts.

(Liautaud, 2001, p. 5).

Consequently, the technical design of such an information system is of fundamental importance to the survival of the organisation. Beer (1985) provides the seminal articulation of what information structure is required for viability. Beer's recursive, information archetype for designing organizations as "viable systems", is critical to the design of information systems. These conditions provide an information system that is sufficient to ensure the organisations "requisite variety" (smartness) to survive in its environment.

[27] Knowledge creation and making tacit knowledge explicit have received considerable attention previously, but this is not the case for information management. Consequently, it will be considered at greater length at this point. Also, given the discussion of the definition of data, information, and knowledge it may be argued that this component really refers to "data" management.

Five levels of information are identified as listed below and shown in Figure 5.24:

- System1: Operational systems.
- System 2: The system that coordinates operations
- System 3: A control function that maintains internal stability. In SC work this system will relate to performance management and the variability of key performance measures such as pipe stock and orders.
- System 4: An intelligence gathering/reporting system for monitoring for the SC total environment. This might be focussed on stakeholder behaviour, and social, technical, economic, environmental and political factors.
- System 5: The policy development system and rapid response crisis management system

Once again, appeal to Peirce's system of categories can help articulate in what sense Beer's conditions are "sufficient" for viability. In understanding the sufficiency of

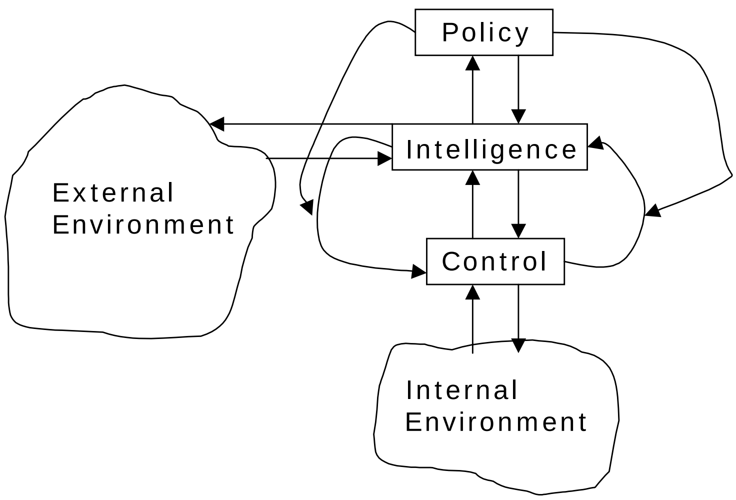

Figure 5.24. Beer's Viable System Model (Beer, 1985, p. 136).

Beer's structure, it is important to again note the distinction between data, information, and knowledge. If Beer's system was purely identifying data systems, then it would only constitute a necessary condition for viability of the organisation.

But clearly other factors come into play and to achieve sufficiency, including an appropriate knowledge base to know what data to collect, and how to interpret it in the context of an organisation's strategic intent (system principle).

In the traditional hierarchical organization, information flows and control systems are provided by the hierarchy; information is diffused from the top to the bottom through the organizational tree. Similarly, information from the bottom (the coal-face) is attenuated as it moves up through the organization. Coordination is provided by a structure of committees. But clearly such a system is going to build in significant delays. It also starts to experience stress as more direct lateral communication takes place, particularly between employees at all levels with external stakeholders.

Information technology removes the need to rely on hierarchy to manage information.

Nevertheless, Beer's viable organization conditions still hold, the major difference in its application being the speed with which data can be collected and accessed and the increased importance of employees being able to access data from all parts in the organisation.

4. The Strategic Learning Experience.

De Geus (1988) captures the essence of strategic learning experience when he describes "planning as learning". In this approach, "hypotheses to the best explanation" are used as a basis for strategic action according to the principles of action research and the scientific method described in Chapter 4.

This step will be considered in detail in Chapters 6 and 7.

Making this Model "Systemic".

In its current state, there are no criteria provided for answering questions such as: "what tacit knowledge needs to be made explicit?"; "what data should be made available through the information system?"; and, "what should our learning be focussed on?". These questions can only be answered by placing the whole structure within the context of an organisational purpose, or strategic intent. In turn, this places the model within the broader context of strategic learning, or action research, to be discussed in the next Chapter.

The term strategic intent was introduced by Hamel and Prahalad (1994) as their term for describing an organisation's "animating dream". While "strategic architecture is the brain; strategic intent is the heart … it implies a significant stretch for the organization … current capabilities and resources are manifestly insufficient to the task" (p. 129). "Direction, discovery, and destiny. These are the attributes of strategic intent" (p. 130). Strategic intent is an active management process that starts with a vision of a desired leadership position and establishes the criterion the organization will use to assess progress (Hamel and Prahalad 1989).

The question is, "how do you develop a statement of strategic intent?". The answer is: "with some difficulty and hard research"! Strategic intent is not an empty vision statement- it has to be backed with numbers. It is achieved by establishing dialectic between the organisation and its environment, in much the same way as the Emery Search Conference does (Emery, 1999).

It can also be achieved using the template shown in Figure 5.25. Note that the elements of the template can each be identified with functional roles in the organisation- the customer value proposition with marketing; management capabilities with operations management and HR, etc. Also note that no one component can be answered without reference to all other components, but you can start the discussion at any point, that is, from any one functional perspective.

A final word about enabling conditions is important. As the experience with Nonaka's model clearly indicates, it is essential to support knowledge management initiatives with appropriate enabling conditions.

Despite the fact that systematic and systemic approaches to knowledge management can be developed, it is generally recognised that these really only constitute necessary conditions for success. To achieve sufficiency, the contextual, enabling conditions must be considered.

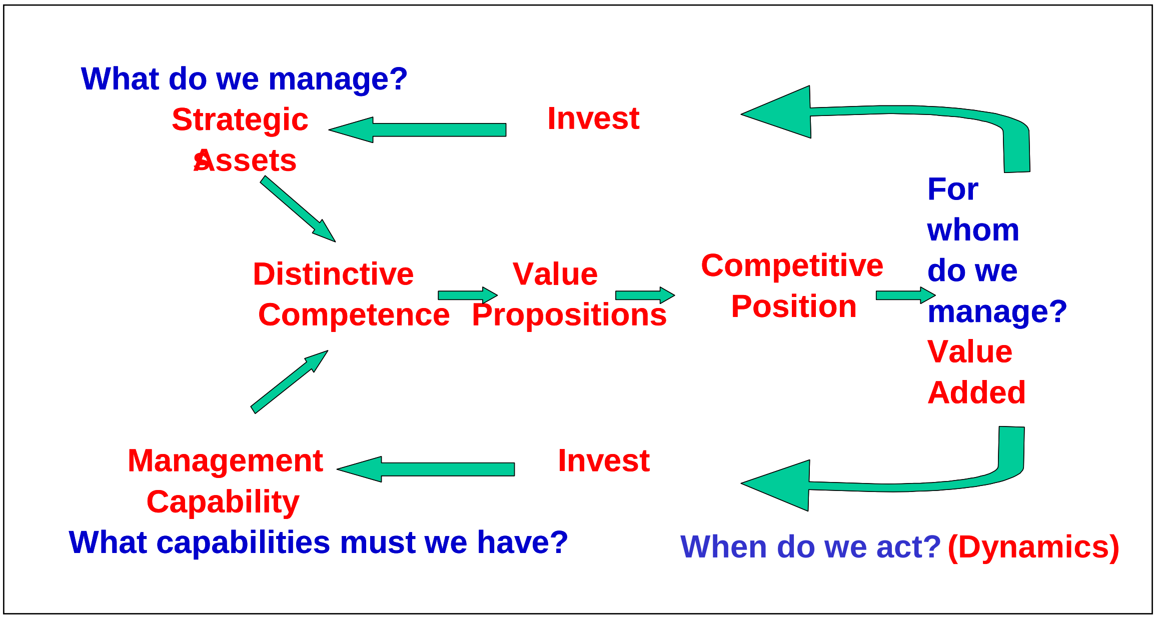

Figure 5.25. A Framework for Establishing Strategic Intent.

There are strong similarities between the enabling conditions identified by different authors. For example, Nonaka and Takeuchi (1995, p. 84) identify the following:

- Intention- aspiration and desire to learn
- Autonomy- knowledge workers need a degree of autonomy which provides the space within which they can experiment and learn
- Fluctuation/ creative chaos- change provides the opportunity to innovate; some degree of "creative chaos" reduces the barriers to innovation
- Redundancy- this is redundancy in functions, ie, additional capacity and flexibility to undertake a variety of tasks, and to have the time to think
- Requisite variety- as defined by Stafford Beer above.

These factors are closely related to those identified as the characteristics of Emery's "Design Principle 2" (DP 2) for organizations (Emery, 1993, 1999), to Ackoff's interactive planning approach (Ackoff, 1981,1994, 1999), and to Morgan's discussion of the introduction of micro-processing technologies into organisations (Morgan, 1989).

Emery (1999) distinguishes between "Design Principle 1" (DP 1) in which the level of authority for operational decisions sit one level above where the operations occur, and DP 2 where authority for these decisions lies at the level of the particular operation. While DP 1 assumes "redundancy of parts" in which the individual only performs a single task and the organization maintains a reserve capacity of individuals but who can only perform the same tasks. DP2 assumes "redundancy of functions" in which the individual can perform multiple tasks and the organization carries additional capacity in this respect.

The organisational learning literature (Dierkes et al, 2001) also assists by identifying "learning capabilities". For example, Senge (1990) defines learning organization as "organizations where people continually expand their capacity to create the results they desire" and identifies three core capabilities and five learning disciplines:

- Creative Orientation (Aspiration):
    - Personal Mastery (Personal growth and learning).
    - Shared Vision (the answer to the question: what do we create next?).
- Reflective Conversation (Communication):
    - Mental Models (the cognitive frameworks with which we make sense of the world).
    - Team Learning (the process of aligning capacity of the team).
- Dealing with Complexity:
    - Systems Thinking (the discipline that integrates the other disciplines and provides the logic for understanding complexity).

As indicated previously, it is important to recognize that Senge emphasizes the duality between individual and group capabilities. For example, you cannot develop aspiration without individuals being able to develop their own capabilities and visions, as well as using processes to establish a shared vision.

Nonaka and Takeuchi (1995, p. 44-45) are critical of Senge's framework and argue that Senge does not provide a *process* for knowledge creation. However, Senge's "team learning", which can be further articulated by the type of learning structures described in Chapter 7 relating to System Dynamics methodology, provides this process.

In fact, there are clear correlations between the various elements of the Nonaka model and Senge's model. Senge's aspiration correlates with Nonaka's "Intention", and Senge's "dialogue" correlates with Nonaka's five-stage evolutionary process. Nonaka and Takeuchi also recognize the role of systems thinking in the codification stage of knowledge management. Senge would argue that knowledge creation occurs as a result of the systems modelling process. But sitting behind Senge's model are theories that are profound and rigorous including the learning theories of Argyris (Argyris, 1992, 1993, 2004; Argyris and Schon, 1996), dialogue theories of Bohm (1996), and the systems theories of Forrester (Forrester, 1961, 1975; Sterman, 2000).

Chapter 6. Business Action Research.

6.1. Introduction.

It is arguable that the learning methodology is the most important component of the approaches to knowledge management described in Chapter 5. In this Chapter, the aim is to focus on action research as it applies to management and business organisations, and to address the question of its scientific validity.

To achieve this aim, the case for action research in business is reviewed and some history of action learning and of action research in general is provided. A model of "Business Action Research" is proposed based on the description of scientific method developed in Chapter 4, and this model is used to propose a more consistent and rigorous approach to System Dynamics methodology in Chapter 7.

The Case for Action Research in Business and Management.

When action research is explicitly linked to management, it brings together three terms that individually mean many different things to different people- indeed, action research attempts to synthesise three areas of theory:

- Theories of Action
- Research theory
- Management theory

Each has a somewhat contentious history with paths that cross from time to time. Action theories are of fundamental concern to sociologists, research is often claimed as the province of the physical scientists, with the work of social scientists being considered dubious, and, of course, the very idea that a useful "theory" of management is possible is much disparaged by practicing managers.

Nevertheless, the case for using action research in management is strong. The case was presented in the most authoritative terms in an exchange between Van de Ven, Argyris, and Beer at a research conference at the Harvard Business School in 1998. The conference was designed to address the “paradox” of change management and was aptly titled “Breaking the Code of Change”, which became the title of the book published on the basis of the conference proceedings, and an article in the Harvard Business Review. (Beer and Nohria, 2000 a, b)[28].

The exchange between Van de Ven, Argyris, and Beer arose out of a reference made by Van de Ven to a case study of business school management by Nobel Prize winner Herbert Simon published as an appendix to the third edition of his seminal book on Administrative Theory (Simon 1964/1976)[29].

Simon writes:

> The tasks of the business school are to train men for the practice of management as a profession and to develop new knowledge that may be relevant to improving the operation of business…Business schools are a particular species in the genus known as professional schools ….Information and skills relevant to the accomplishment of a professional school’s teaching and research goals come from two main sources. First, they come from the world of practice: information about the institutional environment in which the profession is practiced, about the [problems of the practitioner….Secondly, effective access to information and skills within the several sciences that are relevant to and contributing to and contributing to the improvement of professional practice…A professional school administration…..have an unceasing task of fighting the natural increase of entropy, of preventing the system from moving toward the equilibrium it would otherwise seek….All efforts to prevent this equilibrium state of death must be aimed at lowering the

[28] Despite the case for action research being made relevant to a discussion of change management, it is argued that this has direct relevance to any discussion of knowledge management in the sense that knowledge management is inevitably about taking action. An important link is made by understanding that managing change involves framing data to provide information leading to decisions and action. Following Kahneman and Tversky’s (2000) lead, change management can be interpreted as shifting people from being risk averse (and resisting change) to being risk seeking (and adopting change).
[29] An original version was published in the *Journal of Management Studies*, Vol. 4. pp 1 -16 , 1967.

> barriers that impede communication between the discipline-oriented and profession-oriented wings of the faculty…One of the deep sources of communication difficulty between the discipline-oriented and the practice-oriented members.. stems from the difference between science and art, between analysis and synthesis, between explanation and design…The techniques the scientist uses toward his goals are usually called "analytic"…. The techniques of the practitioner are usually called "synthetic"….
>
> Analysis leading to explanation is generally thought to be itself susceptible of analysis and systemization. It is thought to be teachable because it is explicitly stateable. Explicitness and lawfulness are characteristics attributed to science. Synthesis aimed at design is generally thought to be intuitive, judgmental, not fully explicit. Design cannot be fully systemized, hence is an art, so it is said…..A full solution, therefore, of the organizational problem of professional schools hinges on the prospect of developing an explicit, abstract, intellectual theory of the processes of synthesis and design, a theory that can be analyzed and taught in the same way as chemistry, physiology, and economics can be analyzed and taught[30].

(Simon, 1976, pp. 335-356).

While this statement defines the core of the discussion between Van de Ven, Argyris, and Beer, it also provides insight into the importance of systemic thinking in management and the roles of synthesis and analysis. Indeed, one may relate Simon's observations to the scientific method described in Chapter 4, in which he is associating the need for business schools to emphasise synthesis. The model in Chapter 4 would suggest that both aspects of thought are essential, but the issue is

[30] In an interesting sequel to this discussion, Takeuchi (2004, p. 343) describes the principles upon which the Graduate School of International Corporate Strategy (ICS) at Hitotsubashi University has been formed. Takeuchi identifies ICS as a "dialectic organization" where "(W)e utilize knowledge as the key resource to transcend and synthesize the opposing worlds listed below:

- East and West;
- Small and large;
- New and old;
- Practice and theory;
- Cooperation and competition;
- Public and private; and
- Haves and have-nots"

better resolved by noting the importance of abduction, and understanding that management action results from acting on the hypothesis to the best explanation (Chapter 6 extends this argument by suggesting that management is really about action research, the point made by Argyris in response to Van de Ven).

In his paper, Van de Ven (2000) notes the critical influence Simon's observations had on his research approach which he encapsulated as a "baseball diamond" linking reality, conceptual model, theory, and solution as shown in Figure 6.1. But Van de Ven's appreciation tends to be more aligned to Simon's description of the analytic approach with implicit positivist assumptions about problems being well defined, contained and suitable for problem solving as distinct from "puzzle" learning (Emery, 1999, p. 26).

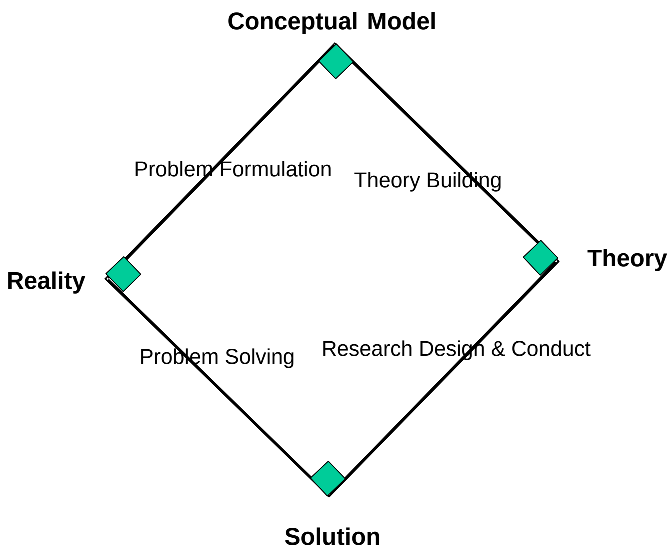

Figure 6.1. Van de Ven's Professional Research Diamond Model

In contrast, Argyris's paper illustrates a number of examples that "exemplify the gaps and inconsistencies in the expert's wisdom" concerning change management; he proceeds to propose a "theory of effective action". He lists six premises to his perspective:

- At the core of human and organizational life is effective action.
- Actions are produced by individuals using their mind/brain

- The way the mind/brain produces actions is to use the designs that are stored in and retrievable from the human mind/brain
- The designs are causal. They specify intentions to be achieved, the actual behaviour required to achieve them, and the values that govern actions
- The designs that are actionable must also be testable, or else we can never assess our effectiveness
- Individuals hold designs that they espouse and designs that they actually use. The key to change is to get at designs in use or theories in use.

Argyris (2000) applies these premises to Van de Ven's model and homes in on the fact that Van De Ven's model is not a theory of action. Argyris observes that Van De Ven's model is:

> …..consistent with normal science rules about developing theory and research. The four perspectives are teleological theory, life-cycle theory, dialectic theory, and evolutionary theory….Van de Ven then specifies some core features of the theories…that may be valid for those mind activities that are used to understand and explain. They are not valid for those activities where the understanding and explanation are in the service of action…..in order for the human mind to produce actions that are observed to be unclear; it must use clear, ruthlessly programmed action-design. Imprecision is produced through precision.

(Argyris, 2000, pp. 423-424).

In his commentary on both papers, Beer identifies the gap between the two positions as symptomatic of the problem of attempting to break the "code of change", and reflective of the differences identified by Simon. He notes the conference's immediate acceptance of Van de Ven's more conventional views on scientific research (in which research may be research for research sake) but describes the "scepticism, defensiveness, and even hostility" that greeted Argyris's view that "academics and consultants in the room were not producing knowledge that was actionable" (that is, where research must have an *action* component) (p 434-5).

Beer traces "our inability to break the code of change" to "the ambivalence of three actors- academics, leaders and consultants- to inquire into the effectiveness of their practice". He goes on to advocate "deep longitudinal inquiry" and advocates a process that:

> …..requires academics to adopt a more clinical and systems orientation to their work. It requires that they accept a common language and framework for describing organizations as systems, and that they see the evaluation as legitimate and important work…Moreover, this research will require that academics, consultants, and CEOs cooperate in the inquiry process….*To make knowledge usable, an action science approach is needed.*

(Beer and Nohria, 2000b, p. 442)

(Italics inserted for emphasis).

Beer then cites an action science process approach he had developed with Russell Eisenstat and implemented in "a large corporation". He claims this approach contributes to the development of an "action and descriptive theory of change". He concludes:

> In order for progress to be made in breaking the code of change, two parallel, but equally important research streams need to be undertaken. The first stream….will produce relevant descriptive theories of organizational change… the second stream will make descriptive knowledge actionable by generating valid theories of the change process itself…..Action theories will close the…. Gap between academics' and consultants' desire to help managers implement research findings and the difficulties of doing so.

(Beer and Nohria, 2000b, p. 444).

Beer and Nohria (2000a) refer to these two streams represented by Van de Ven and Argyris as theory "E", for the rational economic (closed system) business argument, and theory "O", for the more (open system) descriptive process,

Beer was not the first to articulate an action-based approach to change. Obviously Argyris was making reference to his theory of double loop learning and a plethora of associated "organisational learning" theories and practices have emerged (Dierkes, et al, 2001)

In one of the earlier attempts to discuss action research in management, and specifically to organisational development, Cunningham (1993) describes action research as "a term for describing the spectrum of activities that focus on research, planning, theorizing, learning, and development. It describes a continuous process of research and learning in the researcher's long-term relationship with the problem". Cunningham proceeds to demonstrate in quite practical terms how action research can be linked to change management and "other organizational development practices such as strategic planning". He pays particular attention to three sequences of the change process (p73):

- Defining the need for change
- Focussing a direction and developing a commitment to the changes, and
- Implementing the plan.

A significant aspect of Cunningham's coverage is the degree to which he is able to demonstrate the application of qualitative survey methods within the action research process. For example, he identifies the triangulation process with the action research process of gathering information from multiple perspectives (p 170).

He concludes with the observation that "(W)hat makes action research different are the practices encouraging an understanding of a real life problems, involving people in a collaborative relationship, and using grounded concepts" (p 254), and proposes the role of action research in the resolution of a number of management dilemmas that we can still identify with today:

- Total organizational versus Departmental of Group change
- Changing people versus changing structures
- Power versus integrative strategies
- Information gathering versus facilitation
- Top-down versus bottom-up
- Rapid versus slow change.

6.2. Business Action Learning.

Before proceeding to discuss the scientific case for action research, it is important to address the more commonly known area of "business action learning" and understand its relationship to action research. In most cases, references to action learning in business refer to the work of Revans (1971, 1978, 1982, 1998). A prominent example of the use of Revons' model is Boshyk's "Business Driven Action Learning" (BDAL) (Boshyk, 2000, 2002). Boshyk describes BDAL as:

> …a process and philosophy that can help change people change a company's strategy, and the behaviour of its people. In its most accomplished form it can provide breakthrough business results as well as highly rewarding personal and organisational learning and development…As a philosophy, business driven action learning is based on the belief and practice that learning should be tied to business realities, and that some of the best business solutions can come from fellow executives and employees.

(Boshyk, 2000, p xi).

In his second volume, Boshyk sharpens this definition to emphasise leadership and results:

> BDAL is a term used to describe a results-focused orientation to individual leadership development and organizational learning and change. It can be

> summarized as integrating individual development and organizational strategy with business results.

(Boshyk, 2002, p. 30)

As way of an example, Boshyk cites the case of Asea Brown Boveri (ABB), who stated its belief:

> …that its managers learn and develop 70% on the job, 20% through the influence of others, including their bosses, colleagues, and subordinates, and 10% through external courses and seminars.

(Boshyk, 2002, p. xi)

Illustrating the extent to which BDAL has been popularised, Boshyk (2000) is based on papers delivered at the first "Global Forum on Executive Development and Business Driven Action Learning" held in June, 1996. The following multinational companies are represented:

- Daimler Chrysler
- Dow
- DuPont
- General Electric
- Heineken, Shell etc, as part of a Dutch consortium
- Hoffman La Roche and Boehringer Mannheim
- IBM
- Johnson & Johnson
- Motorola
- Philips
- Scancem
- Siemens
- Volkswagen

Boshyk's second volume (Boshyk, 2002), which is based on subsequent global forums (dates not given), broadens the coverage by looking at some "new economy" companies and some not-for-profit organisations. Some attempt is also made to provide a more worldwide perspective by looking at the action learning as practised in three areas of North and South America; Europe; Middle East and Africa; and the Asia-Pacific. This includes some of the emerging markets in Europe[31].

On the basis of the cases, Boshyk concludes that BDAL as practised in some of the best companies involves five key elements:

- The active involvement and support of senior executives;
- Work on real business issues and the exploration of new strategic business opportunities;
- Action research and learning focussed on internal and external company experiences and thinking that can help resolve business issues;
- Leadership development through teamwork and coaching;
- And the implementation of recommendations and follow-up on business issues examined, and the organizational and individual learning that took place, thus enhancing positive business results and ensuring that learning is greater than the rate of change.

(Boshyk, 2000. p xiv).

Boshyk goes on to emphasise that BDAL differs from other forms of action learning because it not only addresses the importance of individual and group learning, but "integrates company-wide learning with individual executive development and teamwork". Furthermore, BDAL embraces a full range of learning methods including:

- Traditional methods (lectures and cases);
- Individual learning (learning journals, self evaluation, coaching etc);

[31] This is an ambitious volume with discussion ranging from more on GE to Tibetan Buddhism and the Action Reflection Learning Philosophy.

- Consulting methods (researching, analysing, interviewing, presenting; communicating, implementing);
- Benchmarking and best practices (experiential learning, best practice visits, competency analysis and gap analysis);
- Team-based learning (facilitation, coaching);
- Information technology (knowledge management, groupware, distributed learning, simulation, videoconferencing).

While the cases described emphasise company practice, few of the cases expose any strong theoretical basis to the design of their approach. Essentially this is left to a chapter by Weinstein (Boshyk, 2002, Ch 1) in which Revons' contribution is emphasised.

Despite the obvious caveats about the objectivity of the cases presented and Boshyk's assessment of the performance of BDAL, his work does provide one of the most comprehensive accounts of action learning in recent business history. In this sense it contrasts with the more theoretical treatments of action research such as that provided by Reason and Bradbury (2001) and the more theoretical coverage of organizational learning such as Dierkes et al (2001).

The Revons' Action Learning Model.

Revons (1971, 1979, 1982, 1998) summarised his approach using the "learning equation":

L = P + Q

where :

L = learning
P = traditional instruction or programmed knowledge; and
Q = "the ability to ask insightful questions when there can be no certainty as to what next might happen".

The significant thing is that while P may be necessary, it is not sufficient for learning to take place. Sufficiency requires both P and L.[32]

Lessem (1993) provides a significant insight into the basis of Revons' approach. Lessem argues that Revons was strongly influenced by English empiricism and "pragmatic traditions"[33], specifically, Francis Bacon (17th Century), Adam Smith (18th Century), and Samual Smiles (19th Century). Revons' evidences this by the manner in which his learning equation draws distinction between his P and Q terms. While Revons is critical of the extent to which these two factors have been separated in management science, one wonders whether Revons is making this distinction largely to emphasise that his approach has a bias towards Q. Lessem observes that Revons:

> …..reveals an almost religious devotion to grounded learning, and to the 'spiritual barter' that fellow learners undergo in the process….. a process whereby our latent capacity for warm and genuine exchanges manifests itself… Revons's mission may well be reflected in the quote from Toynbee's A Study of History:
>
> "Real progress is found to consist in a process defined as 'etherealisation', an overcoming of material obstacles which releases the energies of society to make responses to challenges which henceforth are internal rather than external, spiritual rather than material."
>
> Revons' vision has evolved through a lifetime of action learning, undoubtedly shaped by his experience as athlete, scientist, manager and coalface worker. He has devoted some fifty years to developing his ideas and testing them in companies, the hospital service, in government and education. Perhaps more than anything, he has fought to close the gap, particularly in Britain, between the 'artisan' and the 'scribe'.

(Lessem, 1993, p.63).

[32] Obviously this "equation" is purely symbolic: if "+" is being used as a logical operator, then its additive nature precludes any interaction between P and Q. A multiplicative logical operator would be more appropriate.
[33] This reference to "pragmatic traditions" should not be confused with American Pragmatist philosophy- see Chapter 3.

Lessem concludes that Revons's version of action learning is:

> ….caught between three stools. On the one stool sits Mr Commonsense. He says he does it anyway, so what's the all the fuss about? On the second stool sits Mr Conservative. He says that it all sounds like good stuff, but why should he rock the steady boat? On the third boat sits Mr Social skills. He says that action learning is just one kind of interpersonal process. It has its merits, but so do a whole lot of other approaches.

(Lessem, 1993, p. 78-79).

Lessem describes Revons' learning process model as a triangulation between understanding, action, and reflection and draws parallels with Kolb's Learning Cycle which he claims is "an adaptation, consciously or otherwise of that of Revons". (Lessem 1993, p. 70).[34]

If Boshyk's surveys are a guide, Revons' work has obviously generated a great depth of practice. Indeed quite a remarkable set of "marketing channels" have been developed to deliver the Revons framework and philosophy. These "channels" include:

- The Revons Action Learning & Research Institute established in 1995 at Salford University, UK. This institute cites some 210 research practitioners (as of March, 2003)[35].
- The MiL Institute founded as a non-profit organisation in 1976-77 at Lund University, Germany. This Institute has some 150 companies and 100 professionals in its network and conducts international executive programs in the UK & Europe, US, and Asia. It co-founded the Scandinavian Action Learning Society[36].

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[34] This is something of an audacious claim- Kolb's learning cycle, along with its first cousin- Deming's PDCA cycle, has distinct and identifiable links back to Dewey's experimentalism and hence to Singer and Peirce. It is more likely that it is Revons who (re)discovered a form of this earlier form of learning and scientific method.

[35] See www.revansinstitute.co.uk

[36] See www.milinstitute.se/cgi-bin/uncgi

- The University of Action Learning at Boulder, Colorado, USA, which conducts accredited Bachelor's degrees, Graduate certificates and diplomas, and Master's degrees. It was established within the global framework of the International Management Centres Association (IMCA)[37].
- IMCA - described as "the world's leading Action Learning association"[38].

Revons' model has been developed by others to include further processes. Burke (2001) summarises these developments as follows:

L=P+Q+I ………..Marquardt (adds Implementation)
L=P+Q+C+I ………….Davies (adds Culture)
L=P+Q+WoK+C+I ……… Inayatullah (adds Ways of Knowing).

These extension cast doubt on the sufficiency of Revons' initial model and emphasise the empirical nature of the model.

The key feature of the Revons' approach is its emphasis on "action" with aspects of "research" and "science" left at a somewhat superficial level.

Indeed, Revons' model is an example of an approach which, in Boisot's (1998) terms, is "codified" and diffused but in which the "abstraction" has not taken place.

In this sense, the learning equations represent a codification of experience gained from applications in industry such as those described by Boshyk (diffusion). While components of Revons' action learning clearly align with aspects of Boisot's social learning cycle, the absence of a clear process of abstraction provides the key distinction between Revons' action learning and action research or action science.

6.3. Action Research: Methodologies and Validity.

Reason and Bradbury (2001b, p.3) observe that while many writers trace the origins of action research to "the social experiments of Kurt Lewin in the 1940s" and the

---

[37] See www.u-a-l.org
[38] It has a branch based in Brisbane with further links to websites such as Metafuture.org.

"socio-technical experiments begun at the Tavistock Institute….there are others which deserve acknowledgement". While Reason and Bradbury provides a useful contemporary account of action research, it will serve our purposes in the context of management to follow these more traditional lines starting with Lewin. Indeed, a problem for using the term "action research" in any single field, particularly where you want to make comparisons with positivist research, is that the term "action research" has so many meanings.

Reason and Bradbury comment:

> For the term 'action research' has been used in so many different ways that the term has lost some of its original weight. Sometime it is used to describe positivist research in a 'field' context, or where there is a trade-off between the theoretical interests of the researchers and the practical interests of organization members; sometimes it is used to describe relatively uncritical organizational consulting based on information gathering and feedback…..The action research family includes a whole range of approaches and practices, each grounded in different traditions, in different philosophical and psychological assumptions, pursuing different political commitments.

(Reason and Bradbury, 2001, p. xxiv).

Reason and Bradbury identify the following diverse origins to the various connotations to action research:

- Lewin's exploration of group processes and social inquiry
- Tavistock Institute's experiments with socio-technical systems and social democracy
- Critiques of positivist science and scientism
- Indigenous traditions
- Marxism
- Liberation movements
- Spiritual approaches to inquiry

- Pragmatist philosophy

Reason and Bradbury (2001 b) finally characterise action research in terms of the five "broadly shared features":

- An ultimate goal to improve the human condition
- An agreement to work towards practical outcomes
- The creation of new forms of understanding through experience and reflection
- The application of participative processes
- A reliance on emergent phenomena as "individuals develop skills of inquiry and as communities of inquiry develop within communities of practice" (p 2).

Reason and Bradbury summarise these characteristics in Figure 6.2.

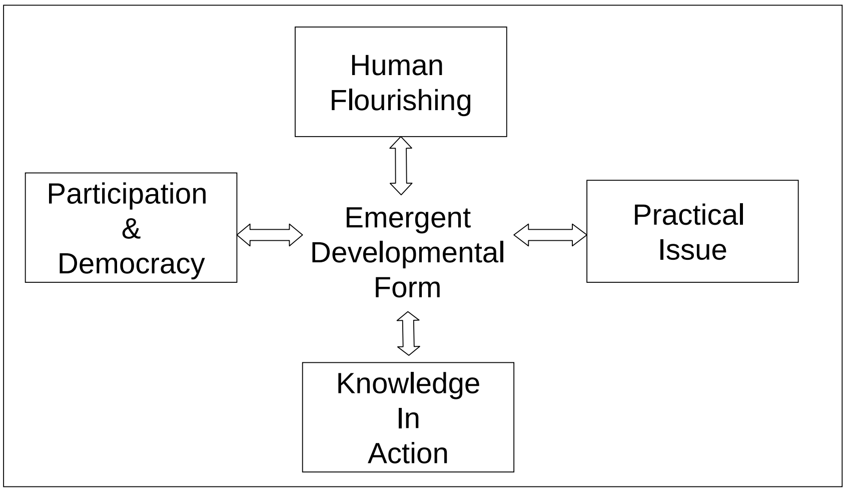

Figure 6.2. Characteristics of Action Research. Reason & Bradbury (2001b, p. 2)

It may not be surprising to note that, although dealing at a high level of aggregation, there is a correspondence between the key characteristics of action research described by Hilary and Bradbury, and the modes of scientific inquiry proposed by Peirce (Chapter 3); see Table 6.1.

Reason & Bradbury	Peirce
Improve the human condition	Resolution of doubt
Practical outcome	Pragmatic maxim
New forms of understanding through reflection & experience	Three modes of inference
Participative processes	Community of inquiry

Table 6.1. Comparison of Reason & Bradbury's View of AR with Peirce.

Action Science.

Argyris, Putman and McLain Smith (1985) introduced the term "Action Science" - a *science* of human action in an attempt to bring action research back to its integrative roots as described by Lewin.

Most, like Argyris et al attribute the origins of action research within social science method to Lewin who's "work in social and applied psychology took the form of action research" (Gold, 1999, p. 253). Most significant is Gold's observation of Lewin's:

> …commitment to the idea that the immediate situation is always implicated in behaviour inevitably led him to attend closely to the contemporaneous social environment to effect behavioral change.

(Gold, 1999, p. 253).

In systems thinking terms, this aligns Lewin with the other open systems theorists coming out of psychology (see Chapter2).

Blum (1955) provides one of the most useful accounts of action research as developed under Lewin at the Research Centre for Group Dynamics, University of Michigan, in the period 1945 – 1955 and pinpoints the scientific objection to action research in these terms:

> The main objection which the action researcher has to meet squarely is that he confuses his role as a scientist with his role as a human, social, political and ultimately a religious being that he ceases to do objective research as he becomes entangled with the world of values.

(Blum, 1955, p. 4).

Argyris et al (1985) address this issue by first recognising three objectives as fundamental to Lewin's approach:

- Learning is the first and overarching objective.
- Any knowledge produced should be formulated into empirically disconfirmable propositions.
- Knowledge can be organized as theory.

In these terms they argue that attempting to use "rigorous research" in the social sciences may be "self limiting":

> We would be content to use the term "action research" if it was not for two factors. First, over the years action research has often been separated from theory building and testing. Leading social scientists distinguish action research from basic research by asserting that the intention of action research is to solve an important problem for a client and not necessarily to test features of a theory….Second, many action researchers understandably conduct their empirical work by following the current ideas about standard scientific research. The dilemma is that some of the currently accepted ideas of rigorous research may be self limiting.

(Argyris et al, 1985, p.x).

Argyris and Schon's (1996) solution to the objection relating to objectivity articulated by Blum was to introduce a process of rigorous reflection.

Argyris et al's approach is an elaboration with a specific emphasis on implementation of Argyris and Schon's two theory-in-use models (I and II). Model 1 theory-in-use corresponds to a form of bounded rationality (Simon, 1964/1976) in which people impose their own meanings on action and become dogmatic about them. Consequently, it becomes difficult for them to openly reflect on their motivations and actions and they become defensive in conversation. Model 1 is also consistent with a closed-systems view of the world in which contexts and environments are locked out (Argyris, 1983, 120).

The capability of being able to effectively reflect on actions and motivations involves the adoption of Argyris and Schon's Model II.

These two modes of learning have become popularised under the headings of single and double loop learning (Argyris and Schon (1974, 1978, and 1996). Argyris (1983) provides a succinct version of the action science perspective). As noted in Chapter 1, Flood and Romm (1996 a,b,c,d) have added a third element of critical reflection that includes ethical considerations; triple loop learning.

The Emery Ecological Learning Model.

Emery (1999, p. 54) points out that while the above approaches to learning address questions such as "are we doing the right things right?" and is "rightness buttressed by power?" and espouse emancipatory practice, they do not address the question of "learning from the environment"; they are essentially assuming a closed system framework as distinct from the "ecological learning" approach that originates from contextualism and sits at the centre of the Emery Open System Model. This approach is best represented by Emery's open systems model (Emery, 1999; 2000) as described in Figures 6.3 and 6.4.

There are two key aspects of this model that make it distinctive: it introduces a "causal texture" of relations in the system environment (L22); secondly, it emphasises that the agents operating in the system can influence this environment (L12). This model is very much about the real time, co-evolution of the system and its environment. The relationships L11, L12, L21, L22 capture the dynamics of this co-evolution (Figure 6.4).

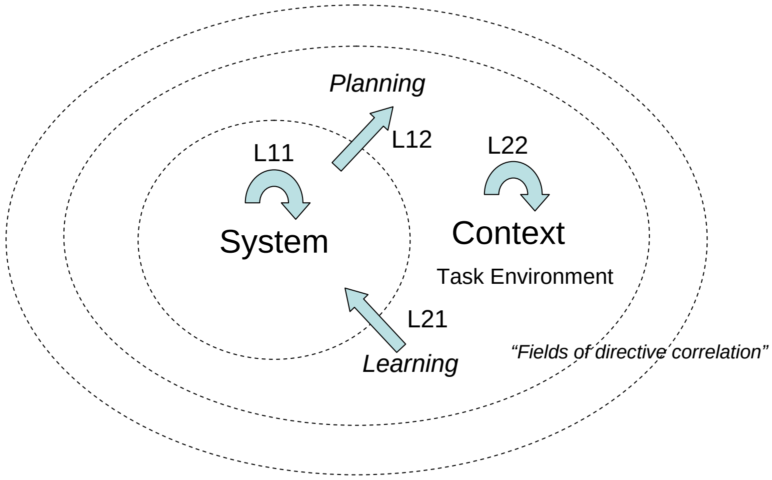

Figure 6.3. Emery's Open Systems Model- A Static View

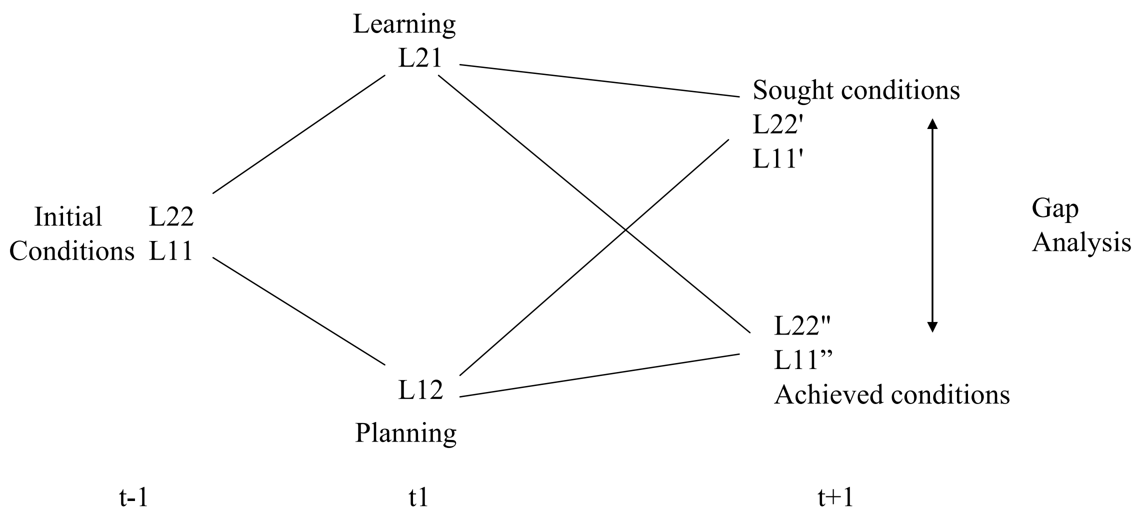

Figure 6.4. Emery's Open Systems Model- A Dynamic View

Emery's OST can be applied recursively with individuals, groups and organisations operating as purposeful, open systems. Consequently, for example, the job of each person in an organisation can be interpreted as managing a network of stakeholder relations, each representing elements in connected networks in the information fields described by Johnson (1996); a virtual organisation. Each person can be described as a knowledge worker in the sense described by Sveiby (2001, pp. 355-356).

To apply this learning framework (for example, as an approach to learning in knowledge management) the following steps can be followed:

1. Establish the enabling conditions for cultural change. For example, Emery (1999, p.211-234) describes a well-developed framework for introducing DP2 into organizations called the "DP workshop. The issue of enabling conditions will be further discussed below.
2. Establish strategic intent. Strategic intent is an expression introduced by Hamel and Prahalad (1989) to describe an organisation's goals in quantifiable terms. It applies the pragmatic maxim by expressing the organisation's purpose in terms of outcomes and can be established using the Emery Search Conference (Emery, 1999). The search conference involves establishing a "community of inquiry" that does not have to represent all stakeholders, but is knowledgeable about their needs and interests and proceeds by exploring the L22 relationships with the intention of defining possible and desirable futures. Using a funnel analogy, the workshop gradually reduces the scope of the conversation down to action plans for implementation.
3. Develop an operational model that makes functional management systemic. This aspect is discussed below.
4. Imbed the complete structure within a learning framework that aligns with strategy implementation (see Chapters 6 and 7).

The Emery model, which has its origins in the Tavistock Institute and traces back to the Heider's theory of perception (see Chapter 2) in which the environment is rich in data which can be understood and is knowable, describes a process of search in which learning is embodied as "the education of perception" (p. 69):

> Throughout, participants use their perceptions and experience as the data on which they build their futures. In data collection, participants collectively contribute changes they have seen. There is no other source other than their perceptions and experience on which to judge the significance of their changes. The ground rule is that 'all perceptions are valid'. This has multiple effects, not the least of which is that people begin to restore their confidence in the value of their perceptions. It also has the effect of preventing those with more formal status from devaluing the perceptions of those with less status.

(Emery, 1999, p. 69).

This stage of ecological learning corresponds to the Peirce's abductive stage of inquiry. The process of continuous ecological and experiential learning continues in the action phases provided the organisation operates according to "Design Principle 2"; redundancy of functions (Emery, 1999. p. 105 – 136). This structure provides an organisational context within which ecological learning can operate (See previous discussion of enabling conditions for knowledge management).

Checkland's Soft System Methodology (SSM).

The action research component of Checkland's Soft Systems Methodology (SSM) (Checkland, 1981; Checkland and Scholes, 1990) has emerged as the most important aspect of SSM[39]. Checkland and Holwell (1998 a, b) recognise this shift of emphasis by giving the action research component the central place in their methodology for information systems work.

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[39] It may be argued that the input-output, mechanical transformation view sitting behind the CATWOE and rich picture processes is actually inconsistent with the open-systems, emergence view that sits behind the learning process defined by Checkland. But understanding the relationship between closed systems thinking and open systems and the importance of these tools in abductive thinking (Chapter 3) resolves this issue.

Checkland and Holwell (1998 b, p. 12) use Argyris et al (1985) to identify four "crucial elements in a research approach which works within a specific social situation:

- A collaborative process between researchers and people in the situation
- A process of critical inquiry
- A focus on social practice, and
- A deliberative process of reflective learning".

The important contribution that Checkland and Holwell makes is the manner in which they articulate the difference between the traditional scientific method with its focus on the replication of results, and action research with its acknowledgement that, quoting from Keynes, social science is not dealing with phenomena that are "homogeneous through time". That is, in social science we are dealing with *open* systems. Checkland and Holwell describe in detail a generic action research cycle that incorporates both single and double loop learning, the double loop reflection being based on three aspects:

- The framework of ideas adopted, F
- The methodology, M used that is based on F, and
- The identification of the area of concern to which this framework may be applied, A.

Reflecting on some 25-30 years experience with the application of the SSM action research model, Checkland concludes that a primary distinction between traditional science and action science is that in traditional science knowledge is progressed through the replication of *experiments*, but in action science, knowledge is progressed through the replication of *process*. (Checkland, 1999).

Checkland and Holwell (1998a) make this same point in their reference to the need for action researchers to increase their appreciation for a "declared epistemology and hence a recoverable research process".

To complete this path of increasing rigour, it is necessary to integrate the threads of this thinking with the model of science explained in Chapter 4, and by further recognising the manner in which Peirce's triadic inferential logic, and the role of abductive inference in particular, to further articulate the relationship between action research (or action science) and "laboratory" science.

To establish this link, we need only recognise the relevance of Dewey's experiential learning cycles shown in Figure 6.5 and its popularisation in more recent times through the work of Kolb (1984) and others, and its adoption in quality management via Shewhart and Deming (1982, p. 88).

While acknowledging the contribution of others such as Jung, Rogers, and Maslow, Kolb identifies Dewey, Lewin, and Piaget as the "foremost intellectual ancestors of experiential learning theory" (Kolb, 1984, p. 15). He identifies seven themes that provide guidance to experiential learning. These are summarised in Figure 6.6.

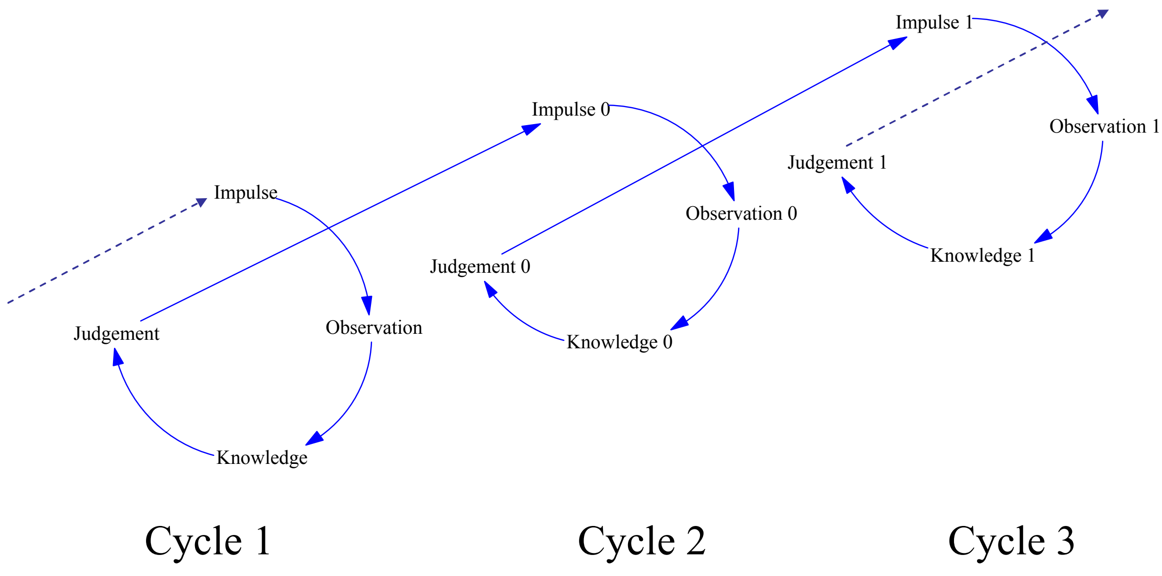

Figure 6.5. Dewey's Experiential Learning Cycle (Kolb, 1984, p. 23).

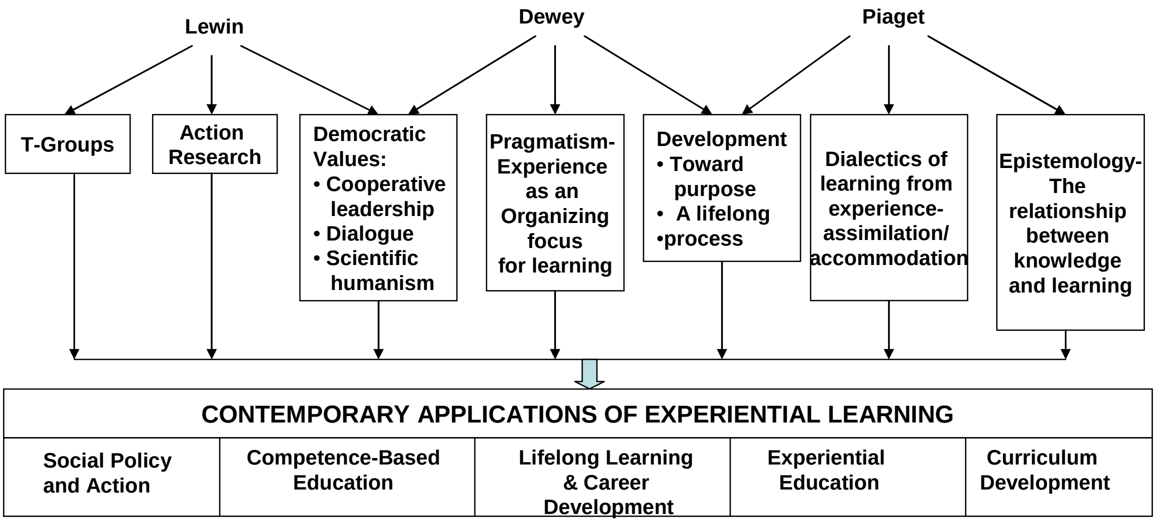

Figure 6.6. Theories of Experiential Learning (Kolb, 1984, p. 17).

Reinforcing the role of dialectic in learning, Kolb argues that each of these models:

> …describes conflict between opposing ways of dealing with the world, suggesting that learning comes from resolution of these conflicts. The Lewinian model emphasises two such dialectics- the conflict between concrete experience and abstract concepts. For Dewey, the major dialectic is between the impulse that gives their "moving force" and reason that gives desire to that direction. In Piaget's framework, the twin processes of accommodation of ideas to the external world and assimilation of experience into existing conceptual structures are the moving forces of cognitive development.

(Kolb, 1984, p. 29).

Kolb (1984, p. 224) identifies "integrity" as the "pinnacle of development. It is the highest level of human functioning that we strive consciously and even unconsciously, perhaps automatically, to reach". For Kolb, making reference to Pepper's world hypotheses:

> (T)he knowledge structure of integrity does not conform to any one of (Pepper's) knowledge structures ….it is usually some integrative synthesis of these in the emergent historical moment…… Thus in integrative learning, knowledge is refined by viewing predicaments through the dialectically opposed lenses of the four basic knowledge structures and then 'acting sensibly'.

(Kolb, 1984, pp 225-226).

This describes the evolutionary path defined in the dialectic approach to science developed in Chapter 4, and provides a learning framework within which to undertake a pluralist approach to systems thinking.

Does Action Research Constitute "Rigorous" Science?

When this question is posed, it is being framed in terms of the received position of positivist science. When posed in these terms, it is not surprising that, as Susman and Evered (1978) conclude, action research in its various guises, does not constitute "rigorous" science.

Susman and Evered's principal reason is that action research cannot meet Hempel's covering-law model of explanation in which "the relationships between actions and their consequences can be explained as particular cases falling under more general laws governing actions and their consequences" (Susman and Evered, 1978, p. 590). Checkland's response is that action research attempts to replicate *processes*, and that the learning structures described by Argyris, Emery, Checkland and Holwell, Kolb and others represent particular cases of "covering laws". Complementing this, it is suggested that the model of the scientific method described in Figure 4.2 represents the "covering law" for AR processes.

Argyris and Schon's attempt to address the problem of objectivity can be added to this, and no doubt other ways of attempting to meet the various criteria of positivist science. But the problem is in the question and the interpretation of what constitutes "rigorous science".

As Susman and Evered point out, there are many deficiencies in positivist science. In particular, as the debate between Argyris and Van de Ven demonstrates, management is about action in open systems. As explained in Chapter 4, whether one are talking about positivist science, or action research, action is taken on the basis of a hypothesis that is always going to be conditional on circumstances relating to the system of knowledge of which the hypothesis is part. In the closed systems world of positivist science, it is presumed that these conditionals are both known and controllable. In open systems, neither assumption is true. So one acts on the basis of the best explanation.

The critical question to be faced by positivist science, is that it only confirms hypotheses under strict conditions. What happens when action is taken on the basis of these hypotheses in the context of an open system? For example, what happens when a drug that has been extensively trialled under laboratory conditions is released into the open community? Do the hypotheses established by positivist research still hold? One never knows, until one tries! That is, one is acting on the basis of a hypothesis to the best explanation and a transition has occurred from a positivist research domain to an action research domain. In this sense the positivist research has simply been part of what Peirce called "retroduction" (Chapter 3)!

The model of science described in Chapter 4 accommodates both positivist research and action research, depending upon whether or not the hypothesis is framed in terms of closed or open systems. In the example of the drug release mentioned above, the early cycles of the dialectic involving synthesis and analysis may be purely designed to undertake positivist research; the later cycles may then relate to action research involving evaluation using triple loop learning. This may result in further cycles of closed system laboratory testing; further retroduction, before releasing a newer form of the drug into the community.

This suggests that positivist research and action research should be understood as being complementary, not in competition with each other.

Table 6.2 sets out some comparisons between the two modes of science based on the above discussion and complements the table offered by Susman and Evered (1979, p. 600).

Conclusions.

In a sense this discussion has come full circle, but before summarising, it is worth returning to an outline of Peirce's approach to inquiry.

In specific consideration of Peirce to action research, it is noted that while many social theorists have discussed pairs of combinations of the three themes- action, research and management, few have contributed to all three. For example, Weber links action theories to economic organisation and hence management (Weber, 1947), but appears to say less about research. Peirce had something significant to say about each of the three terms being discussed. In doing so, he picked a well-defined path through many of the confusions alluded to earlier. In essence this is achieved by the adoption of a distinct worldview (continuity) and a rigorous approach to learning and the creation of knowledge.

Property	Positivist Science	Action Research
Systems frame	Closed	Open
Repeatability	Experimental result	Process
Conditionals on hypotheses	Known and controllable	Unknown and not controllable
Objectivity	Apparent independence of researcher but dependent on the norms of peers	Triple loop learning evaluation; dependent on values of the community of inquiry
Predominant mode of inference	Deduction	Abduction
Action based	No	Yes

Table 6.2. A Comparison of Action Research and Positivist Research.

In his pragmatic maxim, Peirce (1877, 1878) associates meaning with the conception of action - the pragmatic maxim is the “doctrine concerning the meaning, conception, or rational purport of objects, namely, that these consist in the effects which might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of these effects is the whole of our conception of the object”.

William James interpreted this as implying that “beliefs are rules of action”, a statement that Peirce saw as an oversimplification, but one that we can recognise as at least pointing us towards the linkage between belief and action.

With respect to “research” Peirce again comes to our aid with his articulation of modes of inquiry and rules of inference. Peirce describes inquiry as the “process of struggle to pass from a state of doubting to a state of belief” (Hausman, 1993, p 20). Peirce describes this process as one involving a “community of inquiry”, and so places inquiry (and research) as very much concerned with a social process, and, indeed, a process of social action and interaction. In this respect Peirce anticipates the arguments of Thomas Kuhn (Kuhn, 1970).

Peirce’s strict application of logic to the inquiry process as articulated in his three modes of inference- abduction, deduction, and induction- introduces an evolutionary epistemology that pre-empts Popper and establishes the logical foundations for action research.

Peirce, at least as interpreted by Beer (1996) in his discussion of Peirce’s four ways of “fixing belief” (decision making) (Peirce, 1877), adds further to an interesting and productive insight into decision-making, and hence management.

Peirce’s emphasis on the adoption of a social context to science and his advocacy of an evolutionary epistemology that provides a broader approach to science than simple objectivist approaches encompasses the fundamentals of both Kuhn and Popper[40]. In

[40] Churchland, 1986, provides an insightful summary of contemporary developments in the philosophy of science, including a discussion of the contributions of Peirce, Popper and Kuhn.

simple terms, Peirce's adoption of an open system, contextual view (Pepper, 1942), provides the basis to the underlying logic of action research.

In this sense, the links between Peirce's thought and that of a range of contributors start to become clear. In particular, we should recognise that it is Peirce's triadic logic that sits behind Dewey's experiential learning cycle[41].

In summary, the discussion has moved from a position in which action learning, as developed by Revons, is revealed as arguably very well known in industry, buts lacks a sound intellectual basis, that action research has in fact diverse origins and expressions, but that Lewin be recognised as the principal developer in terms of the social sciences notwithstanding the contribution of the Tavistock Institute. The problem of action research not being objective is addressed by Argyris and Schon's concept of single and double loop learning which involves open reflection on processes. This process has been extended in two ways: by Flood and Romm's triple loop learning, and by Checkland and Howell's use of FMA structure in the double loop learning phase. However, as Fred and Merrelyn Emery argue, these approaches ignore the importance of the environment. Instead, Fred and Merrelyn Emery provide an action learning approach rooted in theories of perception. Their approach is called "ecological learning". Consequently, it adds a dynamic to Lewin's model and situates action research within the theory of contextualism with a basis in Peirce's pragmatist philosophy.

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[41] In his early writings Dewey fails to give full credit to Peirce's influence on him. (White, 1977) p. 152 comments that Dewey adopted Peirce's view that "logic was an instrument for arriving at warranted assertions" but only really acknowledged this when Dewey's *Logic* was published in 1938: "The Logic, when it appeared, could very well include a statement of Dewey's sympathy with Peirce. But this sympathy was relatively recent. Despite the fact that Peirce had taught at Johns Hopkins while Dewey was a graduate student there, Dewey was hardly influenced by him then. Peirce was too much of a formalist for the Hegelian Dewey, and too much of an empiricist for the Dewey who thought in terms of organic relations and absolute minds. Dewey's discovery of Peirce came later, when it was possible for Dewey to see more than intellectual gymnastics in formal logic, when he felt that he could account for it in the framework of a more general theory of inquiry. "The later instrumentalism of Dewey marks a period during which any traditional Hegelianism that remained in his thought, remained in spite of his own efforts. The organic unity of idea and fact gave way to the unity of theory and practice; the contradictions between theses and antitheses became conflicting elements in a problematic situation; the Absolute Reason fell before inquiry".
In fact, as revealed in one of Dewey's biographies (Dalton, 2002, p 42) the relationship between Peirce and Dewey became quite acrimonious while they were both at Johns Hopkins, with Dewey being highly critical of Peirce's mathematical approach to logic and identifying Peirce with the physical scientists.

To establish the links between action research and positivist science, consider the model of the scientific method described in Chapter 4 and note that it is consistent with both positivist science and action research. The primary difference between the two types of research is whether or not science is being discussed with respect to closed or open systems.

In linking this model of science to action research its linkages with Dewey's experiential learning cycle should be noted, as well as the further discussion of Kolb, particularly as Kolb includes the role of Pepper's world hypotheses as representing particular knowledge constructs that can be used in dialectic.

Chapter 7. Rethinking System Dynamics Methodology- an Action Research Approach.

7.1. Introduction: Abductive Inference and SD Methodology.

Issues relating to System Dynamics (SD) method and the validation of SD models are an important preoccupation of SD practitioners. In this chapter it is argued that these issues are debated within the framework set by *deductive* logic which is appropriate for closed systems, but not for open systems as typically found in management decision making.

Using the early Forrester- Ansoff and Slevin debate as a prime example (Forrester, 1968; Ansoff and Slevin, 1968), it is shown that while Ansoff and Slevin argue from the position of deductive logic which assumes certainty and no environmental change, Forrester is arguing from an abductive inference framework in which action results from a best available hypothesis resulting from the development and use of an SD model within a broader learning-decision making framework.

In addition, it is argued that the familiar events-patterns-structure tool used in SD is a structured approach to the abduction process. An implication of these arguments is that debates relating to SD methodology need to shift emphasis from the *validation* of models to debates on *evaluation* of the model development process, the implementation of strategies based on model-based thinking, and the associated outcomes.

The relevance of abductive inference- the process of forming hypotheses- to SD methodology has been raised previously by Ryan (1996) and Barton (1999).

As described in Chapter 3, abductive inference is a mode of inference that, along with deduction and induction dates back to Aristotle but was largely overlooked by Western philosophers, and generally confused with induction, until the late 19th century. At this time, the founder of American pragmatist philosophy, Charles

Sanders Peirce, started to establish abduction as a cornerstone of his philosophical framework:

"Abduction consists in studying facts and devising a theory to explain them".
(CP 2: 270).

Management as Abduction:

Forrester's early work identified the shortcomings of management science and operations research as it was being practiced in the 1950s. For example, Forrester (1961) described the search for optimal solutions as "misleading" and "often results in simplifying the problem until it is devoid of practical interest". Management science:

> … must accept the world as it is, not as an idealized abstraction that fails to be meaningful. It must search for improvement, not hold out for the optimum and perfection. It must use the information that is available, all that is pertinent, but, like the manager, it cannot wait for measurement of everything that one might like to know. It must be willing to deal with "intangibles" where these are important. It must speak in the language of the practicing manager.

(Forrester, 1961, p.4).

These sentiments are supported by the decline in rational approaches to problem solving such as those proposed by Kepner and Tregoe (1965). Despite an apparent rationality, these approaches have lost out to the "alternate approaches actually employed by managers on the job" Wagner (2002, p.45). On a broader front the feasibility and desirability of rationality and certainty has been fundamentally questioned by Toulmin (2001), Searle (2001) and others.

In management, it is becoming increasingly acknowledged that people make decisions on the basis of their "best" hypothesis. Of course, what is meant by "best" is subjective. From studies of decision making under extreme pressure as occurs with emergency services, Klein (1998) concludes that:

> We have found that people draw on a large set of abilities that are sources of power. The conventional sources of power include deductive logical thinking, analysis of probabilities, and statistical methods. Yet the sources of power that are needed in natural settings are usually not analytical at all- the power of intuition, mental simulation, metaphor, and storytelling. The power of intuition enables us to size up a situation quickly. The power of mental simulation lets us imagine how a course of action might be carried out. The power of metaphor lets us draw on our experience by suggesting parallels between the current situation and something else we have come across. The power of story-telling helps us consolidate our experiences to make them available in the future, either to ourselves or to others. These areas have not been well studied by decision researchers.

(Klein, 1998, p. 3)[42].

Klein's conclusions also support the importance of better understanding how hypotheses are formed leading to action- the abductive process. Already, there is a growing recognition of the role of abduction in decision making:

- Abduction forms the basis of artificial intelligence (AI) methodology (Josephsen and Josephsen, 1996)
- Abduction has been proposed as the philosophical basis to strategic thinking (Powell, 2001, Powell, 2002; Powell, 2003; Powell, Lovallo, and Caringal, 2006)
- Abduction has been associated with clinical judgment and decision making in medicine (Montgomery, 2006).

In AI work in areas like medicine, hypotheses need to be formed based on the best available evidence and within a prescribed time frame. Appropriate action is then taken on the basis of this hypothesis and outcomes observed. In medicine this corresponds to the adoption of an appropriate treatment regime and seeing whether or

[42] Perhaps this supports the contention that experience with the use of "micro worlds" (Senge, 1990) may prove to be effective management training.

not the patient recovers. (Josephsen and Josephsen, 1996). In this context Josephsen and Josephsen define abduction as "*inference to the best explanation* ...a form of inference that goes from the data describing something to a hypothesis that best explains or accounts for the data. Thus abduction is a kind of theory-forming or interpretative inference" and "the basis to diagnostic reasoning".

Josephsen and Josephsen quote Charniak and McDermott (1985) as "characterizing abduction as variously modus ponens turned backward, inferring the cause of something, generation of explanations for what we see` around us, and inference to the best explanation. They write that medical diagnosis, story understanding, vision, and understanding natural language are all abductive processes". Josephsen and Josephsen take abduction to be "a distinctive type of inference that follows this pattern pretty nearly:

> *D* is a collection of data (facts, observations, givens),
> *H* explains *D* (would, if true, explain *D*),
> <u>No other hypothesis can explain *D* as well as *H* does.</u>
> Therefore, *H* is probably true.

The core idea is that a body of data provides evidence for a hypothesis that satisfactorily explains or accounts for that data (or at least it provides evidence if the hypothesis is better than explanatory alternatives)".

These themes are further articulated in clinical practice by Montgomery (2006).

(Powell, 2001, Powell, 2002; Powell, 2003; Powell, Lovallo, and Caringal, 2006) examine the logical and philosophical foundations of the hypothesis that competitive advantage leads to superior performance. Powell finds that even this widely accepted pillar of strategic thinking has many interpretations and ambiguities. He concludes, however, that "contemporary theories of competitive advantage may find justification in the epistemologies of abductive inference and a pragmatic, instrumentalist theory of truth".

On a lighter side, abduction has also been recognized as the logic of detective work as practiced by Sherlock Holmes (Copi, 1953).

At a more serious level, abduction, if applied inappropriately, can lead to gross error as described by Argyris' "Ladder of Inference" (Ross, 1994). In this case, a (false) assumption is continuously reinforced by what you observe to the extent that you block out other possible explanations. As a consequence you take actions which you believe are soundly based, but are in fact wrong. (Such reasoning can also be used to explain the careless adoption of management "fads" and their subsequent failure).

By demonstrating how different policy decisions can result from using dynamic, compared to static decision-making frameworks, Andersen (1980) emphasizes the importance of declaring the world view that frames the abductive process.

To minimize the likelihood of errors arising from narrow perspectives and incorrect interpretations of data, it is important to attempt to validate the hypothesis using as many approaches as possible (triangulation). These may typically include interviews, case studies, cognitive mapping, and, of course simulation modelling. Simon and Sohal (1996) refer to this process as being "generative" research.

While management might aspire to base action on testable hypotheses of the type associated with deductive inference, the reality is that simple inferences of the type $P \rightarrow Q$ do not adequately reflect the complexity of human and social systems and of the fallible behaviour of individuals.

In fact, management is about taking action based on a "best hypothesis", at a point in time, which may reflect great urgency. The manager, having taken action, then intervenes in the resulting outcomes to make any corrections necessary to achieve the desired goals. Indeed, these goals may be unclear at the outset and only gain clarity through on-going experience.

Consequently, it is observed that management relates most strongly to abductive inference, with deduction and induction providing secondary roles- deduction in transforming hypotheses into their logical consequences, and induction as a means of empirical support.

The Validity of SD Models- The Forrester- Ansoff/ Slevin Debate.

Richardson (2006) provides an excellent summary of the meaning of "validation" and validation processes. Significantly, Richardson titles his presentation: "Model Validation as an *Integrated Social Process*" (my emphasis) and cites the definition established by Forrester (1973), and Forrester and Senge (1980):

"Validation is a process of establishing confidence in soundness and usefulness of a model".

It is contended that Richardson's account is in agreement with the application of abductive inference. However, it is argued that critics of such frameworks are in fact arguing from a position of deductive logic.

Consequently, the debate is at cross purposes. This can be demonstrated by reference to the classic debate in 1968 between Forrester, and Ansoff and Slevin. While Ansoff and Slevin (1968) argue from the perspective of deductive logic, Forrester (1968), although presumably not aware of the abductive framework, argues from an abductive logic point of view. This observation is further strengthened from later contributions, particularly Forrester and Senge (1980).

Following Forrester's publication of the article "*Industrial Dynamics- A major breakthrough for decision makers"* (Forrester, 1958), (and the subsequent publication of the book Industrial Dynamics (Forrester, 1961), Ansoff and Slevin (1968) published "*An Appreciation of Industrial Dynamics*". After outlining the method of Industrial Dynamics, Ansoff and Slevin conclude that "(T)o this point the approach would raise few objections from a majority of practicing management scientists interested in simulation. They would cheerfully admit to being "industrial dynamicists"". But from that point on, Ansoff and Slevin become less supportive noting the following areas of discomfort:

- The use of descriptive data within the context of a completely quantitative model
- The use of the model as a “tool for enterprise engineering” and not as an instrument for forecasting
- An apparent paradox to a models implementation in whereby “(W)hile insisting on reduction of model *content* to fully quantitative terms, he argues that model validation should not meet this requirement”.
- The possibility that any two modelers coming to different conclusions in answer to the same strategic problem.
- Problems with “quality assurance” in the construction of models.
- Establishing “dynamic validity” with historical time series, but with no objective measure of what constitutes “good fit”.
- An assumed ability for the model to cover all “facets’ of reality and to quantify all related variables and a reliance on the “properties” of the Dynamo compiler.
- A perception that Forrester failed to “formalize the processes of abstraction of data from managers and to provide tests of validity of the information obtained”.
- The possibility that the “information feedback viewpoint” may be more appropriate for some areas of business (such as production and distribution) and less appropriate to areas like marketing. Consequently, there is a possibility that the problem is adjusted to fit the modelling approach and not the reverse.
- How can an Industrial Dynamics model be judged as being more beneficial than any other quantitative method?

Finally, Ansoff and Slevin pose the question of whether or not Industrial Dynamics constitutes a feedback “theory” of the firm.

In a later issue of Management Science, Forrester (1968) addressed each of these points under the headings:

- What is Industrial Dynamics?

- Areas of Usefulness
- Structure
- Feedback Loops
- Quantification in Models
- Sources of Information.
- Validity of Models
- Time and Cost.

At this point only Forrester's discussion of validity will be considered, although his discussion of the importance of the theory of structure is of particular significance to the more complete learning structure discussed later in this Chapter.

Forrester argues that controversy over validity "seems to arise from confusion about the nature of proof and about the avenues available for establishing confidence in a model". He stresses two points: firstly, the importance of linking validity to "purpose", and secondly, "to realize the impossibility of proof…. There is no absolute proof but only a degree of hope and confidence that a particular measure is pertinent to linking together the model, the real system, and the purpose" (Forrester, 1968, p. 614). This statement supports his earlier argument (Forrester, 1961, p. 123) that "Any "objective" model validation procedure rests eventually at some lower level on a judgment or faith that either the procedure or its goals are accessible without objective truth[43]".

In the terms of logical inference, it becomes increasingly clear that Forrester is presenting an *abductive* argument, that is, forming a hypothesis that constitutes a best "theory", and acting on it, while Ansoff and Slevin are talking from a perspective defined purely within the realm of deductive inference. That is, Ansoff and Slevin were basing their theory validation process on the logic of modus tollens. Testing validity on the basis of making correct forecasts is a logic appropriate to *closed* systems in which agents are not purposeful. But management is about working in *purposeful open* systems (Ackoff and Emery, 1972). In such systems agents

[43] This quotation was brought to the authors' attention in a question from Tim Quinn to the SD Society's list serve on March 1, 2006

endogenise the information provided by forecasts and adjust their behaviors accordingly, either to meet the forecast (for example, meeting sales “forecasts”), or to ensure that the predictions are not met (for example, if you continue to not observe the traffic when crossing the road, I might forecast that you will get run over! So what do you do?).

It is now a matter of history that each of the points raised by Ansoff and Slevin has been addressed many times within the SD literature (recent examples include Barlas, 1996; and Homer 1996, 1997). Unfortunately, much of this literature continues to debate the issues within a frame set by deductive logic. Consequently, despite some excellent arguments, they never seem to quite escape the inevitable consequences that deductive logic sets for validation. Reframing the debate using abductive logic changes this.

An Abductive View of SD Methodology.

SD modelling has traditionally been expressed as a form structuralism, in which an underlying structure is sought that explains a *pattern* of events, which in turn has been brought to our attention as a single event. This description of SD method clearly aligns with one of Peirce’s most often quoted descriptions of abductive inference: (CP 5: 181)

“The surprising fact, C, is observed.
But if A were true, C would be a matter of course.
Hence, there is reason to suppose that A is true”.

In this instance, C is the pattern of events (the “surprising fact”) drawn to our attention from an initial event, A is an expression of a causal hypothesis obtained by developing an SD model representing the structure that best describes a pattern of events (A → C) and A is the basis for possible future action.

The SD model constitutes “our best hypothesis” upon which we take action. In this sense, various inputs to the modelling process plus simulation experiments constitute the *triangulation* process for building *confidence* in the hypothesis. None of these processes constitutes a *validation* of the model in the sense of deductive logic and modus tollens.

Consequently, the recognition that SD modeling is part of an abductive process, and that the model represents the hypothesis consequent upon the abductive process, places a new level of support for arguments *against* a refutationist stance in which it is deemed possible to formulate a hypothesis that is capable of being refuted through empirical testing. (See Bell and Bell, 1980).

Furthermore, as Emery and Emery (1997) explain in great detail, abduction is founded in "ecological learning" where "ecological learning and retroduction define the logic of discovery". These are ideas associated with *open* systems thinking, and not as Jackson and Keys (1984) argue, partly on the basis of highly flawed definitions of simple and complex systems, as a technique for "simple-unitary" (closed) systems. That is, situations in which "the problem solver can easily establish objectives in terms of system(s) in which it is assumed a problem resides…(and where)… it is also taken for granted that there is little or no dispute about these". (Flood and Jackson, 1991, p. 37).

7.2. An Improved Approach to SD Methodology.

Accepting the argument that SD modelling is an abductive process raises the question of how this relates to the rest of SD methodology. Forrester (1993) provides an insight into what constitutes an effective methodology. In his review of System Dynamics after 35 years:

> The ultimate success of a system dynamics model investigation depends on a clear initial identification of an important purpose and objective. Presumably a system dynamics model will organize, clarify, and unify knowledge. The model should give people a more effective understanding about an important system that has previously exhibited puzzling or controversial behavior. In general, influential system dynamics projects are those that change the way people think about a system. Mere confirmation that current beliefs and

> policies are correct may be satisfying but hardly necessary, unless there are differences of opinion to be resolved. Changing and unifying viewpoints means that the relevant mental models are being altered. But whose mental models are to be influenced? If a model is to have impact, it must couple to the concerns of a target audience. Successful modeling should start by identifying the target audience for the model.

(Forrester, 1993, p. 211).

Although Forrester does not explicitly mention "action", presumably, it is implied that changing mental models will present itself in changed behaviour (or intended behaviour). Elsewhere, Forrester states that the "purpose of SD is to enable managers to take more informed action".

This suggests any SD methodology must cover the following bases:

- Definition of problem/ purpose (related to 'puzzling or controversial behaviour)
- Identification of stakeholders
- Development of model that identifies feedback behaviour
- Learning (single loop learning)
- Changing mental models (double-loop learning)
- Taking action

Expressions of SD methodology including Richardson and Pugh (1981), Wolstenholme (1990), Lyneis (1999), and Sterman (2000) illustrate the type of processes currently used to meet Forrester's goals. (See Figures 7.1 – 7.3)

Richardson and Pugh's model is stronger in its articulation of the model building and simulation phases with a repeated cycling back to improvements in "understanding the system". But little detail is shown regarding the policy analysis and policy implementation phases except to emphasize that (successful) policy implementation requires both sound policy analysis and a good understanding of the system.

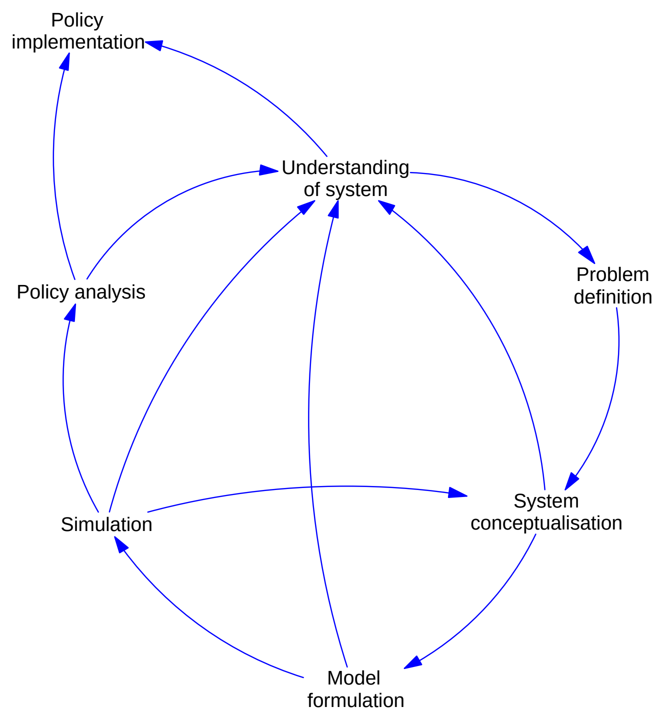

Figure 7.1: Richardson and Pugh' Model (Richardson and Pugh. 1981, p. 17).

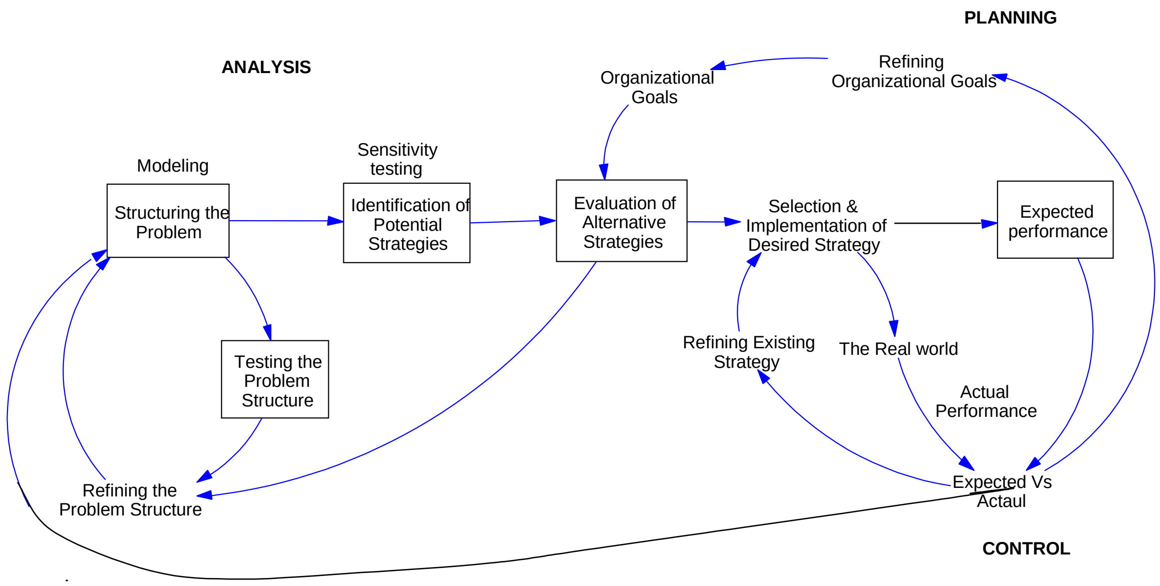

Figure 7.2: An Iterative View of Strategy (Lyneis, 1999).

Lyneis (1999) defines a four-phased approach described in Table 7.1. Lyneis' structure emphasizes the iterative (learning) nature of analysis, planning, and control, where the (reflexive) learning is driven by the gap between actual and desired performance.

Wolstenholme (1990: 4) summarises his methodology under the headings of Qualitative and Quantitative System Dynamics as follows:
Again there is an emphasis on model building and the analysis of system behaviour, but again, very little on implementation.

Sterman's framework shows the SD modeling activity embedded in a "real world" system. It is arguable that his representation most faithfully captures the way in which the modeling activity influences mental models and hence real word behaviour.
Taking these albeit abbreviated representations of SD methodology (and it is totally unfair to separate them from more detailed descriptions!), it is reasonably easy to correlate the model building steps with Peirce's abductive stage of forming a hypothesis. Similarly, those phases associated with simulation experiments can be identified with deductive logic- outcomes resulting from the logic expressed by model are studied, and Peirce's inductive phase can be correlated with those steps in which policy outcomes are studied.

Phase	Description	Main Objective
1	Business structure analysis	Clearly define problem of interest
2	Development of a small, insight-based model	To understand the dynamics of the business by exploring the relationship between the system structure and behaviour over time & educate client
3	Development of a detailed, calibrated model	The purpose of this phase is to: • Assure that the model contains all of the structure necessary to create the problem behaviour • Accurately price out the cost-benefit of alternate choices • Facilitate strategy development and implementation • Sell the results to those not on the client's project team.
4	On-going strategy management system and organizational learning	Develop an iterative view of strategy, compared to the traditional episodic view (that only involves analysis and planning).

Table 7.1. Lyneis' Four-Phase Approach (Lyneis, 1999).

Qualitative SD **(Diagram construction & analysis phase)**	**Quantitative SD** **(Simulation phase)**	
	Stage 1	Stage 2
Purpose: • To create and examine feedback loop structure of systems using resource flows, represented by level and rate variables and information flows, represented by auxiliary variables. • To provide a qualitative assessment of the relationship between system processes (including delays), information, organizational boundaries and strategy. • To estimate system behaviour and to postulate strategy design changes to improve behaviour	Purpose: • To examine the quantitative behaviour of all system variables over time. • To examine the validity and sensitivity of system behaviour to changes in o Information structure o Strategies o Delays/uncertainties.	Purpose: • To design alternative system structures and control strategies based on: o Intuitive ideas o Control theory analogies o Control theory algorithms. In terms of non-optimising robust policy design. • To optimize the behaviour of specific system variables.

Table 7.2. Wolstenholme's Methodology (Wolstenholme, 1990, p. 4).

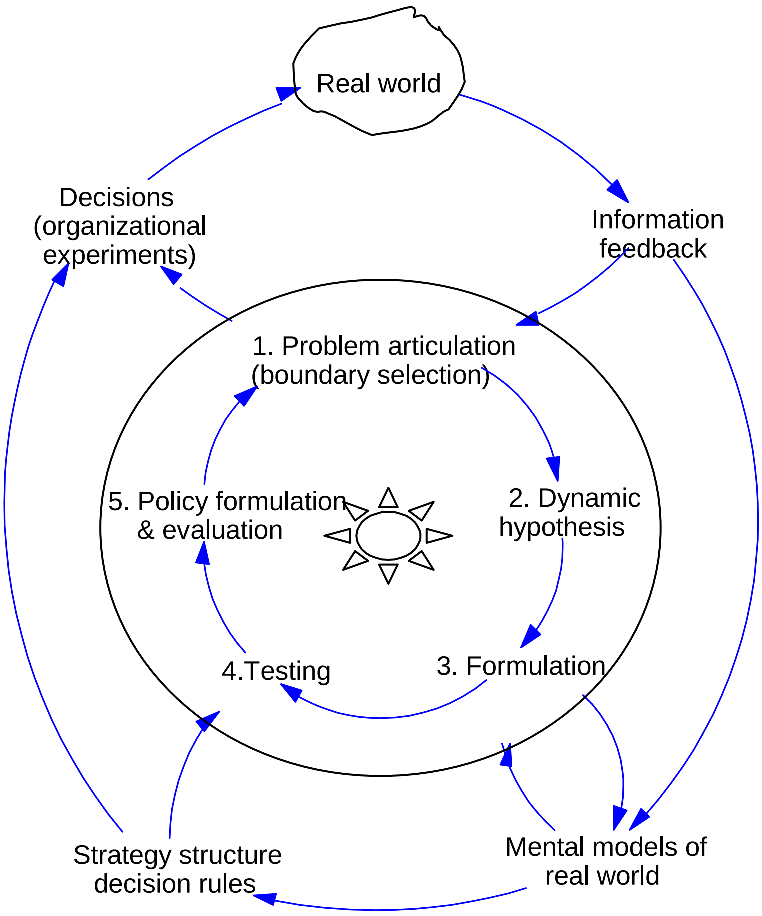

Figure 7.3: Sterman's Version of SD Methodology (Sterman, 2000).

On face value these expressions of SD method may seem to go far enough. But do they? The critical point in Forrester's statement of desired outcomes is the need to change "mental models" as the primary means of changing system behaviour. Senge's (2006) learning model attempts to address this, particularly by introducing Argyris and Schön's (1974) concept of single and double learning. And to this we really need to add Flood and Romm's (1996 a,b,c,d) "triple loop" learning to cover the power, ethical and aesthetic issues. As indicated above, the importance of this stage is pre-empted in Peirce's description of the inductive phase:

> …by Inductive reasonings, appraises the different Probations singly, then their combinations, then makes self-appraisal of these very appraisals themselves, and passes final judgment on the whole result.

(CP: 6: 472).

From Peirce's perspective, changing "mental models" changes a person's sense of reality and hence, in accordance with his "pragmatic maxim", that person's possible actions steps, either conscious or unconscious.

But in total, it is argued that this process constitutes the operation of a "community of inquiry" in the sense described by Peirce and advocated in different terms by Forrester. Sterman's description of the process is most apt:

> Validation is intrinsically social. The goal of modeling, and of scientific endeavour more generally, is to build shared understanding that provides insight into the world and helps solve important problems. Modeling is therefore inevitably a process of communication and persuasion among modelers, clients, and other affected parties. Each party ultimately judges the quality and appropriateness of any model using his or her own criteria.

(Sterman, 2000, p. 850).

In other words, an SD model constitutes a synthesis created by an abductive process performed by a "community of inquiry".

The above discussion leads one to propose a description of the SD methodology that uses Peirce's system of inquiry (Figure 3.3) to better address Forrester's (1987) requirements:

Phase 1: Establishing the problem: Awareness/ scoping

- Novel event is noticed and a pattern revealed
- Establish importance of determining structural cause of this pattern
- Identify stakeholder interests; form "community of inquiry"
- Form a "community of inquiry" and a research team
- Define strategic intent for project expressed as reference modes

Phase 2: Developing a hypothesis (abduction)

- Develop an SD model (s) and associated causal structure

- Use triangulation to build confidence in this "best hunch"
- Use simulations to identify most effective policy setting (Retroduction?)

Phase 3: Define strategies based on causal hypothesis (Deduction)

Phase 4: Implement strategies and monitor performance. Intervene to make corrections as new data/information is revealed

Phase 5. Evaluation (Inductive phase)

- Use triple loop learning to evaluate project
- Form recommendations for future inquiry

Phase 6: Iterate

These phases are further represented in Figure 7.4.

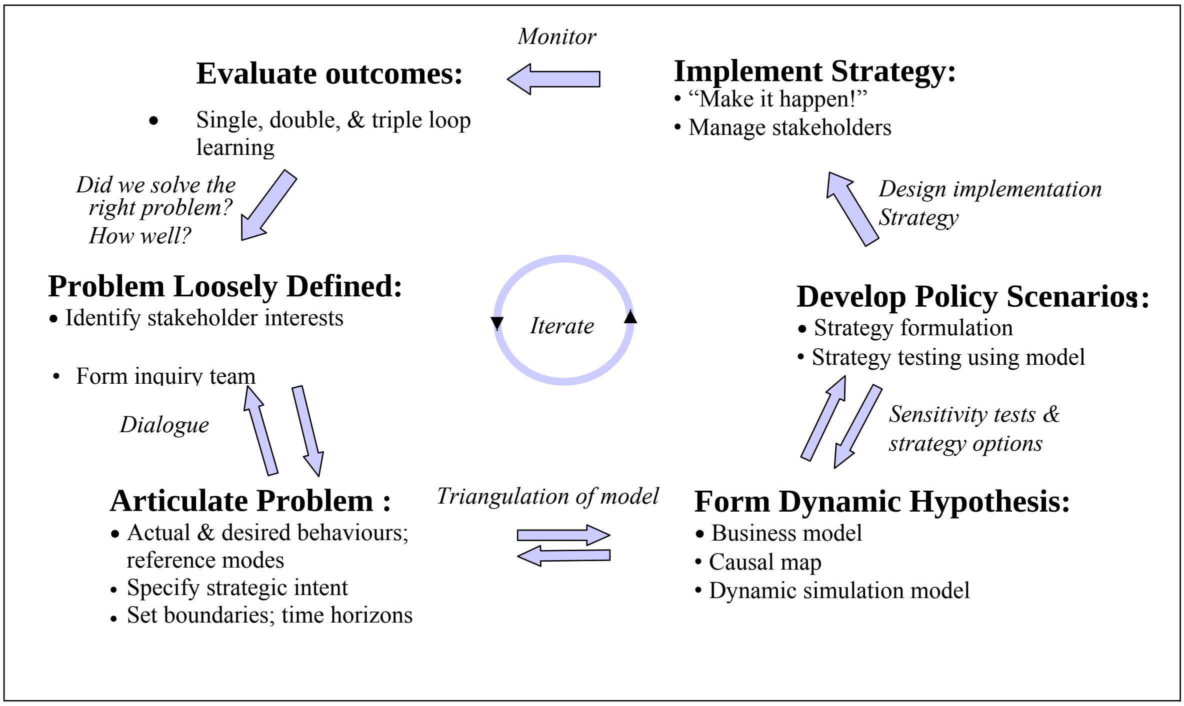

Figure 7. 4: An Enhanced SD Methodology.

Conclusion.

It has been argued that interpreting the structural basis to SD modelling as an abductive process sheds new light on SD methodological debates. Furthermore, when integrated into Peirce's system of inquiry, a generic learning structure can be proposed for SD methodology which involves action steps taken on the basis of a "best" causal hypothesis, and a renewed emphasis on evaluation. Table 7.3 compares the examples considered with the enhanced methodology against Forrester's criteria[44].

Criterion	Richardson & Pugh	Lyneis	Wolstenholme	Sterman	Enhanced Methodology
Definition of Problem	**Y**	**Y**	**Y**	**Y**	**Y**
Stakeholders	**N**	**N**	**Y**	**N**	**Y**
Identifies Feedback Behaviour	**Y**	**Y**	**Y**	**Y**	**Y**
Single-loop Learning	**Y**	**Y**	**Y**	**Y**	**Y**
Double-loop Learning	**Implicit**	**Implicit**	**Implicit**	**Y**	**Y**
Action (Evaluation)	**N**	**Y**	**N**	**Y**	**Y**

Table 7.3 Benchmarking the Approaches Against Forrester's Criteria.

[44] While these comparisons are simplistic, they emphasise the degree to which the mainstream methods fade away when it come to making explicit emphasis on implementation (action) and managing stakeholders.

Conclusions.

This thesis commenced with asking the question "what is systems thinking?" and observed that there were many answers. In general, definitions emphasised "wholes" or "parts" and their inter-relationships. In each case the concept of emergence, characterising a systems principle was important. Another observation was that any given definition is likely to be rooted in the primary discipline of the author.

This thesis concludes that the systems concept is best defined in cognitive terms, and its role in science defined as framing the analysis- synthesis dialectic. This conclusion was reached by tracing the development of the systems concept from antiquity and observing that, by the time of Kant, systems thinking was well established in reference to "systems of knowledge". But this status appears to have been lost by the unintentional consequences of the sole identification of systems thinking with organicism. It is almost as though contemporary systems writers have taken off from where the vitalists finished, adopting the vitalist anti-mechanistic rhetoric and failing to come to grips with basic elements of definition and logic, ignoring history, and failing to recognise the relationship between systems conceptualisation and metaphor.

Although von Bertalanffy plays a pivotal role in all this, it would be wrong to blame von Bertalanffy for the current plight of systems thinking. His destruction of vitalism makes a profound contribution to rational thought and his attempt to develop a General Systems Theory using the open systems concept to describe isomorphism across disciplines reflects genius and profound insight. It was to be his way of making systems of knowledge more scientific, not a total break from the past.

Apart from the cursory reference to von Bertalanffy, systems thinking approaches have developed over the past 50 years more or less in isolation from each other, and in deference to what von Bertalanffy was saying. The current plight of systems thinking, and its attendant confusions, is reflected by Checkland's (1981) statement concerning the status of systems thinking, and the relationship of analysis, synthesis, and systems thinking. This thesis sets out to resolve this confusion. This has been achieved by considering analysis and synthesis in dialectic terms and where systems frame this dialectic. Consequently, the nexus between systems thinking and "systems of knowledge" is re-established and with it, the central importance of systems thinking to the scientific method. The logic of this framework is further enhanced with the support of Peirce's pragmatist architectonic, particularly Peirce's three modes of inference: abduction, deduction, and induction.

There are two important of corollaries to this result:

- Hypotheses cannot be framed unless they are placed in a systemic context. (In positivist science, this is reflected in the importance of conditionals in framing hypotheses).
- Positivist science and action research can each be described in terms of the analysis-synthesis dialectic, respectively relating to closed and open systems.

This relationship with Peirce and the ontological and epistemological frameworks developed, suggests that systems thinking may ultimately be linked with Quine's meaning holism and his naturalistic epistemology, two key elements in Quine's attack on "radical reductionism" with revolutionary consequences for analytic philosophy.

These results are also important to the growing awareness of the practical linkage between systems thinking and action research and an increasing reference to emancipatory issues. This has led to a call for systems thinkers to adopt a pluralistic approach.

For pluralism to be effective, it requires that the philosophical bases of methodologies are made clear. Within this context it has been suggested that Pepper's world hypotheses provide a useful starting point. Furthermore, it has been argued that "strands" of Peirce's pragmatist philosophy (that is, Pepper's contextualism) provide an over-riding framework within which to approach pluralism.

Of particular interest at this point, is to note the emerging importance of dialectic in this thesis. Dialectic has been identified as a basis to adult learning theory, particularly as it relates to using Pepper's world hypotheses in systems thinking, and more generally to knowledge management. But most fundamentally, it has been used to describe the scientific method in terms of the analytic- synthetic interaction. Recognising that systems of knowledge frame this dialectic, places systems thinking at the heart of the scientific method. This gives rise to the further consequence that the scientific method applied to closed and open systems articulates the scientific method in a complementary manner between positivist science and action research.

In a dualistic sense, since dialectic assumes that some pair of "opposites" can be defined objectively, the systems concept becomes fundamental to the dialectic process in general. In other words, starting from a continuous world view, or flux, in which systems can frame events to give them meaning, for however a fleeting passage of time, then the systems construct provides that objectivity fundamental to that dialectic.

These results have been used to address a number of issues relating to knowledge management and action research, with a particular reference to business and management. Specific results obtained include:

1. Rigorous definitions of "data", "information" and "knowledge".
2. Techniques for creating knowledge maps and for measuring and modelling "intangibles".
3. An implementation model for introducing knowledge management practices into functionally based businesses.
4. An enhanced methodology for System Dynamics modelling and application.

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